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1983 Survey of Current Research into Air Infiltration and Related Air Quality Problems in Buildings

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Air Infiltration Centre
Old Bracknell Lane West, Bracknell,
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Annex V Air Infiltration Centre

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PREFACE

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 programs, 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 (Building 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 groundwork 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 dissemmination 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.

Current participants in this task are Belgium, Canada, Denmark, Netherlands, New Zealand, Norway, Sweden, Switzerland, United Kingdom and United States of America.

INTRODUCTION

The Air Infiltration Centre's worldwide survey of current research into air infiltration in buildings provides organisations in participating countries with regularly updated information on on-going research in this field. In particular, one of the major objectives of the survey is to encourage international cross-fertilization of research ideas. The first survey was published in October 1980 and contained an analysis of 65 research summaries received from researchers in 14 countries. The second edition followed in December 1981, with the number of new entries almost doubling to 126. This report contains an analysis of the Centre's third survey of research. It again shows a considerable increase in the number of projects reported, with a total of 187 summaries being received from organisations in 22 countries. A list of contributing countries is reproduced in Appendix 1.

In recognition of the growing importance being attached to the influence of fresh air exchange rates on indoor air quality, the scope of this survey has been specifically extended to include this area of research. A further addition has been to provide an indication of project size in terms of allocation of staff time.

The analysis of results is based on research summaries received from researchers following the distribution of a standardized survey form (Appendix 2) to organisations thought likely to be involved in air infiltration research. To further increase the scale of distribution, the survey form was also reproduced in the May 1983 edition of "Air Infiltration Review". The analysis is presented in two sections. In the first, the results are analysed in terms of specific objectives, project details, parameters with which air infiltration and indoor air quality are related, and allocation of staff time. This information is summarised in tabular form so that the tables may be used as a subject index to the research summaries. The research summaries are reproduced in full in Section 2. Each project is identified by a reference number comprising country identification code (Appendix 1) followed by a number indicating the order in which it appears under the relevant country heading. A list of principal researchers and organisation addresses in contained in Appendix 3.

To facilitate access and regular updating, the research summaries are stored in a computer database which can be rapidly searched using the Air Infiltration Centre's free text retrieval system.

The preparation of this report was only possible as a result of the co-operation of researchers in forwarding details of their studies. The assistance of all who contributed to this survey is acknowledged with gratitude.

Section 1 - Analysis of Results

1.1 SPECIFIC OBJECTIVES

The specific objectives have been divided into fifteen categories (Table 1). These categories, and the range of subjects covered by each, are described in further detail below. In many instances the project objectives encompass several subjects and therefore appear under more than one heading.

The objectives are:

(i) Investigations into indoor air quality and minimum ventilation rates (69 replies)

Over one third of the respondents to the survey cited indoor air quality investigations as a specific objective. This subject has become a key issue because it is recognised that the demands of indoor air quality govern the minimum level of fresh air exchange that is permissable in a building. This, therefore, sets a limiting value for any energy conservation measures involving reduction of air infiltration or ventilation rates. The range of contaminants being investigated is summarised in Section 1.2 and listed in full in Table 4.

(ii) To develop/use techniques to measure/locate sources of air infiltration and air movement (41 replies)

Measurements involving the use of tracer gas, fan pressurization, wind tunnel models, thermography and smoke are being made. Several organisations also report techniques for the measurement of internal and external pressure distributions. Much interest is currently being shown in using techniques to determine air change rates in non-domestic buildings, and developing simplified tracer gas measurement methods. Specific information on measurements is given in Tables 2, 3 and 4.

(iii) To develop/use calculation techniques to predict air infiltration or air flow in buildings (40 replies)

Since the previous survey, the number of projects involving the development or use of calculation techniques has shown a significant increase. The techniques described encompass a wide range of complexity and are being used in all areas of air infiltration research.

(iv) To determine the effect of construction methods and retrofitting techniques on air infiltration/air quality/energy demand (25 replies)

This section includes studies into the performance of airtightness measures, especially as part of a building retrofit. The influence of insulation and weatherstripping is also being assessed. In addition, correlations between airtightness *vs* air infiltration and weather data *vs* air infiltration are reported. In many instances the effects of airtightness measures are being assessed in terms of both energy conservation and indoor air quality.

(v) To evaluate the cost/energy effectiveness of airtightness measures and ventilation strategies (19 replies)

The cost effectiveness of any energy conservation strategy must generally be established before such measures gain widespread acceptance. This topic therefore forms a fundamental aspect of many current projects and is being investigated in several countries. This area of research has shown a substantial increase in growth since the previous survey. Studies into the cost effectiveness of new building design, retrofits, ventilation strategies and heat recovery systems are all included in this section.

(vi) To study the effects of air infiltration on the performance of heating, ventilation and heat recovery systems (17 replies)

The performance of heating and ventilation systems is considerably influenced by air infiltration, with each system demanding an optimum level of building airtightness to ensure its safe and efficient operation. The approaches covered include natural and mechanical ventilation systems, moisture control, forced air heating systems and air-to-air heat recovery devices.

(vii) To develop/recommend airtightness and related standards/guidelines (15 replies)

The need to develop appropriate airtightness standards stems not only from an energy conservation point of view but also from the need to maintain an adequate level of indoor air quality. This subject has therefore taken on considerable importance and several studies are reported. The main emphasis is on recommending appropriate levels of both airtightness and minimum air change rates. Other standards concern measurement methods and heat loss calculations.

(viii) To determine air leakage through specific components (14 replies)

The air leakage characteristics of many specific components are being determined. These components include windows, entrances, vents, facades, weatherstripping and thermal insulation.

(ix) To determine/measure heat loss from buildings due to air infiltration (9 replies)

The range of subjects covered in this section includes the influence of airtightness and air infiltration on energy usage, heat loss modelling and the influence of ventilation systems on heat loss.

The principal aim of many air infiltration studies is to seek ways of reducing heat loss and, in addition to those projects referenced in Table 1, there are many others in which heat loss measurements appear as a key component. These are listed in Tables 2 and 8.

(x) To determine the effects of occupants on air infiltration (7 replies)

The benefits of energy conserving measures can be significantly affected by the actions of occupants, especially in relation to window and door opening. Several studies are devoted to analysing

the need for opening windows, while others are investigating heat losses due to window opening. The benefits of educating inhabitants in the proper use of heating and ventilation systems are also being analysed. Other projects in which the influences of occupants are being considered are listed in Table 6.

(xi) To develop airtight construction/retrofit techniques (7 replies)

A number of new research projects have been reported concerning the development of airtight construction techniques. Projects described include the development of practical design solutions, devising methods for sealing joints and studies into the performance of air/vapour barriers.

(xii) To determine factors affecting air infiltration (6 replies)

Much of the research reported in this section relates to the influence of wind on air infiltration. The influence of internal pressure distribution on air flow is also considered.

(xiii) To determine building pressure distribution (5 replies)

The building pressure distribution is primarily being determined as a function of wind speed and buoyancy effects. Other parameters include building orientation, shape and location. This category also contains research details on time-averaged pressure measurements being made on building facades.

(xiv) Determination/survey of representative values of air infiltration rates (4 replies)

This section lists projects concerned with determining typical values of air infiltration rate for various buildings.

(xv) To determine the air leakage characteristics of buildings (2 replies)

These projects involve the measurement of air leakage in a large number of dwellings. The objective is to categorize air leakage characteristics of buildings according to typical construction practices.

1.2 PROJECT DETAILS

Project details are summarised in terms of measurements and activities (Table 2), tracer gas methods (Table 3), indoor climate measurements (Table 4), building type (Table 5), occupancy patterns (Table 6) and ventilation systems (Table 7).

The most widely reported measurement involves the use of tracer gas (55 replies), with the concentration decay technique being the most popular method. New developments in tracer gas approaches include "passive" continuous emission methods for long or short duration sampling and multi tracer gas methods for air movement studies. Sulphur hexafluoride and nitrous oxide are the most commonly reported tracer gases, followed by carbon dioxide and per fluoro tracers (PFT).

Air leakage measurements using pressurization methods are also being performed extensively. Both component leakage and whole building measurements are reported. In most instances, direct pressurization or depressurization is used although in one project (CA14) a transient technique is adopted in which a pulse of compressed air is discharged into the building, and in another (US30) alternating (AC) pressurization is used.

Approximately 40% of the organisations making indoor climate measurements are monitoring radon concentrations. This subject has attracted much worldwide interest recently, with projectsbeing reported in Canada, Finland, the Netherlands, Sweden, Switzerland, the United Kingdom and the United States. This interest follows concern regarding the potential carcinogenic properties of the gas. Under certain geological conditions, naturally occurring radon passes from the underlying strata into the building. If the building is poorly ventilated, undesirably high concentrations of the gas can occur. Measurements are being made to determine the extent of the problem, the risk involved and methods to minimise the ingress of radon. Other important pollutants under investigation include moisture, combustion products such as oxides of nitrogen and carbon monoxides, formaldehyde and particles (smoke, dust, etc). A complete list of the pollutants being studied is given in Table 4.

Energy consumption and heat loss measurements continue to form a fundamental part of many projects. These measurements range from a simple analysis of annual fuel consumption records, to detailed measurements of roof, floor and facade heat loss.

Air movement measurements have steadily grown in importance. An understanding of air flow patterns is particularly necessary in order to maximise ventilation efficiency at low air exchange rates. For similar reasons, measurements of a "multi-cell" nature are also becoming more common. Such methods enable the influence of internal partitioning on air movement to be determined.

Other measurements being made include full scale and wind tunnel pressure measurements, both of which provide valuable input for mathematical modelling studies. Finally, leak detection techniques using smoke and thermography are reported.

Research activities mentioned for the first time in the replies include surveys, literature studies, the creation of databases and the preparation of design guidelines (Table 2b). The range of topics included in these activities covers not only air infiltration, air quality and energy studies but also parameters influencing air infiltration rates - particularly climate.

Of the projects for which the type of building in which measurements are being made is stated, just over half relate to single family and apartment dwellings (Table 5). The remaining buildings identified are commercial premises, industrial buildings, schools, hospitals, farm buildings, individual rooms and climatic chambers. Compared with the previous survey, measurements in industrial buildings have increased substantially, while proportionately fewer measurements are being made in single family dwellings.

Where information was provided, 60% of the projects relate to occupied buildings, 14% to simulated occupancy and the remainder are concerned with measurements in unoccupied buildings (Table 6)

Natural ventilation accounts for almost 50% of the systems referenced (Table 7). The continuing popularity of natural ventilation is widespread with organisations in 15 countries referring to such systems. Countries in which natural ventilation is not mentioned include those with particularly severe climates such as Canada, Finland and Sweden. Heat recovery systems are mentioned in several research summaries with both air-to-air systems and exhaust air heat pumps being investigated. Mechanical ventilation systems operated by indoor air quality sensors are also being studied.

1.3 PARAMETERS WITH WHICH AIR INFILTRATION AND AIR QUALITY ARE RELATED

In almost all instances,air infiltration is being related to wind velocity and internal/external air temperatures. Air quality is being related to sources of pollution, building airtightness, air change rates and building location. A complete list of parameters is printed in Table 8. In general, parameters are linked to the various project objectives. Following weather and temperature, the most widely cited parameters are performance of building components, occupant behaviour, air quality and the effect of heating, ventilating and heat recovery systems. The remaining parameters are pressure differences, humidity, structural design, exposure, comfort levels, year of construction, air movement and internal obstructions.

1.4 ALLOCATION OF STAFF TIME AND DISTRIBUTION OF RESEARCH PROJECTS

Information on the staff time allocated to each project was stated in 50% of the survey replies. These results are summarised in Figure 1. The median time allocation for each project is 2000 man hours, while the research effort for 75% of the projects is under 5000 man hours. Thus the typical time being spent on individual projects is in the region of between 1 and 3 man years. There are notable exceptions, however, with long term research projects of over 50,000 man hours of effort being reported in Canada (CA9), the United States (US18) and West Germany (DE1). In total, it is estimated that this survey documents one million man hours of research effort.

The distribution of research effort by country is illustrated in Figure 2. Virtually half of the stated time allocation is accounted for by research in the United States (32.4%) and Canada (16.9%). West Germany (a non-participant in the Air Infiltration Centre) comes third with 14.8%, while the non-participating countries as a whole account for over a fifth of the research time. The United Kingdom comes fourth, followed by the Netherlands and Sweden. The aggregate time stated by organisations in Belgium, Denmark, New Zealand, Norway and Switzerland amounts to just 2.5% of the total. Because response to the survey is entiraly voluntary, there is likely to be some distortion in these results, particularly in relation to the non-participating countries (especially France and Eastern Europe) where penetration of the survey was limited. Furthermore, individual

large scale or long term projects can account for a significant slice of a country's total research effort. Nevertheless, it is thought that these results provide a fairly accurate picture for the participating countries and West Germany.

The distribution of projects among types of organisation is illustrated in Figure 3. Approximately 39% of the research projects are being undertaken by universities or polytechnics, 36% by government or public sector research establishments and 25% by private sector organisations.

1.5 CONCLUSIONS AND DISCUSSION

In common with the previous two surveys, this third survey of research has revealed a diverse range of projects, covering all aspects of air infiltration research. Possible areas of weakness include occupancy effects and studies into the long term durability of low leakage structures. There is also still much to be understood regarding the overall energy effectiveness of airtightness measures and the influence on energy demand of choice of ventilation strategy.

Recent concern regarding the possible harmful effects that low air exchange rates may have on indoor air quality is much in evidence. This, perhaps, highlights the need to be sure that design and retrofit approaches are well planned and are conducted in conjunction with a proper programme of measurements. To ensure an acceptable internal environment, coupled with an optimum level of energy efficiency, it is essential that ventilation needs are properly assessed and adequately met. The most frequently reported indoor pollutant is radon but moisture and the products of combustion from cooking and heating appliances are also being extensively investigated.

In recognition of the need to consider ventilation, both in terms of energy conservation and indoor air quality, many countries are preparing and implementing standards or guidelines governing airtightness and minimum air change rates. Much research in the field of minimum ventilation rates is still necessary but it is encouraging to note that progress in this area is being achieved.

A move towards air infiltration studies in non-domestic buildings has resulted in a strengthening of research in multi-cell applications. To support this work, a number of multi tracer gas techniques have recently been introduced.

Instrumentation and measurement techniques still largely remain research tools. Steady-state pressurization instrumentation is available commercially but tracer gas equipment is not available as a complete package. The development of a per fluoro tracer technique for both short and long time-averaged measurements has a good market potential (US14). The passive nature of both the continuous emission source and adsorption tube collector means that expensive site instrumentation may be avoided. Further development at the Lawrence Berkeley Laboratory of the alternating pressurization technique will hopefully yield a portable system for the measurement of air leakage (US30). An advantage of this approach is that the leakage characteristics of the building may be determined at pressures corresponding to those experienced in reality.

Predictive techniques involving the development and application of mathematical models continue to form an essential component of many research projects. Several of these models have also been investigated by the Air Infiltration Centre as part of a validation exercise. The results of this study have shown that excellent agreement between calculated and measured rates of air infiltration are possible but that care must be exercised in specifying both the leakage characteristics of the building and the surface pressure distribution. Further modelling studies, particularly to verify turbulent fluctuation assumptions and air movement predictions are necessary. It is hoped that some of the models investigated by the Centre will become more generally available, especially as design tools.

The analysis of research effort being devoted to each project reveals that these research studies are of a fairly short duration, typically representing between one and two man years of effort. This tends to reflect a general funding policy favouring short term research projects. Nevertheless, the total staff commitment documented in this report is estimated to amount to one million man years.

Information on air infiltration research will continue to be updated and made available to organisations in participating countries. It is envisaged that the results of the next survey will be published in November 1985.

FIGURE 1: Allocation of staff time

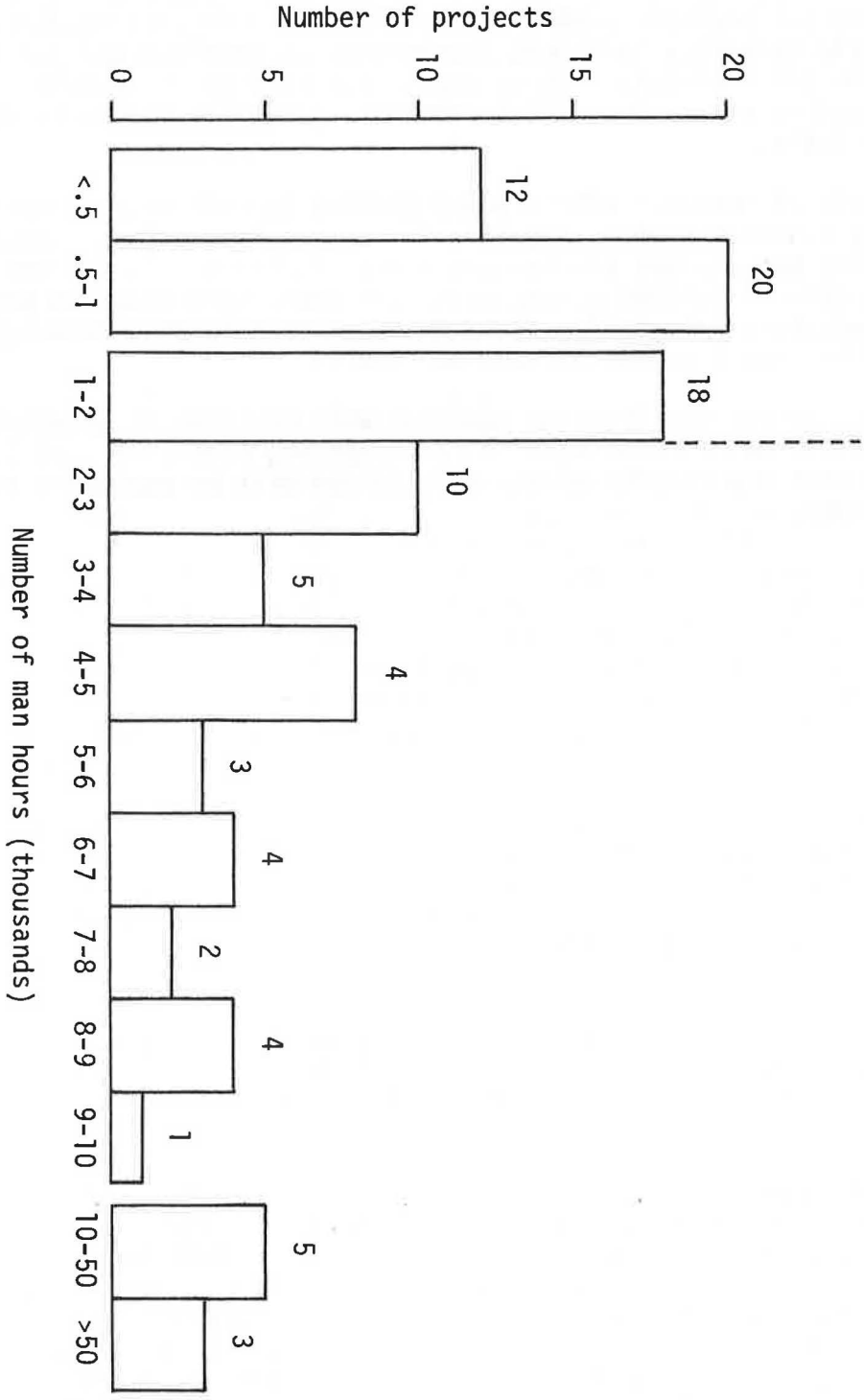

FIGURE 2: Approximate distribution by country of staff allocation
(based on 95 replies, total man hours ≈ 500,000)

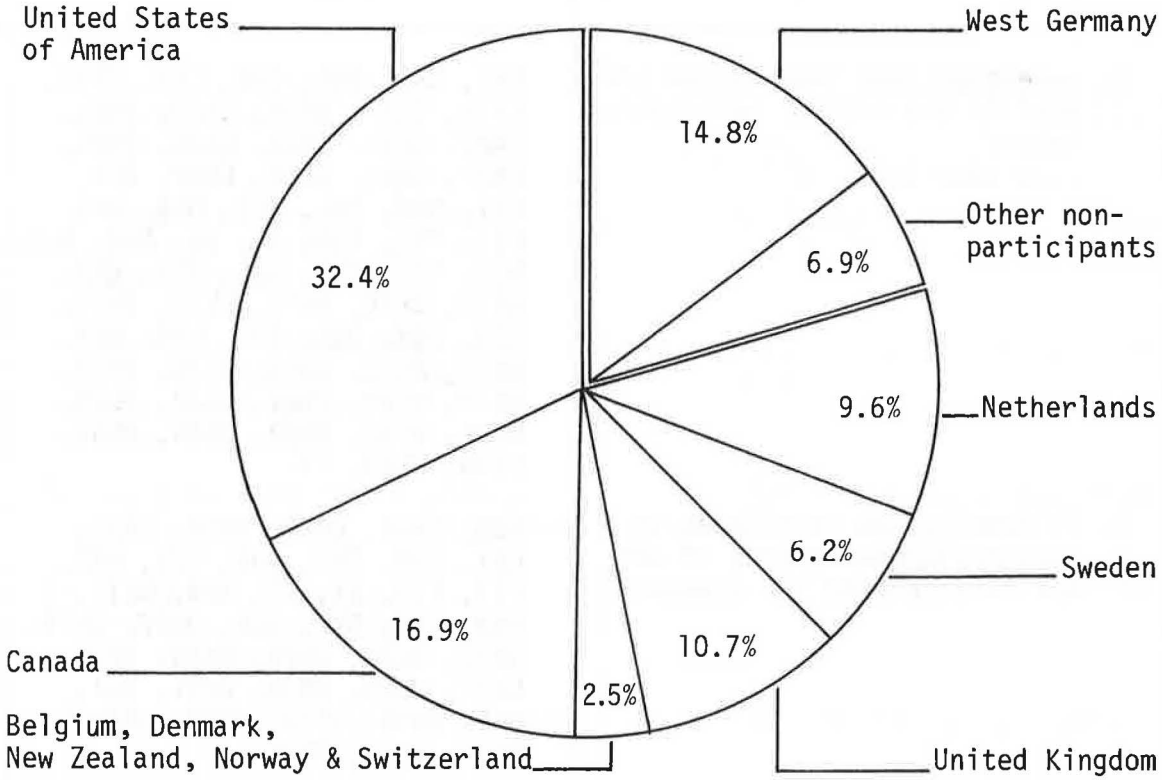

FIGURE 3: Project distribution among types of organisation

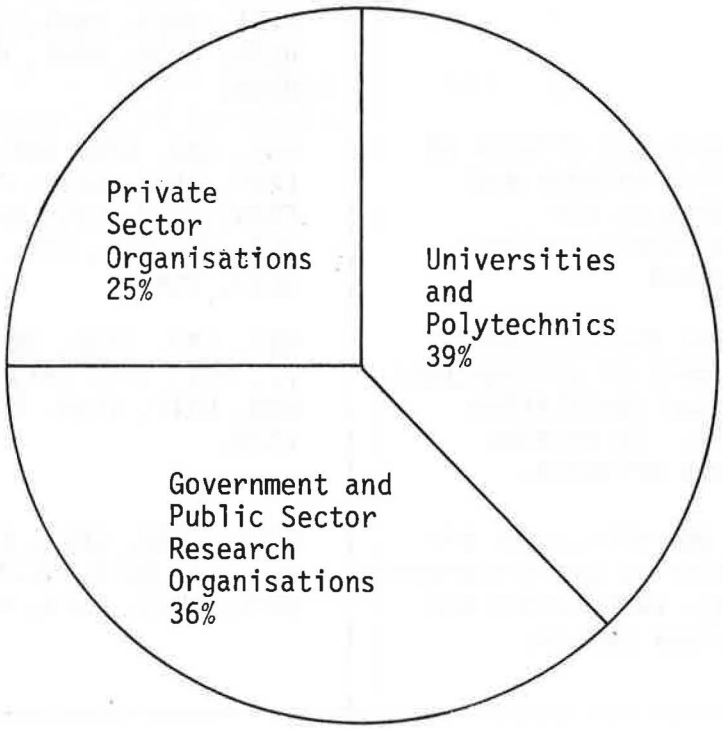

TABLE 1 - SPECIFIC OBJECTIVES

OBJECTIVES	PROJECT REFERENCE NUMBER
1. Investigations into indoor air quality and minimum ventilation rates. *(see also Table 4)*	CA1, CA2, CA5, CA8, CA9, CA13, CA16, CA17, CA18, CA20, CA21, CA22, CA23, CA24, CA25, CA26, CA27, CA28, CA29, CA32, CH3, CZ1, DE8, DK1, DK2, DK3, DK4, FI1, FI2, FI4, J4, J5, NL2, NL3, NL6, NZ1, PL2, SE6, SE9, UK1, UK15, UK16, UK17, UK30, UK31, US3, US4, US5, US7, US8, US9, US10, US12, US15, US16, US18, US19, US20, US21, US22, US23, US31, US32, US33, US34, US36, US39, US40, Y1.
2. To develop/use techniques to measure/locate sources of air infiltration and air movement.	BE2, CA14, CA20, CA32, CA35, CH1, CH2, CH5, CH6, CZ1, DK2, FI1, FI3, J1, J2, NL9, NL11, UK3, UK4, UK7, UK8, UK12, UK19, UK22, UK23, UK24, UK25, UK26, UK27, UK29, UK30, UK31, US1, US2, US14, US17, US27, US30, US38, US44, US47.
3. To develop/use calculation techniques to predict air infiltration or air flow in buildings.	BE2, CA10, CA11, CA32, CA34, CH1, DE4, FI3, H1, J2, J6, NL5, NL8, PL1, PNG1, SE1, SE7, SE10, UK3, UK4, UK16, UK18, UK19, UK20, UK22, UK26, UK27, UK30, UK31, US23, US27, US28, US32, US35, US38, US41, US42, US45, US46.
4. To determine the effects of construction methods and retrofitting on air infiltration/air quality/ energy demand.	AU1, CA2, CA4, CA6, CA7, CA9, CA11, CA15, CA18, CA28, CA29, CA30, CA37, CH1, CH3, DK4, FI1, IT2, J1, PL1, SE8, US13, US24, US33, US43.
5. To evaluate the cost/energy effectiveness of airtightness measures and ventilation strategies. To develop performance criteria.	BE1, CA3, CA30, DE1, DE3, DE5, F1, FI1, IT1, SA1, SE2, SE4, UK9, UK17, UK28, US1, US13, US25, US28.
6. To study the effects of air infiltration on the performance of heating, ventilation and heat recovery system.	CA11, CA30, CA31, CA32, FI2, FI4, DE7, J3, NL13, NL17, SE7, UK6, UK11, UK15, US13, US25, US39.

contd/.

TABLE 1 - SPECIFIC OBJECTIVES

OBJECTIVES	PROJECT REFERENCE NUMBER
7. To develop/recommend airtightness and related standards/guidelines.	CA22, CA23, CH6, DE2, FI3, NL7, NL15, NL16, SE3, SE9, UK17, UK30, US10, US11, US22.
8. To determine air leakage through specific building components.	NL5, NL12, NL13, NL17, NL18, SE6, UK2, UK5, UK11, UK13, UK14, US6, US16, US37.
9. To determine/measure heat loss from buildings due to air infiltration. *(see also Table 2)*	CH5, DE4, FI2, IT2, NL1, NZ1, PL1, SE7, UK21.
10. To determine the effects of occupants on air infiltration.	BE2, CA11, CA37, NL4, NL9, NL14, NL15.
11. To develop airtight construction/retrofit techniques.	CA12, CA16, CA19, CA33, FI3, NO2, UK10.
12. To determine factors affecting air infiltration.	CH5, DE6, F1, NL10, SE5, UK5.
13. To determine building pressure distribution.	CA32, CA34, PL1, SE1, SE5.
14. Determination/survey of representative values of air infiltration.	AU1, NO1, US2, US35.
15. To determine the air leakage characteristics of buildings.	CA19, CA36.

TABLE 2 - PROJECT DETAILS (a) MEASUREMENTS

MEASUREMENT	PROJECT REFERENCE NUMBER
1. Tracer gas *(see also Table 3)*	AU1, BE1, BE2, CA5, CA11, CA20, CA30, CH2, CZ1, DE3, DE7, DK2, F1, J2, J3, J4, NL2, NL6, NL9, NL10, NL12, NO1, NZ1, SA1, SE3, SE4, SE8, UK3, UK4, UK7, UK8, UK9, UK11, UK13, UK16, UK22, UK23, UK26, UK28, UK29, US1, US6, US7, US8, US14, US21, US26, US27, US28, US33, US38, US39, US43, US44, US47,
2. Pressurization tests (DC) (air leakage measurements)	
(a) whole building	AU1, BE1, BE2, CA4, CA7, CA10, CA15, CA16, CA19, CA30, CA33, CA36, CA37, CH1, DE3, DE7, FI1, FI3, J1, J2, J4, NL12, NL16, NO2, NZ1, SE4, SE7, UK3, UK9, UK10, UK28, US1, US6, US33, US38, US39, US43, US44.
(b) components	BE1, CA32, CH1, CH5, F1, FI1, FI3, IT2, PL1, SE3, UK2, UK5, UK14, UK25, UK26, US37, US47.
3. Pressurization tests (AC) and (transient)	CA14, US30.
4. Indoor climate (odour, moisture, pollution, etc.) *(see also Table 4)*	CA3. CA5, CA7, CA8, CA9, CA13, CA18, CA20, CA21, CA25, CA30, CH3, CH4, DK1, DK3, DK4, FI1, FI2, FI4, J5, NL2, NL3, NL5, NL6, NL9, PL2, SE6, UK1, UK16, US4, US5, US8, US10, US15, US16, US18, US19, US20, US21, US22, US23, US26, US31, US33, US34, US36, Y1.
5. Energy consumption/heat loss measurements. Heating/cooling system performance.	CA3, CA7, CA15, CA29, CA30, DE2, DE3, DE4, DE6, F1, FI2, FI4, NL1, NL5, NL13, NL14, SE2, SE3, SE4, SE7, SE8, UK9, UK10, UK15, UK17, UK21, UK28, US24, US25, US33.
6. Internal pressure/air flow distribution.	CA34, FI1, NL5, NL8, NL11, NL12, NL13, NL15, NL17, NO2, PNG1, SE3, UK12, UK19, UK24, UK29, UK30, US17.

contd/.

TABLE 2 - PROJECT DETAILS (a) MEASUREMENTS

MEASUREMENT	PROJECT REFERENCE NUMBER
7. Multi-cell investigations *(see also Table 5 - commercial premises)*	CH2, FI3, H1, J6, NZ1, SE3, UK3, UK7, UK18, UK29, UK30, US14, US28, US45.
8. Facade pressure distribution/ pressure difference.	CA32, CA34, CH5, J3, NL5, NL8, NL10, NL12, NL16, PL1, SE5, UK26, UK30.
9. Wind tunnel models.	J3, NL18, PNG1, SE1, UK3, UK30, UK31, US7, US29.
10. Thermography	FI3, NO2, PL1, SE3, US1, US47.
11. Smoke.	FI3, SE3.

TABLE 2 - PROJECT DETAILS (b) OTHER ACTIVITIES

ACTIVITY	PROJECT REFERENCE NUMBER
1. Calculation techniques.	BE1, BE2, CA10, CA32, CA34, CA35, DE2, DE3, DE4, F1, FI3, H1, J2, J6, NL5, NL8, NL9, NL12, NL13, NL16, NZ1, NO2, SE1, SE4, SE5, SE7, SE10, UK3, UK5, UK8, UK13, UK16, UK18, UK19, UK20, UK22, UK26, UK27, UK30, UK31, US12, US13, US16, US21, US23, US24, US27, US28, US32, US33, US35, US41, US42, US45, US46.
2. Surveys	CA19, CA21, CA26, NL1, NL2, NL4, NL14, NO1, NZ1, US21.
3. Literature studies/reviews/ bibliographies	CA22, CA23, CA27, CH4, CH6, NL18, US10, US22, US35, US40.
4. Compilation of databases	NL7, US30, US41.
5. Preparation of guidelines	CA24, CA29, CH4.

TABLE 3 - PROJECT DETAILS: ANALYSIS OF TRACER GAS TESTS

(a) TECHNIQUE	PROJECT REFERENCE NUMBER
1. Decay	CH2, J2, NZ1, SE4, UK6, UK11, UK13, US1, US33, US38.
2. Constant concentration	AU1, CH2, SE4, UK3.
3. Constant emission	CH2
4. Automatic sampling	UK3
5. Bag/bottle/grab sampling	CA13, US4, US43
6. Multi tracer gas	NZ1, UK7, UK9, UK31, US14
7. Passive techniques	CA20, US8, US14

(b) TRACER GAS	PROJECT REFERENCE NUMBER
1. Carbon dioxide	J2, UK8, UK11, UK13, US8
2. Carbon monoxide	J4
3. Ethane	DE7
4. $Krypton_{85}$	CZ1
5. Methane	US26
6. Nitrous oxide	AU1, BE1, CH2, UK16, UK23, UK26
7. Sulphur hexafluoride	CA11, NL2, NZ1, SA1, US1, US6, US27, US39.
8. Perfluoro tracers	CA20, US1, US8, US14, US33
9. Ethylene	J4

TABLE 4 - PROJECT DETAILS: ANALYSIS OF INDOOR CLIMATE MEASUREMENTS

POLLUTANT	PROJECT REFERENCE NUMBER
1. Allergens	US18
2. Asbestos	CA22, US9, US20
3. Carbon dioxide	DK1, NL5, NL6, US20, US21, Y1
4. Carbon monoxide	CA22, CA26, NL2, US12, US18, US20, US21, US23, US31, Y1.
5. Carcinogens	CA22
6. Condensation (moisture, humidity)	CA5, CA16, CA21, CA32, DE8, DK1, NZ1, UK1, US17, US5, US16, US25, US36.
7. Formaldehyde	CA9, CA18, CA20, CA22, NL3, US4, US20, US21, US23, US31, US32, Y1.
8. Fungi/mould	CA22
9. Micro organisms, bacteria, viruses, etc.	CA5, CA22, CA27
10. Nitrogen oxides	CA18, CA22, J5, NL2, SE9, US4, US12, US19, US21, US23, US31, US33, US36.
11. Odours	CA27, NL5, NL6, SE9, US10, US36.
12. Ozone	CA22, US18, US23
13. Particles (smoke, dust, etc.)	CA9, CA22, DK1, NL2, NL6, UK9, US18, US23, US33, US34, Y1.
14. Radon	CA8, CA13, CA18, CA20, CA22, CA24, CA25, CH3, FI1, FI2, NL9, SE6, UK16, UK30, US4, US6, US15, US31, US34.
15. Sulphur compounds	US4, US21, US23, Y1
16. Other	Y1 (ammonia phenol)

TABLE 5 - PROJECT DETAILS: BUILDING TYPE

BUILDING	PROJECT REFERENCE NUMBER
1. Dwellings (primarily single family, low rise)	AU1, BE1, BE2, CA4, CA7, CA8, CA9, CA10, CA11, CA14, CA15, CA16, CA18, CA19, CA20, CA21, CA22, CA23, CA24, CA25, CA26, CA27, CA28, CA29, CA30, CA31, CA32, CA33, CA36, CA37, CH1, CH2, CH3, CH5, DE1, DE3, DE4, DE7, DK3, F1, FI3, J1, J3, J4, J5, NL1, NL2, NL3, NL4, NL8, NL9, NL10, NL12, NL16, NL17, NL18, NO1, NZ1, PNG1, SA1, SE1, SE2, SE3, SE4, SE5, SE7, SE8, UK3, UK6, UK7, UK10, UK11, UK16, UK17, UK20, UK21, UK23, UK25, UK28, UK29, US1, US8, US18, US21, US24, US31, US39, US43.
2. Dwellings (multi-storey)	CH5, DK2, DK4, FI2, FI3, FI4, H1, J1, J3, NL8, NL10, NL14, NL15, PL1, UK18, US19, US38.
3. Commercial premises (offices/public buildings, etc.)	CA1, CA5, CA8, FI1, NL6, PNG1, UK3, UK15, UK20, UK26, UK31, US17, US26, US36, US44, US47, Y1.
4. Industrial buildings (warehouses, factories, etc.)	CA2, NL11, PL2, UK4, UK18, UK19, UK22, UK27, US9, US27, US35.
5. Schools (educational buildings, etc.)	CA5, CZ1, DK1, NL3, NL5, PNG1, UK8, UK9, UK13, UK26, US6.
6. Individual rooms	CH4, DE5, DE6, J2, NL12, NL17, UK19
7. Climatic chambers	CH4, DK3, SE9, UK5, US16
8. Hospitals	CA5, UK20, US10, US22
9. Farming/agricultural buildings	CA6, US13
10. Other	UK5 (freight containers) FI1 (museum)

TABLE 6 - PROJECT DETAILS: BUILDING OCCUPANCY

OCCUPANCY	PROJECT REFERENCE NUMBER
1. Occupied	CA1, CA3, CA9, CA11, CA15, CA37, CH2, CH3, DE1, DE3, DE8, FI2, NL2, NL4, NL5, NL6, NL14, NL15, PL1, SA1, SE2, SE7, UK8, UK13, UK16, UK17, UK26, UK31, US6, US14, US20, US22, US24, US36, Y1.
2. Unoccupied	AU1, BE1, CA11, CZ1, DE5, DE7, J1, J2, NL8, PL1, SE4, UK3, UK11, UK17, UK21.
3. Simulated occupancy	CA11, DE6, H1, IT1, NL5, SE4, UK3, US8.

TABLE 7 - PROJECT DETAILS: VENTILATION SYSTEM

SYSTEM	PROJECT REFERENCE NUMBER
1. Natural	AU1, BE1, CZ1, CH1, CH3, CH5, DE1, DE3, DE4, DE7, DK4, J3, NL3, NL5, NL8, NL10, NL14, NL15, NL17, NL18, NO2, PL1, PNG1, SA1, UK3, UK5, UK8, UK9, UK10, UK11, UK26, UK31, US6, US8, US13, US16, US18, US28, US29, Y1.
2. Mechanical	CA11, CA16, CA29, CA31, CA32, CA33, CH5, CZ1, DE3, DE7, DK1, FI1, FI2, FI3, FI4, H1, J1, NL1, NL4, NL8, NO2, PL1, PL2, SE2, SE3, SE4, SE8, UK3, UK6, UK9, UK13, UK20, US4, US7, US10, US16, US18, US22, US25, US26, US27, Y1.
3. Heat recovery systems	CA32, CA33, DE1, FI4, IT1, NL13, SE2, SE8, UK9, US1, US4, US25, US39.
4. Mechanical ventilation controlled by indoor air quality.	SE9, UK15, US26.

TABLE 8 - PARAMETERS WITH WHICH AIR INFILTRATION/AIR QUALITY ARE RELATED

PARAMETER	PROJECT REFERENCE NUMBER
1. Wind velocity 2. External air temperature 3. Internal air temperature	In almost all instances air infiltration is related to these parameters.
4. Air quality/sources of pollution/health problems	CA2, CA8, CA9, DE1, DK1, DK2, J4, NL2, NL3, NL5, NL6, NL9, PL2, SE6, UK16, UK19, US4, US9, US12, US14, US15, US19, US20, US22, US23, US32, US34, US39, Y1
5. Effect of heating, ventilation or heat recovery system.	CA11, CA32, FI1, FI2, FI3, FI4, H1, J5, NL4, NL8, NL13, NL17, SE2, SE3, UK22, US1, US4, US7, US14, US22, US23, US27, US28.
6. Energy consumption/heat loss	BE1, CA1, CA2, CA4, DE6, IT2, SE7, UK10, UK28, US33.
7. Envelope pressure/pressure difference	BE2, IT2, NO2, SA1, SE2, SE6, UK2, UK13, UK14, UK20, US29.
8. Humidity/moisture	BE2, CA9, CA32, CH4, DE1, DE6, DE7, DK2, J2, PL2, US1, US8, US16, US18, Y1
9. Occupants (including window/door opening habits, activities, etc.)	CA3, CA11, CH2, CH3, DE1, DE2, DE3, FI2, H1, IT1, J5, NL2, NL4, NL5, NL6, NL9, NL12, NL13, NL14, NL15, SE4, SE7, UK3, UK8, UK9, UK13, UK14, UK17, UK21, UK31, US22, US23, US24, US33, US36, Y1.
10. Performance/leakage characteristics of building components. Building airtightness, pressurization results.	BE1, BE2, CA3, CA7, CA10, CA11, CA13, CA15, CA16, CA18, CA19, CA32, CA33, CA35, CA36, CA37, CH1, CH2, CH3, DE1, DE7, FI1, FI3, IT1, J2, J3, J4, J6, NL5, NL16, NZ1, PL1, SE1, SE4, SE7, UK3, UK6, UK16, UK17, UK26, US6, US16, US26, US28, US29, US30, US38, US39, US43, US44, US47.
11. Structural design, geometry, building dimensions, materials	AU1, CA1, CA6, CA12, CA18, CA19, CA34, CH5, FI3, FI4, IT2, NL2, NL8, PL1, UK16, UK22, UK27, UK29, US4, US9, US24, US47.

contd/.

TABLE 8 - PARAMETERS WITH WHICH AIR INFILTRATION/AIR QUALITY ARE RELATED

PARAMETER	PROJECT REFERENCE NUMBER
12. Terrain/exposure of building	CA34, NL10, NL18, NO2, NZ1
13. Year of construction	FI3
14. Air change rate	CA5, CA13, CA18, CH4, DE1, NL3, SE3, SE6, SE7, SE8, UK1, US10, US32, US39
15. Comfort levels	CA4, DK4, PNG1, UK1, UK2
16. Other	UK7 (air movement) UK18 (internal obstacles)

Section 2 - Research Summaries

AUSTRALIA

#REF AU1 Air infiltration characteristics of buildings
PRINCIPAL RESEARCHER(S)
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Commonwealth Scientific and Industrial Research Organisation CSIRO)
Division of Building Research
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Victoria 3190
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SPECIFIC OBJECTIVES
Air infiltration rates of typical Australian houses. Measurement of their overall permeability at 50 Pa pressure difference. Correlation of the two sets of measurements. Study of the effect of constructional details on infiltration rates.
PROJECT DETAILS
Houses are usually single-storey, detached dwellings 120-200 m2 in plan area, of timber frame construction with brick cladding, but some are of full brick with cavity brick external walls. Naturally ventilated, with gas or electric heating. Infiltration rates are determined using a modified constant concentration technique with N2O tracer gas. Permeability is measured by the pressurization technique. Unoccupied houses are studied.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather (wind speed and direction, indoor/outdoor temperature difference), surface area of building, degree of exposure to weather, permeability.
START DATE 01:01:1979
END DATE on-going

BELGIUM

#REF BE1 Integration of energy saving techniques for dwellings
PRINCIPAL RESEARCHER(S)
Ir. M. Guillaume
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Belgian Building Research Institute
Lombardstreet 41
1000 Brussels
Belgium
Telephone: (02) 653 88 01
Telex: 25682 CETEX B
SPECIFIC OBJECTIVES
Global efficiency of some heating systems in thermally insulated houses.
PROJECT DETAILS
2 single houses, 8x13m floor, brick, natural ventilation, electrical and oil system, N2O tracer gas, unoccupied buildings, pressurization, air leakage of windows and doors. Theoretical/model calculation. Temperature without heating.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Outside temperature, wind velocity and orientation, energy consumption, indoor resultant temperature, performance of windows and doors.
START DATE 01:01:1981
END DATE 01:02:1985
APPROX NO MAN HOURS 20,000
BIBLIOGRAPHY
Guillaume, M. Integration of energy saving techniques for dwellings EEC, 7 May 1982

Guillaume, M. Global efficiency of some heating systems in well thermal insulated houses CIB-S-H, September 1983

Guillaume, M. Integration de differences possibilites d'economie d'energic dans le domaine de l'habitation. EEC D6XII, November 1983

#REF BE2 Case studies of low energy houses (air infiltration)
PRINCIPAL RESEARCHER(S)
Ir. P. Caluwaerts
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SPECIFIC OBJECTIVES
Analysis of measurement and prediction techniques of air infiltration. Influence of building users.
PROJECT DETAILS
Compare by experiments different measurement techniques and prediction techniques on case studies (tracer gas, pressurization and their relation). Collect statistical information on users' habits on ventilation and infiltration (open doors and windows). Relate them to prediction figures of air infiltration rates.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind speed direction, indoor temperature, outdoor temperature, air leakage area, pressure difference on facades and for some practical publications, humidity.
START DATE 01:09:1982
END DATE 31:08:1986
BIBLIOGRAPHY
Nusgens, P. (University of Liege), Caluwaerts, P. (BBRI) Determination of the ventilation rate in a series of social houses CIB-S.17 (Holzkirchen (partly out-of-date) 7 July 1977)

CANADA

#REF CA1 Environment survey of 1106 office, professional and clerical workers
PRINCIPAL RESEARCHER(S)
E. M. Sterling
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Theodor D. Sterling Limited
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Canada
Telephone: (604) 733 2701
Telex:
SPECIFIC OBJECTIVES
To determine the effect of indoor environment and air quality on health and comfort of office workers.
PROJECT DETAILS
A Work Environment Survey questionnaire was constructed and administered to 1106 office and professional clerical workers in 20 buildings in the New York City area. The survey questionnaire was self- administered and machine readable. Responses were evaluated to determine potential building, life style or occupational factors related to wide- spread incidence of building illness symptoms including eye irritation, headaches and fatigue. Of particular concern are effects of air quality and use of new office equipment such as video display terminals and photocopiers.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
An architectural inventory of building characteristics including environment control systems, configurations, interior layout and furnishings, equipment and energy, and reported

health and comfort complaints of building occupants.
START DATE 01:01:1981
END DATE 01:12:1983
BIBLIOGRAPHY
Sterling, E.M., Sterling, T.D. Health and comfort problems in air conditioned office buildings. Proceedings of the Second International Conference on Building Energy Management, Ames, Iowa, May-June 1983

Sterling, E.M., Sterling, T.D., McIntyre, E.D. New health hazards in sealed buildings. American Institute of Architects Journal, April 1983, pp64-67.

Sterling, E.M., Sterling, T.D., Hartel-Kobayashi, D., McIntyre, E.D. Health and comfort in modern office buildings: Results of a work environment survey. (Report prepared for the Office and Professional Employees International Union), Theodor D. Sterling Limited, Vancouver, BC, 1983.

#REF CA2 Building information system
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
Development of a building diagnostic information system and software. A computer based archive to catalogue results of the growing number of epidemiological, hygiene, architectural, engineering, air quality and energy studies.
PROJECT DETAILS
The Building Information System is a collection of programs and files organised with the primary objective of exploring the information contained in existing investigation reports. The system is designed to accommodate:

1. different types of study situations. 2. different originating and dominating problems to which studies respond. 3. different levels of detail and study parameters between and within studies. 4. different enquiry purposes, i.e. epidemiological, industrial hygiene, engineering, etc. Special search routines will allow the collating of symptoms with architectural, engineering or industrial hygiene information. The database is being constantly enlarged to include additional studies as they become available. The final system will be made available for research purposes to qualified investigators.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
All parameters which are contained in existing investigations will be included.
START DATE 01:05:1982
END DATE 01:10:1983
BIBLIOGRAPHY
Sterling, T., Sterling, E. The epidemiology of building illness. Second International Symposium of Epidemiology in Occupational Health, Montreal, 1982.

Sterling, T., Sterling E. Building illness in the white collar workplace. International Journal of Health Services, (in press).

Sterling, T.D., Sterling, E.M., Dimich-Ward, H. Air quality in buildings with health related complaints. ASHRAE Trans., (in press)

#REF CA3 Building modification study
PRINCIPAL RESEARCHER(S)
E.D. McIntyre and E.M. Sterling
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SPECIFIC OBJECTIVES
Development of performance criteria for energy and environment retrofits of modern buildings and design of new energy conserving buildings.
PROJECT DETAILS
Methods are being explored of evaluating environmental performance of buildings from plans and field studies. Criteria are being developed to integrate design, ventilation and lighting solutions for modern energy conserving buildings responding to case studies of environmental performance of problem buildings.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Performance of building components, behaviour of occupants, indoor and outdoor sources of pollution, indoor and outdoor thermal environment.
START DATE 01:04:1982
END DATE 01:09:1983
BIBLIOGRAPHY
Sterling, E.M., McIntyre, E.D., Sterling, T.D. New health hazards in sealed buildings. American Institute of Architects Journal, April 1983, pp64-67

#REF CA4 Evaluation of major residential energy conservation retrofits
PRINCIPAL RESEARCHER(S)
G. Proskiw, P.Eng.
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SPECIFIC OBJECTIVES
Evaluation of reduction of the air leakage rates in houses retrofitted with a variety of conservation options.
PROJECT DETAILS
As part of a much larger project investigating major residential energy conservation retrofits, the air leakage rates of 120 houses will be determined before and after the retrofits. Retrofit options include air leakage sealing, single and double wall retrofits, basement and attic insulation upgrading, furnace replacement, etc.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Energy and economic benefits, comfort levels.
START DATE 01:03:1983
END DATE 01:12:1983

#REF CA5 The effect of indoor relative humidity on survival of airborne micro-organisms and the related absenteeism in schools and hospitals.
PRINCIPAL RESEARCHER(S)
G.H. Green
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Department of Mechanical Engineering
University of Saskatchewan
Saskatoon
Saskatchewan S7N OWO
Canada
Telephone: (306) 343 3101
SPECIFIC OBJECTIVES
To determine the effect of ventilation and indoor

humidity upon the airborne micro-organism levels and relate them to school absenteeism.
PROJECT DETAILS
Laboratory studies have shown that indoor relative humidity has a great effect on the survival of airborne micro-organism. Two studies, one in a school and the other in an office building, have shown that the survival decreases several magnitudes as the indoor humidity is increased towards 50%.Study is being extended to include ventilation as a parameter.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Ventilation (outdoor air) plus infiltration measured with tracer gas.
START DATE 01:04:1983
END DATE 01:07:1984
APPROX NO MAN HOURS 2400
BIBLIOGRAPHY
Sale, G.S. Humidification to reduce respiratory illnesses in nursery school children. Southern Medical Journal, 65, No.7, 1972.

Green, G.H. The effect of indoor relative humidity on absenteeism and colds in schools. ASHRAE Trans., 80, Part 2, 1974.

#REF CA6 Air infiltration in greenhouses
PRINCIPAL RESEARCHER(S)
G.H. Green
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Department of Mechanical Engineering
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SPECIFIC OBJECTIVES
This is a part of the study of energy conserving measures in greenhouses.
PROJECT DETAILS
A mobile blanket inside and outside the structure has been operated and the measurement of infiltration is a part of that study.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Comparison between types of greenhouse structure, glass and polyethylene covered.
START DATE 01:01:1980
END DATE 01:01:1984

#REF CA7 Weatherization
PRINCIPAL RESEARCHER(S)
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Ministry of Municipal Affairs and Housing
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Telephone: (416) 965 9108
SPECIFIC OBJECTIVES
To evaluate energy savings achieved by tightening existing (65) houses in four communities. Also to monitor results in case problems occurred.
PROJECT DETAILS
65 houses of varied construction, type and age. Houses tightened under depressurization methods. Test carried out at each tightening package, fuel bills collected and analysed, re-inspection of each house undertaken after one year and air quality test carried out on 20 houses.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Other tightening of envelope.
START DATE 01:10:1981
END DATE 01:09:1983
APPROX NO MAN HOURS 3000
BIBLIOGRAPHY
Report to be finalised by September 1983.

#REF CA8 Radon in housing, commercial and public buildings.
PRINCIPAL RESEARCHER(S)
R.S. Eaton
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Low Level Radioactive Waste Management Office,
Atomic Energy of Canada Ltd.,
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Ontario,
K1A 1E5,
Canada.
Telephone: (613) 236 6444
Telex: 053 4867
SPECIFIC OBJECTIVES
To reduce radon/radon daughter concentration in buildings in uranium mining and processing communities.
PROJECT DETAILS
When air sampling indicates higher than acceptable radon/radon daughter levels, to undertake remedial measures. These measures include removal of source contaminant when possible or ventilation of the soil surrounding the foundation or sealing the foundation in contact with the soil or improving the ventilation of the living volume.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Radon daughter concentration. Present criterion is 0.02 wl
START DATE 01:02:1976
END DATE 01:12:1983
APPROX NO MAN HOURS Estimated 100 person years.
BIBLIOGRAPHY
Eaton,R.S. Radon and radon daughters in public, private and commercial buildings in communities associated with uranium mining and processing in Canada. Proceedings of Second Special Symposium "Natural Radiation Environment", Bombay, India, January 1981, p489. Published by Wiley Eastern Limited, New Delhi, India, 1982 ISBN 0 85226 889 0

#REF CA9 Study of health status of residents in homes insulated with urea formaldehyde foam (UFF) before and after remedial measures are undertaken.
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
To determine whether the health of occupants of houses insulated with UFF differs from that of other households and whether there is any change after remedial measures are carried out.
PROJECT DETAILS
The health status of 1800 residents of urea formaldehyde foam insulated (UFF) homes is to be compared with that of 600 residents of non-UFF homes. The characteristics to be examined will include formaldehyde exposure, the presence of medical symptoms, tests of nasal and pulmonary function, test of sense of smell, a skin test for formaldehyde allergy and the equivalent of a "Pap smear" on cells obtained from the nose. The health status of all residents is to be re-examined after a period of one year, during which 2 subgroups of the UFF homes will have undertaken different forms of remedial action, while a third UFF subgroup will have taken none.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
temperature, humidity, smoking, symptoms of ill-health, pulmonary and nasal function, nasal cytology, sense of smell and contact allergy to formaldehyde.

START DATE 01:10:1982
END DATE 31:12:1985
APPROX NO MAN HOURS (82-83) 18, (83-84) 23,400, (84-85)21,600, (85) 2,160
BIBLIOGRAPHY
Broder, I. et al Changes in respiratory variables of grain handlers and civic outside workers during their initial months of employment. Br. J. Indust. Med (in press).

Hyland, R.H. et al A systematic controlled study of pulmonary abnormalities in rheumatoid arthritis. J. Rheum (in press)

Broder, I. Preventive medicine - respiratory health. Proceedings of Health and Safety Symposium, The Canadian Grain Handling Association, Winnipeg, Manitoba, February 1983, pp51-53.

#REF CA10 An infiltration model for a one-storey house based on the Encore- Canada simulation
PRINCIPAL RESEARCH(S)
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SPECIFIC OBJECTIVES
To develop an infiltration model to predict infiltration rates for various wind velocities and indoor-outdoor temperature differences.
PROJECT DETAILS
Encore-Canada was used to establish the basic relationships between the variables and to establish the empirical model. Since Encore-Canada uses a house leakage number in its determination of infiltration, the first empirical model developed was a relationship between the results of a blower door test and the house leakage number. The infiltration model was then developed relating infiltration to wind velocity, indoor-outdoor temperature difference and the leakage number. By determining the leakage number from results of a blower door test, the infiltration equation can more closely predict leakage in a specific house.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind velocity, temperature difference, pressure difference vs air flow from a blower door test.
START DATE 01:11:1980
END DATE 01:06:1983
BIBLIOGRAPHY
Ahmed, O. An approach to develop a simplified infiltration model for residential buildings M.A.Sc. Thesis, University of Windsor, 1983.

#REF CA11 Full-scale measurements of air infiltration and ventilation in houses.
PRINCIPAL RESEARCHER(S)
D.J. Wilson
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Department of Mechanical Engineering
University of Alberta
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Alberta
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SPECIFIC OBJECTIVES
To develop infiltration/weather correlations for Canadian houses and to measure the effect of combustion heating flues, mechanical ventilation, occupancy effects and retrofits.
PROJECT DETAILS
Six unoccupied test house modules with full basements, simultaneously continuously monitored by computer controlled SF6 tracer gas injection. Identical (6.7 x 7.3 m in plan) wood frame houses (one brick clad) have varying insulation and sealing with factor of 3 variation in both infiltration and overall heat loss. Occupancy effects simulated only during short intervals by manual opening of doors and windows. One house has computer controlled exhaust fan.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, simulated occupancy, mechanical ventilation, individual component leakages. (Note: no air quality measurements)
START DATE 31:12:1980
END DATE 31:12:1985
APPROX NO MAN HOURS 4000/year
BIBLIOGRAPHY
Wilson, D.J., Pittman, W. Air infiltration with wind from a single direction (To appear in ASHRAE Trans. 1983)

Dale, J.D., Wilson, D.J., Ackerman, M. Adaptable modules for air infiltration studies in home heating. Seminar on Air Infiltration and Ventilation, Building Research Establishment, Watford, UK, 14-16 April 1980

#REF CA12 Buildability as a factor in the design of building details for airtightness
PRINCIPAL RESEARCHER(S)
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Telephone: (403) 286 9770
SPECIFIC OBJECTIVES
To ensure that the design of details for airtightness can be met by ensuring that they are practical and simple.
PROJECT DETAILS
Evaluating design details with respect to buildability while ensuring that the objectives, i.e. airtightness, etc., are achieved. It is hoped that, as a result of this exercise, we will be able to derive guidelines, an evaluation of failures and recommendations in practice. Case studies will be published regularly. Note: This project is practical and makes use of actual design details.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Buildability, construction practice, methodology
START DATE 01:06:1982
END DATE on-going
BIBLIOGRAPHY
Mattar, S.G., Morstead, H. Construction methods and the design of building envelope details. Third Canadian Masonry Symposium, Edmonton, Canada, 6-8 June 1983

Mattar, S.G. "Buildability" and the design of building enclosures (paper in preparation)

#REF CA13 Seasonal influence and comparison of measurement techniques for radon and radon daughter concentrations in energy efficient homes.
PRINCIPAL RESEARCHER(S)
R.G. McGregor

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Radiation Protection Bureau
National Health and Welfare
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Telephone: (613) 998 8658
SPECIFIC OBJECTIVES
A study of seasonal variation and stratification of radon and radon daughter concentrations between levels of 35 multi-level energy efficient homes.
PROJECT DETAILS
Various grab sample techniques will be used to measure radon and radon daughter concentrations. Solid state nuclear track detectors will be used to obtain quarterly average radon concentrations. Both active and passive integrating measurement techniques will be used for determination of average radon and radon daughter concentrations in selected homes. Results will be evaluated with respect to air change rates and airtightness measurements conducted on the homes.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air change rate, airtightness.
START DATE 01:03:1982
END DATE 31:03:1984
BIBLIOGRAPHY
McGregor, R.G., et al Background concentrations of radon and radon daughters in Canadian homes. Health Physics, Vol.39, pp285-289, August 1980

Letourneau, E.G., et al Lung cancer mortality and indoor radon concentrations in 18 Canadian cities. 16th Midyear Topical Symposium, Health Physics Society, Alburquerque, USA, 10-14 January 1983.

Letourneau, E.G., et al The design and interpretation of large surveys for indoor exposure to radon daughters. To be presented at International Seminar on Indoor Exposure to Natural Radiation and Related Risk Assessment, Capri, Italy, 3-5 October 1983.

#REF CA14 Pressure pulse infiltration meter
PRINCIPAL RESEARCHER(S)
Dr. G.K. Yuill
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Lion Industries Ltd.
35 Trottier Bay
Winnipeg
Manitoba
R3T 3R3
Canada
Telephone: (204) 475 8393
SPECIFIC OBJECTIVES
Development of a pressure pulse technique for measuring house airtightness.
PROJECT DETAILS
A device was developed which releases a timed pulse of compressed air into a house. A pressure transducer produces an electronic signal which can be correlated to house airtightness. This avoids the need for an installation in a door.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:04:1982
END DATE on-going
APPROX NO MAN HOURS 600

#REF CA15 The effect of thermal envelope upgrading in residential dwellings.
PRINCIPAL RESEARCHER(S)
W.R. Jones
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Research Division
Ontario Hydro
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Ontario
M8Z 5S4
Canada
Telephone: (416) 231 4111 ex 6253
Telex: 06 984 525
SPECIFIC OBJECTIVES
To determine the heating demand reductions and energy savings that are possible by upgrading the thermal envelopes of existing houses and to identify any resulting problems, in support of customer information programs.
PROJECT DETAILS
Sixteen occupied frame-construction houses were thermally upgraded (3 homeowner airseal, 4 contractor airseal, 4 basement insulation, 4 airseal and basement insulation, 1 attic insulation) and monitored with digital demand recorders (15 min electric space heating demand) for one heating season. The previous heating season was similarly monitored in a dual fuel (oil/electric) experiment. Airtightness tests using fan depressurization were conducted before and after upgrading. Analysis will compare before and after load lines (best fit of space heating demand vs outdoor temperature).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Extent of retrofit airsealing.
START DATE 01:05:1983
END DATE 31:12:1983 (possible extension for another heating season)
APPROX NO MAN HOURS 2500
BIBLIOGRAPHY
Jones, W.R., Stricker, S. Ventilation requirements and natural air leakage in residences Ontario Hydro Research Review No.4, December 1981.

#REF CA16 Low energy housing studies: "Taped Glasclad System"
PRINCIPAL RESEARCHER(S)
J.M. Dewil
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Technical Centre
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Telex: 064 76121
SPECIFIC OBJECTIVES
To integrate air leakage reduction, controlled ventilation and high insulation levels into a low energy house with a greatly reduced susceptibility to moisture-related problems.
PROJECT DETAILS
To build a highly-insulated, wood-frame house with a continuous wall airflow retarder obtained by taping the joints of the external vapour-permeable, air-retarding skin on an insulating glassfibre sheathing, using a specially developed "all weather" tape. Any condensation in the wall will be restricted to the outer skin, away from wood framing members and will be able to evaporate or sublime outwards through the vapour-permeable skin.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
The leakage characteristic of the house will be determined by fan depressurisation, and ventilation at 0.5 ach will be provided, with the house slightly depressurised to minimize exfiltration.
START DATE 01:01:1974
END DATE 31:12:1984
BIBLIOGRAPHY
(Complete report on the project available in 1984)

#REF CA17 Short-circuiting between fresh air intakes and exhausts of buildings as source of indoor air pollution

PRINCIPAL RESEARCHER(S)

Mr R H Ferahian, ACGI, DIC, M.Sc.(Eng.), M.I.C.E., M.ASCE.

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#1416 Westmount
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Canada
Telephone: (514) 484 5492

SPECIFIC OBJECTIVES

PROJECT DETAILS

Literature survey and report on case studies where such short-circuiting was a cause of indoor air pollution. Identify design defects and code infringements and, if possible, identify code improvements.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

START DATE 01:01:1981

END DATE on-going

BIBLIOGRAPHY

Ferahian, R.H. Indoor air pollution - some Canadian experiences Presented at the International Symposium on Indoor Air Pollution, Health and Energy Conservation, Amherst, MA, USA, 13-16 October 1981

#REF CA18 Air quality measurements in residences

PRINCIPAL RESEARCHER(S)

R.S. Dumont

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National Research Council of Canada
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Canada
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SPECIFIC OBJECTIVES

1. Determine pollutant levels of major pollutants in Canadian residences. 2. Determine interaction of pollutant levels with (a) building materials and (b) air change rates.

PROJECT DETAILS

1. A preliminary survey of 50 residences has been undertaken to test for formaldehyde and radon gas. 2. A followup study has been undertaken with 50 well-sealed houses to test for formaldehyde, radon and nitrogen dioxide.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

Building tightness, materials used, air change rates.

START DATE 01:01:1982

END DATE on-going

BIBLIOGRAPHY

(none to date)

#REF CA19 Determination of air leakage characteristics of residences and development of means of reducing air leakage.

PRINCIPAL RESEARCHER(S)

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SPECIFIC OBJECTIVES

1. Determination of air leakage characteristics of residences. 2. Development of means of reducing air leakage.

PROJECT DETAILS

1. Survey of house air leakage values has been undertaken for Canadian houses (pressurization technique). 2. Experimental methods for sealing houses have been developed and are being refined.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

Building tightness, wind speed, temperature difference, wind direction, building geometry.

START DATE 01:01:1977

END DATE on-going

BIBLIOGRAPHY

Dumont, R.S., Orr, H.W., Figley, D.A. Airtightness measurements of detached houses in the Saskatoon area. Division of Building Research, National Research Council of Canada, Ottawa, BRN No.178, 1981.

Dumont, R.S. Airtightness measurements of houses sealed to reduce air leakage. Accepted for publication, ASHRAE Journal, 1983.

Energy efficient housing: a prairie approach. Dept of Mechanical Engineering, University of Saskatchewan, Canada, 1980.

#REF CA20 Time averaged measurement of air quality

PRINCIPAL RESEARCHER(S)

Mr. P. Deacon

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Contracted to:
Peter Rowles
Co-generation Associates

SPECIFIC OBJECTIVES

To monitor, comment upon and correlate air quality and air change characteristics of up to 30 energy-efficient homes over a 3-month winter period.

PROJECT DETAILS

The measurements were made using passive dosimeter techniques to give values that are averages over time. All homes were monitored for radon gas, and 14 homes were monitored for formaldehyde and natural air change rate using a perfluorocarbon tracer.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

START DATE 01:01:1983

END DATE 30:06:1983

#REF CA21 Moisture study.

PRINCIPAL RESEARCHER(S)

Mr. A.J. Houston

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SPECIFIC OBJECTIVES
To study moisture-troubled National Housing Act (NHA) homes to determine the extent, nature and geographic distribution of moisture problems.
PROJECT DETAILS
Using the study results, a methodology was developed to (a) analyse climatic and construction data and estimate the number of NHA homes affected, (b) assess the physical causes of moisture damage through a review of national and international literature and (c) investigate the possibility of utilizing vent stacks as a practical measure to reduce moisture in Newfoundland.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1982
END DATE 31:03:1983

#REF CA22 Indoor air pollution and housing technology
PRINCIPAL RESEARCHER(S)
Mr. P. Russell
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Subcontracted to:
Bruce Small and Associates
R.R. No.1
Goodwood
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LOC 1AO
Canada
SPECIFIC OBJECTIVES
To review the scientific literature on indoor air pollution and to document research of pollution in residences.
PROJECT DETAILS
The major pollutants found in Canadian homes were reviewed - carbon monoxide, nitrogen oxide, radon gas, formaldehyde, tobacco smoke, ozone, asbestos, dust and moulds, bacteria and viruses, and a host of organic chemical vapours some of which are known or suspected carcinogens. The study recommends a four-fold approach to the indoor air pollution - (a) short circuit major potential hazards, (b) deal with low pollution, (c) spread and apply present knowledge, (d) foster more research and discussions on regulations.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:06:1982
END DATE 31:12:1982

#REF CA23 Updating health standards for residential construction.
PRINCIPAL RESEARCHER(S)
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Telex: 0533674
Subcontracted to:
Karl Raab
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Vancouver
BC
V6R 2E1
Canada
SPECIFIC OBJECTIVES
To review the building codes, especially the National Building Code and to evaluate those sections which relate to atmospheric health risks.
PROJECT DETAILS
The report concludes that there is considerable scope for improvement of the building codes in the realm of atmospheric health risks and suggests specific changes.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:09:1982
END DATE 31:10:1982

#REF CA24 Radon gas (Problem Land series of publications)
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
To publish a layman guide to radon gas problem land.
PROJECT DETAILS
The publication describes the nature of the problem of radon gas. Preventative and remedial measure to reduce the gas is described.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1982
END DATE 3:07:1983

#REF CA25 Instrumentation for detection of radon at potential building sites.
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
PROJECT DETAILS
The project findings indicate that the vulnerability of buildings to entry of radon from the soil is as dependent on soil permeability within 3m of the basement, as it is on the rate of radon emission from the soil. Instrumentation is available but methodology needs to be developed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE not stated
END DATE 28:02:1983

#REF CA26 Hazardous heating and ventilation conditions in housing.
PRINCIPAL RESEARCHER(S)
Mr. P. Russell

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Subcontracted to:
Hatch and Associates
Energy Mines and Resources
Health and Welfare Canada
SPECIFIC OBJECTIVES
To document the hazardous heating and ventilation episodes that have occurred in Canadian housing during the past 3 years where products or combustion have been the cause.
PROJECT DETAILS
The incidence of carbon monoxide poisoning in residences from 72:82 has been documented. So far as records have allowed, the causes have been identified with the following predomination - damaged or blocked chimneys, reverse flow in chimneys, appliance failure. Nearly 300 episodes are referred to.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:02:1983
END DATE 31:08:1983
BIBLIOGRAPHY
(Report to be available during second half of 1983)

#REF CA27 Biomethylation of arsenic in preserved wood foundations
PRINCIPAL RESEARCHER(S)
Mr. P. Russell
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Subcontracted to:
E. Doyle
Forintek
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Ontario
Canada
SPECIFIC OBJECTIVES
To conduct a literature search and field episode research to determine the toxicity level of trimethylarsine gas.
PROJECT DETAILS
Isolated incidences of a pungent odour occurring in houses built with pressure treated wood foundations have occurred. The source has been found to be trimethylarsine which is generated by micro-organisms feeding on the arsenic in the preservative. This only occurs in damp conditions and the resultant gas occurs in low concentrations and is of low toxicity. The report chronicles the incidents and research on biomethylation.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:09:1982
END DATE 31:01:1983

#REF CA28 Strategies for healthy residential environments
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
To investigate technical and non-technical methods for improving indoor air quality.
PROJECT DETAILS
This study will provide a predominantly qualitative assessment of strategies for minimizing indoor pollution.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1983
END DATE 30:04:1983
BIBLIOGRAPHY
(Report available during second half of 1983)

#REF CA29 Builders' guidelines for controlled ventilation in new houses
PRINCIPAL RESEARCHER(S)
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Housing and Urban Development Association of Canada (HUDAC)
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Ontario
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Telephone: (416) 364 4135
Subcontracted to:
H. Katzin
IBI Group
SPECIFIC OBJECTIVES
To publish a brief document, targetted to the building contractor, describing how to provide safe and healthy ventilation in housing.
PROJECT DETAILS
Residential ventilation rates recommended in ASHRAE 62-82 are used as a basis for the design of ventilation systems for new houses. Systems are described to accommodate all types of heating. Status as July 1983 - guidelines are in draft form. Performance of installations in several houses representing a variety of house types, heating systems and locations to be measured in 83-84 heating season, before finalisation of guidelines.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
BIBLIOGRAPHY
Guidelines to be available second half of 1984

#REF CA30 Performance evaluation of the Apple Hill energy-efficient homes
PRINCIPAL RESEARCHER(S)
Mr. P. Deacon
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Canada
Telephone: (613) 748 2984 Telex: 0533674

Contracted to:
P. Rowles
Co-generation Associates Ltd.
SPECIFIC OBJECTIVES
To evaluate the energy efficient operation of 50 houses and to evaluate the operation of separate furnace rooms.
PROJECT DETAILS
To study monitors, comment upon and correlate various physical measurements. The measurements include energy consumption, airtightness, air change, air quality and neutral pressure plane position. A commentary on installation and use of separate rooms for combustion equipment is included.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:03:1982
END DATE 31:08:1983

#REF CA31 Upgrading residential forced air filtration
PRINCIPAL RESEARCHER(S)
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Subcontracted to:
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Canada
SPECIFIC OBJECTIVES
To investigate improved methods and materials for filtering air and to identify impediments to their implementation.
PROJECT DETAILS
The report describes the effectiveness of various filtration media which are or could be used in residential forced air ventilation systems. Equipment, operating and marketing factors that impede the improvement of ventilation air filtering are discussed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:03:1982
END DATE 03:04:1982

#REF CA32 Airtightness and ventilation of residential buildings
PRINCIPAL RESEARCHER(S)
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National Research Council
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Canada
Telephone: (613) 993 1421
Telex: 0533145
SPECIFIC OBJECTIVES
To develop methods for estimating the air change rate and air pressure distribution of a house, as these factors affect the space heating requirement, indoor air condition and potential for moisture problems of a house.
PROJECT DETAILS
1. Residential ventilation - to study the interaction (airchange and pressure distribution) of house airtightness, weather factors, combustion systems (furnaces), mechanical ventilation systems with and without heat recovery apparatus and passive ventilation measures (vent stack, fresh air openings in the basement wall and to the furnace return air duct). 2. Development of airtightness measurement techniques - to develop methods for in-situ measurement of air leakage rates through building envelope elements such as walls, floors and ceilings, and to obtain air leakage data for design purposes. 3. Development of air change prediction methods - to develop computer algorithms for predicting air leakage, air movement and moisture movement in buildings, and to develop a simple air leakage prediction method.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather factors, forced ventilation rates, airtightness values, neutral pressure level, RH, moisture content of wood framing.
START DATE not stated
END DATE on-going
APPROX NO MAN HOURS 2.5 person years
BIBLIOGRAPHY
Shaw, C.Y. A correlation between air infiltration and airtightness for houses in a developed residential area ASHRAE Trans., Vol.87, II, 1981.

Shaw, C.Y., Brown, W.C. Effect of a gas furnace chimney on the air leakage characteristic of a two-storey detached house. Proceedings of 3rd AIC Conference, London, UK, 1982

Shaw, C.Y. The effect of mechanical ventilation on the air leakage characteristic of a two-storey detached house. (To be published)

#REF CA33 Alternative approaches to improving the airtightness of existing and new houses.
PRINCIPAL RESEARCHER(S)
R.E. Platts, P.Eng.
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436 MacLaren Street
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Ontario
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Canada
Telephone: (613) 236 7179
Telex: 053 4472
SPECIFIC OBJECTIVES
Proof of concept of 'Structural Sealing' (SS) and 'Final Entry Point Sealing' (FEPS) methods as means of improving the airtightness of existing and new houses during reconstruction.
PROJECT DETAILS
1. Existing houses - progressive airtightening of five existing houses using innovative techniques for sealing the major hidden air leaks, e.g. exterior wall/floor intersections, airtightness testing after each sequence of work to determine its contribution, four variations of SS and FEPS were used. 2. New houses - three units of a six-unit-row house project are being structurally sealed to determine the feasibility of such measures and the difficulties of integrating them along with the normal construction sequences. Mechanical ventilation with heat recovery is to be installed and monitored in all houses where significant airtightening may affect the indoor air quality.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
1. Existing houses - the final airtightness of each house can be related to the initial pre-sealing levels. 2. New houses - the airtightness of the three sealed units will be compared to the three conventionally built units of

the same project.
START DATE 01:01:1983
END DATE 31:08:1983
APPROX NO MAN HOURS 1875
BIBLIOGRAPHY
Investigation of a technique to reduce air leakage in the wall cavities of older homes. Prepared for Canada Mortgage and Housing Corporation by Scanada Consultants Ltd., Ottawa. June 1983

First trials of comprehensive airtightening of existing houses. Prepared for Canada Mortgage and Housing Corporation by Scanada Consultants Ltd., Ottawa, August 1983

#REF CA34 Analytical determination of building internal pressures induced by wind.
PRINCIPAL RESEARCHER(S)
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Montreal
Quebec
H3G 1M8
Canada
Telephone: 18:07:1983
SPECIFIC OBJECTIVES
A computer program will be developed to evaluate the wind-induced internal pressures of buildings with known porosity given the external wind pressure distribution.
PROJECT DETAILS
Based on the wind-induced external pressure distribution for a building and the respective infiltration, the internal pressure can be calculated because of the air balance inside the building. The computer program will be adjusted to be used with a micro-computer for easy use in engineering offices. Internal pressures evaluated analytically will be compared with those measured in various experimental studies. Also comparisons with standards and codes of practice will be carried out.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Exposure, wind speed and direction, building geometry.
START DATE 01:01:1983
END DATE 31:1:1986

#REF CA35 Wind effects on airtightness measurements
PRINCIPAL RESEARCHER(S)
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S7N 0X1
Canada
Telephone: (306) 664 6925
Telex: 074 2484 SARECO
SPECIFIC OBJECTIVES
To evaluate the results of airtightness tests using the fan pressurization method based on an exponential relationship.
PROJECT DETAILS
A modified form of regression analysis has been developed for the above relation, and the resulting analytical method has been applied to airtightness test data. The method appears to be fairly successful in isolating wind effects from the test data. Potentially, the method offers a much better way of analysing airtightness test data, but it first needs to be evaluated under controlled conditions.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Flow constant 'a', exponent 'b' and the mean wind effect 'c'.
START DATE 01:05:1982
END DATE 31:05:1984
BIBLIOGRAPHY
Eyre, D. The analysis of airtightness test data with wind influence. Energy Conservation Technology for Buildings, SRC, (a project of the Energy Conservation and Oil Substitution Branch, Energy Mines and Resources, Canada, July 1982

#REF CA36 Airtightness tests on 200 new houses across Canada
PRINCIPAL RESEARCHER(S)
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Telex: 074 2484 SARECO
SPECIFIC OBJECTIVES
To establish a database on the airtightness performance of houses built according to current building practices across Canada
PROJECT DETAILS
Fan pressurization was used to test groups of 20 houses in each of 10 locations across Canada. The houses, which were selected by HUDAC, were to be representative of the style, type of construction and size of houses built in a particular locality. The technical commentary includes an error analysis on the equipment used for the tests.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Equivalent leakage area per above grade surface area (ELA/A) at 10 Pa, (V) at 50 Pa and relative velocity (Q/A) at 10 Pa.
START DATE 01:04:1982
END DATE 31:08:1983
BIBLIOGRAPHY
Sulatisky, M., Gleadhill, M. Draft report: Airtightness tests on 200 new houses across Canada: Results and technical commentary. Energy Conservation Technology for Buildings, SRC (a project of the Energy Conservation and Oil Substitution Branch, Energy Mines and Resources, Canada, August 1983).

#REF CA37 Airtightness tests and occupant effects on energy conservation
PRINCIPAL RESEARCHER(S)
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Telex: 074 2484 SARECO
Under subcontract to:
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30 Campus Drive
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SPECIFIC OBJECTIVES
To conduct airtightness tests in 100 houses in the same sub-division in Windsor where data was collected over a 5-year period on energy use and occupant effects.

PROJECT DETAILS
The airtightness tests were carried out using a door-fan unit. All the houses were of similar construction and were built by the same contractor. Future work will analyze the database statistically, correlating energy use, airtightness and occupant effects.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Equivalent leakage area at 10 Pa, air changes per hour at 50 Pa and flow rate per above grade surface area at 10 Pa.
START DATE 01:05:1982
END DATE 31:05:1984
BIBLIOGRAPHY
Colborne, W., Wilson, N. Airtightness tests on 108 well-documented houses in Ontario Energy Conservation Technology for Buildings, SRC (a project of the Energy Conservation and Oil Substitution Branch, Energy Mines and Resources, Canada, April 1983).

CZECHOSLOVAKIA

#REF CZ1 Air infiltration in a school building
PRINCIPAL RESEARCHER(S)
Ing. M. Breda
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Building Research Institute
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102 21 Praha 10
Prazska 16
Czechoslovakia
Telephone: 752641 9
Telex: 122688 VUPS C
SPECIFIC OBJECTIVES
Check measurement of air renewal in classrooms from the point-of-view of indoor environment hygiene.
PROJECT DETAILS
1. 3-storey building, U-form plan of about 50 x 80m, exterior walls of light-weight panels (FEAL sandwich). 2. Natural air renewal with short-term forced extract, warm-water central heating with a heat exchanger station attached to a district heating network. 3. Tracer gas Kr85 (neither the building pressure conditions nor the air pollution were determined). 4. Scintillation set for determining the specific activity of Kr85 within the range of 1-10 (MBq/m3). Three probes located on various places in the classroom. 5. People (pupils) not present. 6. Calculations of air renewal depending on time (daily regime, 2-year regime).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Inside/outside air temperature, wind speed and direction. State of using the building's components, such as windows and doors, was not ascertained. Surveying the activities of people living in rooms is not carried out (measuring in the absence of people). The pollution sources were not surveyed. In short periods, the influence of forced air exhaustion on the air renewal was determined.
START DATE 10:01:1981
END DATE 31:12:1983
APPROX NO MAN HOURS 700
BIBLIOGRAPHY
Breda, M. Measuring the air renewal using a radioactive indicator.

DENMARK

#REF DK1 Quality of the air and the amount of fresh air in classrooms
PRINCIPAL RESEARCHER(S)
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Danish Building Research Institute
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2790 Horsholm
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Telephone: (02) 86 55 33
SPECIFIC OBJECTIVES
Indoor climate measurements are made in eleven different schools, all with big mechanical ventilation plans, in conjunction with a questionnaire asking pupils' reaction to indoor climate.
PROJECT DETAILS
The pupils are from thirteen to sixteen years old. The experiment in each school takes three days. The amount of fresh air is different each day. Measurements were made for (a) the amount of CO2 in the air, (b) the number of pupils in the classrooms, (c) the total amount of fresh air going into the classrooms, (d) the temperature of the air, (e) the content of moisture in the air, (f) the amount of dust in the air. The pupils fill in a questionnaire after each lesson. This asks (1) has the indoor climate during the last lesson been pleasant or unpleasant, (2) is the air fresh, neutral or stuffy, (3) choice of comfortable temperature on a seven-point scale, (4) was the air humid, neutral or dry. The objective is to determine the air change rate necessary to satisfy a specified percentage of pupils that the air is fresh. The results will enable guidelines to be made for running ventilation plans in schools regarding both economical and welfare effects.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
CO2 content in the air.
START DATE 01:03:1982
END DATE 31:12:1983
APPROX NO MAN HOURS 1500

#REF DK2 Measurements of ventilation in retrofitted multi-storey houses
PRINCIPAL RESEARCHER(S)
G.R. Lundqvist
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Institute of Hygiene
Universitetsparken 180
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Denmark
Telephone: (06) 128288
SPECIFIC OBJECTIVES
To measure changes in air infiltration and ventilation rates in flats in which an epidemiological study reflecting health and comfort changes has been carried out.
PROJECT DETAILS
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Humidity, suspended particulate matter
START DATE 01:06:1983
END DATE 30:06:1985

#REF DK3 Suspended particulate matter (SPM) in airtightened buildings, human exposure and health effects
PRINCIPAL RESEARCHER(S)
G.R. Lundqvist
ADDRESS
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Telephone (06) 128288
SPECIFIC OBJECTIVES
Field measurements have shown increased concentrations of SPM in retrofitted houses. This study will examine the acute health effect of this environmental factor in a climate chamber with controlled exposure conditions.

PROJECT DETAILS
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Suspended particulate matter.
START DATE 01:06:1982
END DATE 31:12:1984
BIBLIOGRAPHY
(Project report available after termination date)

#REF DK4 Health and comfort changes among tenants after draught proofing of their flats.
PRINCIPAL RESEARCHER(S)
G.R. Lundqvist
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Institute of Hygiene
Universitetsparken 180
DK 8000 Arhus C
Denmark
Telephone: (06) 128288
SPECIFIC OBJECTIVES
The aim of the study has been to measure the health and comfort changes among tenants in both a study and a control group defined by changes or no changes in their flats.
PROJECT DETAILS
The flats in the study group had window renewal and draught proofing carried out in the autumn 1981. This was supposed to reduce air infiltration and natural ventilation and so improve the energy balance in the buildings. The flats and tenants in the control group were similar to those in the study group except that no physical changes were made.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
41 questions regarding indoor climate, health and comfort as reflected by the tenants once a month.
START DATE 01:01:1981
END DATE 30:06:1983
BIBLIOGRAPHY
Iversen, M., Bach, E., Lundqvist, G.R. A prospective study of health and comfort changes among tenants before and after energy conservation measures in their flats. Project report, Arhus, Denmark, August 1983 (in Danish) (an English version will appear).

FINLAND

#REF FI1 Ventilation systems for building renovation - the experimental building "Kasarmikatu 24".
PRINCIPAL RESEARCHER(S)
P. Saarnio
ADDRESS
Technical Research Centre of Finland (VTT)
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SF-02150 Espoo 15
Finland
Telephone: 90 4561
Telex: 12 2972
SPECIFIC OBJECTIVES
Practical comparison between various ventilation systems. Measurements of airtightness, air change rates, local leakages, pressure conditions, radon concentration, etc.
PROJECT DETAILS
The building (built 1897, renovated 1981) is now the Finnish Museum of Architecture. For experimental purposes, the ventilation system was run in three alternative ways: (a) Mechanical supply and exhaust (0.7 ach). (b) Mechanical exhaust (0.7 ach). (c) Exhaust from toilets only (0.2 ach). The results show that exhaust ventilation needs special supply air arrangements in the building envelope to guarantee a sufficient ventilation in each room.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Ventilation system, leakage distribution.
START DATE 01:01:1982
END DATE 30:10:1982
APPROX NO MAN HOURS 1000
BIBLIOGRAPHY
Saarnio, P. Airtightness, pressure differences and indoor climate in the experimental building "Kasarmikatu 24". CIB W67 Seminar on Air Infiltration Control and Indoor Air Quality, 15 June 1983, Vtaniemi, Finland. (The complete research report has been published in Finnish by the National Board of Building).

#REF FI2 Ventilation and warm-air heating in blocks of flats (three experimental projects).
PRINCIPAL RESEARCHER(S)
J. Heikkinen, M. Laukkanen, J. Railio
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Technical Research Centre of Finland (VTT)
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SF-02150 Espoo 15
Finland
Telephone: 90 4561
Telex: 12 2972
SPECIFIC OBJECTIVES
Monitoring of energy balance, indoor climate and performance of ventilation and heat distribution in new experimental multi-storey buildings.
PROJECT DETAILS
Various combinations of mechanical supply and exhaust ventilation and heat distribution have been investigated in experimental buildings. The evaluation consisted of (a) micro- computer-based data collection and analysis (energy and indoor temperatures), (b) manual measurement of thermal indoor climate, airtightness, radon concentration, system performance, (c) interviews with the inhabitants.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Heat distribution, utilisation of structures as supply air ducts, occupants' behaviour.
START DATE 01:01:1980
END DATE 31:05:1984
APPROX NO MAN HOURS 9000 (3000 per project)
BIBLIOGRAPHY
Heikkinen, J., Laukkanen, M., Ralio, J. Evaluation of a warm-air heated block of flats with air recirculation in each room Ministry of Trade and Industry, Report D21, 63pp, Helsinki 1983 (in Finnish with English summary).

(Other projects to be reported approximately October 1983 and August 1984)

#REF FI3 Air infiltration research
PRINCIPAL RESEARCHER(S)
J. Railio
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Finland
Telephone: 90 4561
Telex: 12 2972
SPECIFIC OBJECTIVES
Development of airtightness requirements, calculation models, measurement methods and airtight buildings.
PROJECT DETAILS
(a) Calculations: multi-cell models, flow equations for each room. (b) Output: leakages, mechanical air flows, pressure conditions. (c) Parts: "Exhaust air model", "Supply air model", "Leakage model". (d) Measurements: pressure method for whole small houses or flats, collector chamber for local leakages, smoke test or infra-red thermography for localization, pressure differences

with multi-manometers. Possibly "cooling method" as preliminary test. Special attention will be paid to appropriate method combinations in large buildings. (e) Constructions: airtight joints. Possibly also supply air intake through building envelope will be developed. (f) Requirements: For whole buildings, parts of buildings, structures and joints.

The research work will be continued in two new residential areas, where the long-time performance of the building envelope will be tested. Measurements for total airtightness and local leakages for some typical construction joints will be carried out once or twice a year until 1986-87.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, building components, ventilation system, (possibly "auxiliary parameters": age, size and type of building).
START DATE 01:02:1979
END DATE 31:12:1982
BIBLIOGRAPHY
Railio, J., Saarnio, P. Instructions for airtightness and air change rate requirements.To be published in VTT's report series, September 1983 (in Finnish)

Saarnio, P. The calculation model for airtightness and ventilation.To be published in VTT's report series, October 1983 (in Finnish with English summary)

Railio, J., Saarnio, P. Suggestions for airtightness requirements.Final report of the Air Infiltration Research. To be published in VTT's report series, October 1983 (in Finnish with English summary)

#REF FI4 Heat recovery from exhaust air in existing blocks of flats.
PRINCIPAL RESEARCHER(S)
J. Railio
ADDRESS
Technical Research Centre of Finland (VTT)
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SF 02150 Espoo 15
Finland
Telephone: 90 4561
Telex: 12 2972
SPECIFIC OBJECTIVES
Field investigations on supply air and heat recovery systems, built afterwards in existing multi-storey houses. Energy conservation, system performance, indoor air.
PROJECT DETAILS
Measurements were carried out both before and after the construction of supply air and heat recovery systems. Air was supplied either (a) each room (expensive, best air quality), (b) each flat (suitable in small flats) or, (c) the stairway (cheap, risk for low ventilation in bedrooms). Certain risks were observed due to poor design or poor maintenance. Energy savings and improvement of thermal indoor air were still gained in each case.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Supply air system, maintenance of ventilation, height of building.
START DATE 01::4:1980
END DATE 31:12:1982 (detail studies also in 1983)
APPROX NO MAN HOURS 5000
BIBLIOGRAPHY
Railio, J. Heat recovery in existing blocks of flats.Ministry of Trade and Industry publication series D, 100pp, Helsinki 1983 (in Finnish with English summary, approximately August 1983)

Railio, J. Heat recovery from exhaust air in existing blocks of flats.Proceedings of IX CIB Congress, Stockholm, 15-19 August 1983

FRANCE

#REF F1 Air permeability in new dwellings.
PRINCIPAL RESEARCHER(S)
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France
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Telex: 900427 CETIDA F
SPECIFIC OBJECTIVES
To improve our understanding of the phenomena of air infiltration sites in dwellings and make proposals for their reduction.
PROJECT DETAILS
(a) To improve our theoretical understanding of air infiltration in dwellings. (b) To report on air permeability measurements (by depressurization) of sections. (c) To determine leakage penetrations.(d) To determine the portion of heat loss due to air infiltration.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1982
END DATE 31:03:1983
APPROX NO MAN HOURS 700

GERMANY

#REF DE1 Air infiltration and ventilation in buildings.
PRINCIPAL RESEARCHER(S)
Dr. L. Trepte
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Dornier System GmbH
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West Germany
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Telex: 0734209-0 DOD
SPECIFIC OBJECTIVES
Comparison, economical and technical assessment of different ventilation systems to find possibilities for reducing the energy need of buildings.
PROJECT DETAILS
Minimum ventilation rates (correlated with IEA Annex IX). Fireplaces in buildings, requirements for air infiltration. Comparison of ventilation systems in experimental houses. Comparison and tests of different ventilation systems in occupied buildings, investigation of inhabitants behaviour. System studies about air infiltration. Heat recovery, development of a test method for standards.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature, air exchange rate, wind humidity. Performance of windows, doors and fireplaces. Behaviour of occupants. Source of pollution.
START DATE 01:08:1980
END DATE 30:06:1985
APPROX NO MAN HOURS 70,000
BIBLIOGRAPHY
Heidt, F.D., Haberda, L., Trepte, L. Impact of air infiltration and ventilation on energy losses of buildings.Int. Cong. on Building Energy Management, Pavoa de Varzim, Portugal, 12-16 May 1980.

Daler, R., et al Ventilation patterns of windows and adjustable natural ventilation systems. Proceedings 3rd AIC Conference, London, UK, Sept.1982.

15 reports concerning "Minimum ventilation rates" (restricted to IEA-Annex IX members)

#REF DE2 Investigation about the annual heat consumption of today's well-insulated buildings
PRINCIPAL RESEARCHER(S)
Prof. Dr.-Ing. H. Esdorn
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West Germany
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SPECIFIC OBJECTIVES
The rules for calculating the annual heat consumption as described in the German Standard VDI 2067 should be advanced by taking into account the influence of solar radiation, inside heat sources and user habits. This influence gets more important with the better insulation of the buildings.
PROJECT DETAILS
The measuring results of energy consumption for heating and hot-water supply, as well as the corresponding climatic data, are available for a great number of residential buildings. The heat loss by transmission and the energy produced by solar radiation as well as the inside heat sources will be calculated by a dynamic computer simulation program. From the measured data and the simulation results, the heat loss due to ventilation can be calculated. This result contains the ventilation habits of the tenants.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Meteorological data, tenant data.
START DATE 01:01:1984
END DATE 31:12:1985

#REF DE3 Demonstration project "Landstuhl": Energy-saving and the use of solar energy within one and two family houses.
PRINCIPAL RESEARCHER(S)
Dr. D. Oswald
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SPECIFIC OBJECTIVES
A study of energy-saving building designs and techniques that incorporate both active and passive solar components.
PROJECT DETAILS
Comparison of the results of energy-balance calculations with measured data for different types of occupied buildings. Quantification of the air change rate component of the overall heat balance for natural and mechanically-driven ventilation systems for different types of heating systems (including warm air heating). Pressurization test and air change rate measurements with a tracer gas.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature inside and outside. Wind direction and velocity. Behaviour of occupants.
START DATE 01:01:1983
END DATE 31:12:1987
APPROX NO MAN HOURS 750

#REF DE4 Comparative measurements of ventilation systems on one-family twinhouses
PRINCIPAL RESEARCHER(S)
Dr. H. Werner
ADDRESS
Fraunhofer-Institut fur Bauphysik
Postfach 1180
D-8150 Holzkirchen
West Germany
Telephone: 08024 5055
SPECIFIC OBJECTIVES
Air changes and evaluation of air infiltration energy losses caused by central and de-central apparatus under natural climatic conditions
PROJECT DETAILS
Comparative investigations in two identical test houses (twinhouses) about the energy supply in relation to infiltration rates, inside/outside temperature differences, solar radiation and wind. One house was the standard with natural infiltration caused by cracks and gaps. In the other house the systems were tested.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind speed and direction, inside/outside temperature difference.
START DATE 01:01:1981
END DATE 31:12:1982
APPROX NO MAN HOURS 2000
BIBLIOGRAPHY
Holz, D.U., Kunzel, H. Zusammenhang zwischen der Fugendurchlassigkeit von Fenstern und dem Luftweschel im Raum. Bericht des Fraunhofer-Institut fur Bauphysik, Nr. B Ho 7/77, Dez. 1977

Werner, H. Comparative measurements of different ventilation systems in one-family twinhouses (not yet published)

#REF DE5 Passive solar warm-air heating and ventilating system.
PRINCIPAL RESEARCHER(S)
E. Boy
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West Germany
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Telex: 7 255 167
SPECIFIC OBJECTIVES
Development of a device for passive solar warm-air heating and ventilation systems that is both economically viable and marketable.
PROJECT DETAILS
Passive thermosyphoning warm-air heating system combined with energy storage in walls, floors or ceilings in an unoccupied test room.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature inside and outside. Wall temperatures.
START DATE 01:01:1983
END DATE 31:12:1984
APPROX NO MAN HOURS 900

#REF DE6 Draught problems in air conditioned rooms
PRINCIPAL RESEARCHER(S)
E. Meyer
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West Germany
Telephone: 08024 5055
SPECIFIC OBJECTIVES
Investigation of the physical causes of draught problems.
PROJECT DETAILS
Heat transfer measurements at a simulated test person in an air conditioned test room.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air temperature, air circulation, air humidity, radiation heat flux

START DATE 01:01:1979
END DATE 31:12:1983
APPROX NO MAN HOURS 400
BIBLIOGRAPHY
Mayer, E. Thermal environment and thermal comfort: new instruments and methods.Proceedings 6th Int. Symposium on Temperature, Washington, DC, 1982

#REF DE7 Air ventilation in buildings
PRINCIPAL RESEARCHER(S)
Dr. H. Werner
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Telephone: 08024 5055
SPECIFIC OBJECTIVES
Part project: comparison of different ventilation systems and ventilation equipment in unoccupied test-houses.
PROJECT DETAILS
Measurements in buildings - (i) two one-family houses, (ii) each house c. 100m2, brick (k=0.6 W/m2K), (iii) natural and mechanical ventilation, electrical heating, (iv) air change measurements with ethane, measurements of pressurization, (v) instrumentation - FID, (vi) unoccupied building.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
(a) weather (temperature, wind, humidity, solar radiation), (b) degree of window, door and air vent opening.
START DATE 01:07:1981
END DATE 31:12:1983

#REF DE8 Rules for determining minimum rates of air-change from the standpoint of building physics.
PRINCIPAL RESEARCHER(S)
Dr. H. Kunzel
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Fraunhofer-Institut fur Bauphysik
Postfach 1180
D-8150 Holzkirchen
West Germany
Telephone: 08024 5055
SPECIFIC OBJECTIVES
Highly insulated walls combined with too little natural air infiltration through windows can lead to condensation- induced structural damage.
PROJECT DETAILS
Report describing the necessary air change rates for different types of buildings, different size and construction, different occupant behaviour and different types of heating systems to prevent condensation-induced problems.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:07:1982
END DATE 31:12:1983
APPROX NO MAN HOURS 400

HUNGARY

#REF H1 Calculation of air circulation by the flow-in-networks method
PRINCIPAL RESEARCHER(S)
Prof. Dr. A. Zold
ADDRESS
TU Budapest
Muegyetem rkp. 3
Budapest 1111
Hungary
Telephone: (01) 664 011
Telex: 225931
SPECIFIC OBJECTIVES
Calculation of air circulation and infiltration heat loss by the flow-in-networks method.
PROJECT DETAILS
The dissipation work spent by flowing air to overcome resistance is the 'cost function', its minimum corresponds to the equilibrium condition. Algorithm is established by method of dual gradients. The size of building/network can be approximately 1000 vertices/rooms/5000 edges/doors, etc. The program is used in the design praxis of multi-storey up-to-date buildings.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature, wind, performance, simulated behaviour of occupants, stack effect, auxiliary mechanical ventilation.
START DATE 01:01:1973
END DATE 31:12:1973
APPROX NO MAN HOURS 4000
BIBLIOGRAPHY
Air circulation in buildings by the flow-in-networks method.Periodica Polytechnica, Budapest, Vol.22 No.1, 1978

Berechnung des Filtrationsluftaustausches in Gebauden, Heizung, Luftung Haustechnik, No.6 1973, p245-247

ITALY

#REF IT1 Energy saving in buildings by controlling ventilation and heat exchanging with vitiated air
PRINCIPAL RESEARCHER(S)
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Italy
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Telex: 310679 MONTED I
SPECIFIC OBJECTIVES
Realisation of a part of a window able to act as heat exchanger for heat recovery from vitiated air.
PROJECT DETAILS
The project is aimed at the study of energy saving that can be obtained by installing a particular device on windows to act as a heat exchanger of vitiated air. The research will be carried out on an indoor model with simulated weather conditions.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, performance of windows, simulated behaviour of occupants.
START DATE 01:09:1983
END DATE 30:09:1984
APPROX NO MAN HOURS 1200

#REF IT2 Technological and energetic evaluation of existing building external windows methods to decrease the heat load rate due to air infiltration.
PRINCIPAL RESEARCHER(S)
A.M. Grosso
ADDRESS
Istituto di Tecnologica dell'Ambiente Costruito (Dipartimento di Scienze e Tecniche per i Processi d'Insediamento)
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10125 Torino
Italy
Telephone: 011 688861
Telex: 220646 POLITO I
SPECIFIC OBJECTIVES
Obtainable energy saving in a building valuation by sealing window joints

PROJECT DETAILS
1. General analysis of technologies applicable on existing buildings (especially the cast-in-situ of sealant packings). 2. External window air permeability measurement before and after the installation of silicone rubber packings (a) in a fixed laboratory on window-standard and (b) with a moving laboratory on building-standard window. 3. Energy evaluation of obtained results and their possible generalization to existing buildings
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Pressure coefficient, wind speed, flow coefficient, time constant of thermal loss, neutral plane and building shape
START DATE 01:09:1982
END DATE 31:03:1983
APPROX NO MAN HOURS 560
BIBLIOGRAPHY
Grosso, M., Peretti, G., Gonella, D. Report of the research December 1982

Grosso, M., Peretti, G., Gonella, D. Interventi sui serramenti esterni per una riduzione della permeabilita all'aria Case Editrice "L'Annuario ", 1983/1984

Grosso, M., Peretti, G., Gonella, D., Vicari, L. Air infiltration control method: sealing the joints

Energy and buildings (in course of publication)

JAPAN

#REF J1 Research on airtightness of various types of houses
PRINCIPAL RESEARCHER(S)
H. Yoshino and S. Murakami
ADDRESS
Department of Architecture
Faculty of Engineering
Tohoku University
Sendai 980
Japan
Telephone: 0222 22 1800 (4651)
SPECIFIC OBJECTIVES
Airtightness of various types of 25 houses was investigated by the pressurization method and this was compared with other data including the houses of US, Canada and Sweden
PROJECT DETAILS
(1) Types of buildings: 7 detached wooden houses, 15 concrete apartments, one concrete town house and one concrete detached house. (2) Size: Detached houses are 80-100 m2 and apartments are 40-100 m2. (3) System: Almost all of the houses have mechanical ventilation for kitchen and bathroom. Some have hot water central heating system. (4) Measurements being taken: Fan pressurization. (5) Instruments: Indoor/outdoor pressure - capacitance manometer. Air volume - thermister anemometer. (6) Almost all the houses are unoccupied.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air infiltration is not measured.
START DATE 01:10:1975
END DATE 31:12:1982
BIBLIOGRAPHY
Murakami, S., Yoshino, H. Research on airtightness of various types of house.Transaction of the Architectural Institute of Japan, January 1983 (predicted)

#REF J2 Validation of several predicting methods of air infiltration using three types of test houses, the airtightness of which are different from each other.
PRINCIPAL RESEARCHER(S)
H. Yoshino
ADDRESS
Department of Architecture
Faculty of Engineering
Tohoku University
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Japan
Telephone: 0222 22 1800 (4651)
SPECIFIC OBJECTIVES
To verify the predicting method of air infiltration by measuring the airtightness and air infiltration of three types of houses, the airtightness of which are different from each other.
PROJECT DETAILS
(1) Measurements in building. (a) Types of building - detached wooden houses containing one room. (b) Size - all houses are 3.6m wide x 6.4m deep x 2.4m high. (c) No ventilation system, no heating system. (d) Measurements being taken - airtightness is measured by the fan pressurization technique. Air infiltration is measured by CO2 concentration decay technique. (e) Instruments - indoor/outdoor pressure difference is measured by capacitance manometer, wind speed by windmill type anemometer, temperature by thermocouples and the electric potentiometer. (f) Unoccupied. (2) Theoretical calculation - infiltration is predicted by the several theoretical calculations which are proposed by Bahnfleth, Sepsy, Tamura and Grimsrud
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
(1) Weather (wind speed, temperature and humidity). (2) Performance of buildings (windows are always closed).
START DATE 01:08:1982
END DATE 31:12:1982
BIBLIOGRAPHY
Yoshino, H., Hasegawa, F., Utsumi, Y. Verification of several prediction methods of air infiltration using three types of test house. Report for Tohoku branch meeting of the Architectural Institute of Japan, 13 November 1982.

#REF J3 Natural ventilation of dwellings
PRINCIPAL RESEARCHER(S)
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Institute of Industrial Science
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Roppongi
Minato-Ku
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Japan
Telephone: 03 402 6231
SPECIFIC OBJECTIVES
Experimental study of natural ventilation using full-scale test house and wind tunnel modelling
PROJECT DETAILS
(a) Measuring: wind pressure coefficient, air change rate by tracer gas method. (b) Tracer gas: C2H4, F.I.D. detector. (c) Type of building: detached house, apartment house. (d) Parameter: opening of windows and doors, shape of rooms, wind direction, etc.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather (wind), performance of building component.
START DATE 01:09:1981
END DATE 31:03:1984
APPROX NO MAN HOURS 1500
BIBLIOGRAPHY
Murakami, S. et al Natural ventilation of dwellings. Part 1, Part 2 Annual meeting of Architectural Institute of Japan, Septemer 1983

#REF J4 Ventilation design of dwellings concerned with airtightness

PRINCIPAL RESEARCHER(S)
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Japan
Telephone: 03 402 6231
SPECIFIC OBJECTIVES
Study of diffusion of combustible gas and prevention of explosion from gas leak caused by residents.
PROJECT DETAILS
Concerned with airtightness of house and with scientific gravity of leaked gas.
Building type: house. Construction type: wood. Measurements: pressurization, gas leakage concentration. Tracer gas: C2H4, F.I.D. detector (tracer gas is prepared so that specific gravity is equal to 1.6 or 0.6 by mixing CO or HE).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather (wind), performance of building components, source of pollution.
START DATE 01:04:1983
END DATE 31:03:1984
APPROX NO MAN HOURS 1000
BIBLIOGRAPHY
Murakami, S. et al Gas diffusion in room model. Part 5, Part 6. Annual Meeting of Architectural Institute of Japan, September 1982

Murakami, S. et al Gas diffusion in room model. Part 7, Part 8, Part 9. Annual Meeting of Architectural Institute of Japan, September 1983.

#REF J5 Personal exposure to nitrogen dioxide in ambient air
PRINCIPAL RESEARCHER(S)
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Hongo
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SPECIFIC OBJECTIVES
To find the dependence of personal exposure to NO2 on season, behaviour of subjects and residential conditions.
PROJECT DETAILS
10 housewives were chosen as subjects. Their personal exposure levels to NO2 were directly measured with a personal monitor called a filter badge. Measurements were performed 7 days in each month from January to December 1982. Behaviour of subjects and residential conditions were answered by questionnaire.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Behaviour of subjects, type of space heater and period of space heater in use.
START DATE 01:10:1981
END DATE 31:12:1983
BIBLIOGRAPHY
Yanagisawa, Y. A badge-type personal sampler for measurement of personal exposure to NO2 and NO in ambient air.Environment International, Vol.8, 235, 1982

#REF J6 Air infiltration calculation method in multi-rooms
PRINCIPAL RESEARCHER(S)
K. Ochifugi
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Faculty of Engineering
Hokkaido University
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SPECIFIC OBJECTIVES
The development of the practical and simple calculating method regarding the air infiltration caused by temperature difference and wind pressure.
PROJECT DETAILS
1. Modelling the tall multiple building into four types - single model, shaft model, floor model, multiple model. 2. Calculating air infiltration and room air pressure in each model. 3. Comparing and analysing results.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature difference, wind velocity, flow coefficient, window area, opening area, shaft area.
START DATE 01:01:1980
END DATE 31:12:1984
BIBLIOGRAPHY
Ochifugi, K., Kusuda, T. Air leakage calculations for NBS Administration Building U.S.A. Bulletin of Engineering, Hokkaido University, No.113, February 1983.

NETHERLANDS

#REF NL1 The use and energy consumption of small local exhaust fans in Dutch dwellings.
PRINCIPAL RESEARCHER(S)
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6200 AL Maastricht
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SPECIFIC OBJECTIVES
Energy conservation
PROJECT DETAILS
The necessary information is acquired from suppliers and, by enquiries in some residential quarters, from users. Based on these enquiries, an estimation is made of the energy consumption during a heating season of these exhaust fans.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 11:01:1979
END DATE 31:12:1981

#REF NL2 Characterization of air pollution in Dutch houses
PRINCIPAL RESEARCHER(S)
E. Lebret, B. Brunekreef, J.S.M. Boleij, D. Noij, K. Biersteker
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Department of Air Pollution
Department of Environmental and Tropical Health
Agricultural University Wageningen
PO Box 8129
6700 EV Wageningen
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Telephone: 08380 82684
SPECIFIC OBJECTIVES
Characterization of indoor air pollution in the Netherlands in relation to occupant exposure and possible health effects of occupants.
PROJECT DETAILS
Type of houses: common Dutch houses. Number of houses: over 900. Pollutants: carbon monoxide, nitrogen oxide, respirable suspended particulates, hydro carbons. Ventilation: SF6 tracer experiments in kitchens, ventilation habits by

diary and questionnaire. Measurements: weekly average samples and real time measurement.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Outdoor temperature, real occupant behaviour, sources (smoking, gas appliances, building materials, consumer products).
START DATE 01:10:1980
END DATE 01::9:1984 (prolongation on specific items until 1985)
BIBLIOGRAPHY
Biersteker, K. Discussion indoor-outdoor air quality relationships.J. Air Poll. Control Assoc., 32, 1982, pp909-913.

Lebret, E. et al Indoor air pollution in the Netherlands. VIth World Congress on Air Quality, Paris, 16-20 May 1983, Voordracht door E. Lebret

Brunekreef, B., Boleij, J.S.M. Long term average suspended particulate concentrations in smokers' homes. Int. Arch. Occup. Environ. Health, 50, 1982, pp299-302.

#REF NL3 Ventilation and formaldehyde concentration
PRINCIPAL RESEARCHER(S)
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Telex: 41714 NL
SPECIFIC OBJECTIVES
Determination of the formaldehyde concentration in houses, buildings and schools.
PROJECT DETAILS
Separate reports for an approximate total of 500 determinations up to 1.5.83, of the formaldehyde concentration in houses and schools from particle board in relation to the rate of ventilation. Included: determination of natural ventilation rate in houses and schoolrooms.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Formaldehyde concentration in relation to ventilation rate.
START DATE 01:01:1978
END DATE on-going
APPROX NO MAN HOURS 8 hours per determination

#REF NL4 Patterns in heating and ventilation behaviour of occupants of newly-built terraced houses.
PRINCIPAL RESEARCHER(S)
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Netherlands
Telephone: 15 569330
Telex: 38071 ZPTNO NL
SPECIFIC OBJECTIVES
To obtain information on the ventilation behaviour and motives of occupants in relation to weather conditions and internal heat distribution of houses.
PROJECT DETAILS
In newly-built terrace houses (brick, mechanical ventilation, gas heated) and together with measuring technical parameters, extensive verbal interviews were taken with about 55 of the occupants to gain an accurate insight into the energy- related household behaviour and motives. In addition, during a period of 14 days (28 January - 10 February 1983) under very variable weather conditions, logbooks were completed by about 35 occupants concerning (per hour) the people at home, the position of the room thermostat, the periods with open windows and the opening of trickle ventilators in the different rooms, the use of the radiator values and the positions of the doors inside the house.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather conditions, heat distribution, behaviour of occupants, use of ventilation provisions, use of windows.
START DATE 01:01:1983
END DATE 31:07:1984
APPROX NO MAN HOURS 500

#REF NL5 Natural ventilation in schools
PRINCIPAL RESEARCHER(S)
Ir. A M van de Beek
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Technical University of Eindhoven (FAGO. Bouwkunde)
Den Dolech 2
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Netherlands
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SPECIFIC OBJECTIVES
(a) A mathematical model for the calculation of air flow in an integrated environment school. (b) The simulation of opening and closing a window in a classroom in relation to radiator-heating.
PROJECT DETAILS
(a) Wind (velocity, direction), temperature difference, surroundings (roughness), pressure differences, openings, air flows, CO2 concentrations (occupants). (b) The air flow through a window, the radiator capacity, number of occupants, air temperature, CO2 concentration, to open or close the window, energy, air quality. Projects (a) and (b) are both computer models
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
For both models - (a) temperature, wind velocity, wind direction, (b) windows, doors, form of the building, (c) simulated behaviour, (d) odour
START DATE 01:02:1981
END DATE 31:12:1982
APPROX NO MAN HOURS 30,000 (during my study at university)
BIBLIOGRAPHY
de Gids, W.F. Calculation method for the natural ventilation of buildings.TNO Research Institute for Environmental Hygiene, Delft, Netherlands, 1978

Phaff, J.C. et al Onderzoek naar de gevolgen van het openen van een raam op het binnenklimaat van een kamer IMG-TNO Rapport, Nr C448, 1980

#REF NL6 Minimum fresh air supply per person
PRINCIPAL RESEARCHER(S)
Dr Ir H.B. Bouwman
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SPECIFIC OBJECTIVES
To determine the minimum fresh-air supply per person to avoid complaints about odour
PROJECT DETAILS
This investigation is carried out as a field study in office rooms. The odour-concentration was determined by the olfacto meter method. The persons who worked in the investigation office rooms and the persons who visited these rooms were questioned. The investigation was carried out under normal working conditions. The office workers involved were informed about the purpose of the research project.

The effective fresh air (outside air) supply (m3/h) was measured by the HE tracer gas method. The CO2 concentration was continuously measured by infra-red absorption method. The number of people present in the rooms was continuously counted. In some cases smoking was allowed and the number of cigarettes counted. The CO2 concentration was also calculated, based on the number of persons, their average height, weight, etc. and the fresh air supply. There was a good correlation between the calculated CO2 concentration and the measured value.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Number and activity of occupants, CO2 concentration.
START DATE not stated
END DATE not stated
APPROX NO MAN HOURS
BIBLIOGRAPHY
Bouwman, H.B. Onderzoeh naar minimum verse luchttoevoer ISSO Research Report No.1, August 1981 (in Dutch)

#REF NL7 Short reference year for weatherdata (SRY)
PRINCIPAL RESEARCHER(S)
Ir A.M. v. Weele
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Postbus 20740
3001 JA Rotterdam
Netherlands
Telephone: 010 146116
SPECIFIC OBJECTIVES
Dutch standard for weatherdata for energy calculations for building and solar systems existing of only 1344 hourly weatherdata.
PROJECT DETAILS
Analysis of Dutch weatherdata (period 1960-80) (a) developing statistical model to generate a SRY (b) generating a Dutch SRY (c) computer calculations to check and compare with calculations with 10 year hourly weatherdata.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
A simple model is used to check the wind data of SRY
START DATE 01:01:1980
END DATE 31:12:1983
APPROX NO MAN HOURS
BIBLIOGRAPHY
Verkort Referentie Jaar voor buitencondities (Short Reference Year for weather conditions) ISSO Publication 12, July 1983 (in Dutch) (This publication contains the Dutch draft standard NEN 5060 with the same title)

#REF NL8 Dutch standard for heatloss calculations for buildings
PRINCIPAL RESEARCHER(S)
Ir G.G. Franke
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Netherlands
Telephone:010 146116
SPECIFIC OBJECTIVES
1. Heatloss calculation method for buildings. 2. Calculation of heatloss caused by infiltration and ventilation. 3. Calculation of heatloss caused by transmission.
PROJECT DETAILS
A method to estimate and calculate the infiltration and ventilation through building leakage, for different types of ventilation system.

Measurement of the air flow through the building envelope by pressurization of the building (several rooms). Type of building - house and apartment made of brick and concrete with/without mechanical ventilation system that was closed during the pressurization. Flow measurement by rotation anemometer. Pressure measurement by a watergauge manometer. Furnished but unoccupied buildings.

Development of a calculation method based on measurement of airtightness of the building envelope in practice. Study of the Dutch weather data.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Dutch weather data, building construction and ventilation system.
START DATE 01:01:1979
END DATE 31:12:1984
APPROX NO MAN HOURS

#REF NL9 Infiltration rates in dwellings and their effect on radon
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
To study the continuous air infiltration in dwellings, inclusive of behaviour effects. To develop equipment for continuous measurement.
PROJECT DETAILS
A calculation study will be carried out for about 5 different group plans. Measurement equipment for continuous measurement will be developed. In one dwelling, extensive ventilation measurements will be carried out. This study is part of the national research programme on radon in dwellings.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, behaviour, radon levels
START DATE 01:06:1982
END DATE 21:12:1984
APPROX NO MAN HOURS 4800

#REF NL10 Analysis of factors influencing pressure differences on houses in relation to natural ventilation and energy consumption.
PRINCIPAL RESEARCHER(S)
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Telephone: (15) 569330
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SPECIFIC OBJECTIVES
To quantify the effects of nearby obstacles on the pressure distribution.
PROJECT DETAILS
The aim of the study can be seen as a continuation of the completed study 'Natural ventilation and energy consumption'. Measurements were made in dwellings and apartments of infiltration, pressure differences, temperatures, position of windows and doors, airtightness of building and building components. Infiltration measurements were made using katharometers with He as tracer, pressure differences using electronic pressure transducers (VALYDINE), temperatures with copper-constantan thermocouples and the positions of windows and doors with microswitches. All buildings are low-rise and have volumes of approximately 200 to 300 cubic metres. Analysis of already gathered pressure data will be made.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, obstacles such as trees, hedges, fences, etc.
START DATE 01:10:1983
END DATE 31:05:1984
APPROX NO MAN HOURS 800
BIBLIOGRAPHY
de Gids, W.F. Investigation of the relationship between the natural ventilation of a flat and meteorological conditions. Institute for Environmental Hygiene-TNO, Delft, 1977

de Gids, W.F. Natural ventilation and energy consumption EC-Brussels, October 1979

de Gids, W.F. Wind-tunnel and on-site pressure measurements on a house and the effect of pressure on infiltration. ASHRAE, Detroit, 1979

de Gids, W.F. Calculation method for the natural ventilation of buildings. Institute for Environmental Hygiene-TNO, Delft, 1978

de Gids, W.F. Natural ventilation and energy consumption. Institute for Environmental Hygiene-TNO, Delft, 1981

#REF NL11 Ventilation in welding halls
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
To collect data for ventilation and air movement in halls with welding processes.
PROJECT DETAILS
The study is part of a large survey on health conditions in factories. Measurements will be carried out in about 7 factories. The measurements consist of air flow rates, air flow patterns, air velocity, etc.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, the welding process
START DATE 01:04:1983
END DATE 30:06:1984
APPROX NO MAN HOURS 600

#REF NL12 Ventilation in dwellings with sound attenuated ventilation provisions.
PRINCIPAL RESEARCHER(S)
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Telephone: (15) 569330
Telex: 38071 ZPTNO NL
SPECIFIC OBJECTIVES
To establish ventilation rates in dwellings with sound attenuated ventilation provisions.
PROJECT DETAILS
Measurements will be carried out in about 5 dwellings. The measurements consist of pressure distribution, infiltration rate, air flow within the room, sound insulation and air leakage. With the aid of the Institute's model, some calculations should be carried out for weather conditions other than those measured.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, behaviour, sound insulation
START DATE 01:10:1982 END DATE 31:12:1984
APPROX NO MAN HOURS 600

#REF NL13 Heat recovery and warm air heating systems in relation to infiltration
PRINCIPAL RESEARCHER(S)
W.F. de Gids and M. Dubbeld
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SPECIFIC OBJECTIVES
To study the air tightness of the shell and the interior with respect to these systems and energy consequences
PROJECT DETAILS
A parametric calculation study will be carried out. The performance of the system and system components such as fans, duct, grids, will be studied. Also different levels of airtightness and airtightness distribution will be investigated.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, system performance, behaviour
START DATE 01:11:1983
END DATE 31:12:1984
APPROX NO MAN HOURS 800

#REF NL14 Occupants' behaviour and motivation in relation to natural ventilation
PRINCIPAL RESEARCHER(S)
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Telex: 38071 ZPTNO NL
SPECIFIC OBJECTIVES
To obtain information about the behaviour, motivation and changes in motivation due to an educational program
PROJECT DETAILS
Measurements and enquiries will be made in approximately 150 apartments of position of windows, temperature and energy consumption, during two subsequent heating seasons. After the first heating season, the information will be analysed. The next heating season, half the occupants will get information on how to use their windows in an energy- efficient way. The effects in changing the motivation will be studied. Position of windows will be recorded with microswitches, temperatures with thermocouples, energy consumption with yearly gas-meter readings.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, behaviour of occupants
START DATE 01:01:1982
END DATE 31:12:1986
APPROX NO MAN HOURS 4000

#REF NL15 Pressurization tests in dwellings in relation to natural ventilation
PRINCIPAL RESEARCHER(S)
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Telex: 38071 ZPTNO NL
SPECIFIC OBJECTIVES
To establish the benefits of educating inhabitants of dwellings with respect to the use of ventilation provisions.

PROJECT DETAILS
Measurements will be carried out in 100 representative dwellings. The distribution of the air leakage will be measured in at least 25 dwellings. With this information a parametric calculation study will be carried out to find out the effects of known behaviour and 'educated' behaviour. The results will also be used for the Dutch standard on airtightness.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, building practice, behaviour
START DATE 01:06:1983
END DATE 31:12:1984
APPROX NO MAN HOURS 2500
BIBLIOGRAPHY
de Gids, W.F. Investigation of the relationship between the natural ventilation of a flat and meteorological conditions.Institute for Environmental Hygiene-TNO, Delft, 1977

de Gids, W.F. Natural ventilation and energy consumption.EC-Brussels 362-78-EEN

de Gids, W.F. Wind-tunnel and on-site pressure distribution measurements on a house and its effect on infiltration. ASHRAE, Detroit, 1979

de Gids, W.F. Calculation methods for the natural ventilation of buildings.Institute for Environmental Hygiene-TNO, Delft, 1978

#REF NL16 Air leakage of houses
PRINCIPAL RESEARCHER(S)
W.F. de Gids
ADDRESS
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PO Box 214
Delft
Netherlands
Telephone: (15) 569330
Telex: 38071 ZPTNO NL
SPECIFIC OBJECTIVES
To study air leakage of houses in order to establish a standard.
PROJECT DETAILS
This study includes measurement of a representative sample of houses on air leakage, gathering information about the distribution of air leakage over the building envelope, calculations for different air leakages and pressure distributions of infiltration and heat loss due to infiltration, methods to improve air leakage paths in building construction. The study wil be carried out in different steps.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, performance of building components
START DATE 01:01:1982
END DATE 30:06:1985
APPROX NO MAN HOURS 800
BIBLIOGRAPHY
de Gids, W.F. Improvements of the pressurization test method for measuring the air leakage of buildings.Proceedings 1st AIC Conference, Windsor, UK, 1980

de Gids, W.F. Influence of different parameters in infiltration heat loss.Proceedings 2nd AIC Conference, Stockholm, Sweden, 1981

de Gids, W.F. An overview of the air leakage in dwellings.C525, Delft, May 1983

#REF NL17 Air flow and indoor climate of various ventilation openings.
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
The aim of the study is to determine air flow through a window or ventilation device and the resulting air flow in a room in the winter.
PROJECT DETAILS
Measurements in a test room using various types of ventilation device. Comparison of air flow through windows in several houses with flow through ventilation devices in a test room (uniform velocity, low turbulence intensity)
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather (wind) for field measurements, shape and position of ventilation
START DATE 01:01:1982
END DATE 31:05:1983
APPROX NO MAN HOURS 1400
BIBLIOGRAPHY
Crommelin, R.D., et al Natural ventilation comfort and energy consumption measurements in a test room. Report C513, Institute for Environmental Hygiene-TNO, Delft, 1983

#REF NL18 Analysis of ventilation through one opening only.
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
To determine the ventilation rate through one opening only, by fluctuations due to turbulence.
PROJECT DETAILS
Literature study, measurements on-site and of scale models, study of possibilities and limitations of natural ventilation in large halls. The aim of the study is to find the relationship between ventilation rates, meteorological and local wind, local turbulence and temperatures.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, obstacles as houses, trees, etc.
START DATE 01:08:1982
END DATE 31:12:1984
APPROX NO MAN HOURS 800
BIBLIOGRAPHY
Phaff, J.C. et al Consequences of the opening of one window on the indoor climate in a room.Report C448, Institute for Environmental Hygiene-TNO, Delft, 1980

NEW ZEALAND

#REF NZ1 Study of air leakage in houses
PRINCIPAL RESEARCHER(S)
M.R. Bassett
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New Zealand
Telephone: 357 600
Telex: 30256 BRANZ NZ
SPECIFIC OBJECTIVES
Investigation of the part that air infiltration plays in moisture control and winter space heat loss.

PROJECT DETAILS
A survey of the airtightness of houses, components and building materials is nearing completion. Air infiltration rate measurements using SF6 as a tracer gas are being made in houses to confirm predictive models based on weather, site and airtightness data. Multi-gas tracing methods are being investigated to measure airflows between living spaces and building cavities.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Met. station wind speed, site exposure and building airtightness characteristics.
START DATE 01:06:1981
END DATE 31:12:1983
BIBLIOGRAPHY
Bassett, M.R., Shaw, C.Y., Evans, R.G. An appraisal of sulphur hexafluoride decay technique for measuring air infiltration rates in buildings ASHRAE Meeting, Cincinnati, Ohio, USA, July 1981

Bassett, M., Preliminary survey of air tightness levels in New Zealand houses.Institution of Professional Engineers NZ Annual Conference, Hamilton, 1983

NORWAY

#REF NO1 Survey of tracer gas in single family houses
PRINCIPAL RESEARCHER(S)
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Norway
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SPECIFIC OBJECTIVES
Survey of ventilation rate and air infiltration in single family houses
PROJECT DETAILS
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Outdoor and indoor temperature, wind
START DATE 01:01:1982
END DATE 31:12:1983

#REF NO2 Thermal insulation and airtightness of buildings
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
Development and testing of new building design details to improve thermal insulation and airtightness performance.
PROJECT DETAILS
The project is divided into several sub-projects: (1) Mainly residential buildings, both under construction and older existing buildings. (2) Wood frame and concrete structures with wood frame infill panels. (3) Both natural and mechanical ventilation, mainly electric heating. (4) Pressurization, thermography, air flow measurements inside structures. (5) Standard pressurization equipment, special investigation (air flow measurements in ventilated construction, in order to determine performance requirements for wind barriers).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind pressures and performance of wind barriers (no special investigation into types of air pollutants is included).
START DATE 01:01:1983
END DATE 31:12:1985
BIBLIOGRAPHY
Uvslokk, S. Air infiltration model validation, the ENCORE computer program.The Norwegian Building Research Institute, Report to AIC, 20 January 1983

PAPUA NEW GUINEA

#REF PNG1 Correlation of wind tunnel and full scale natural ventilation
PRINCIPAL RESEARCHER(S)
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Papua New Guinea University of Technology
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Papua New Guinea
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SPECIFIC OBJECTIVES
To determine the order of accuracy that can be expected when estimating airflow rates through naturally ventilated buildings in humid, tropic climate using wind tunnel wind speed co-efficient approach.
PROJECT DETAILS
(1) Type of building: Office and classrooms, building housing Dept. of Fisheries and Forestry. (2) Size and type of construction: 2-storey, 23mx53m timber framed with glass louvred walls without insect screening, timber shingle roof. (3) Ventilation: Natural, through louvred internal and external walls. Ceiling fans fitted in most rooms. (4) Measurements: Miniature cup anemometers recording wind are being used for measuring mean airflow at specific points inside the building and at 10 metre high reference point clear of the building where wind direction shall also be recorded. A hot wire 2-channel anemometer will be used for obtaining mean velocity coefficients from the wind tunnel model. (5) Instruments: RIMCO miniature 1.25" cup anemometers impulse light chopper type with digital counters supplied by Rauchfus Instruments P/L, Mitcham, Victoria, Australia. 10 metre reference recordings anemometer is a GILL CUP TYPE meteorological instrument 'Stellma' 2-channel constant temperature hot-wire anemometer supplied by Leonard Electronics, Ashbury, New South Wales, Australia.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Thermal comfort
START DATE 01:01:1981
END DATE 31:12:1983
APPROX NO MAN HOURS 500
BIBLIOGRAPHY
Aynsley, R.M. Natural ventilation model studies. Proceedings of International Workshop on Wind Tunnel Modelling Criteria and Techniques in Civil Engineering Applications, National Bureau of Standards, Gaithersburg, Maryland, April 1982

Aynsley, R.M. Wind tunnel modelling for civil engineering applications.Proceedings of International Workshop on Wind Tunnel Modelling Criteria and Techniques in Civil Engineering Applications, National Bureau of Standards, Gaithersburg, Maryland, April 1982

POLAND

#REF PL1 Air change rates of typical Polish buildings (Silesia) and the influence of specially tight outer walls and windows on infiltration and energy consumption.
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
(a) Comparison of infiltration between 20 buildings with good and bad thermal insulation. To study effects of heat losses, real energy consumption, and conservation. (b) Comparison of measurement results with existing infiltration models. Numerical investigation about pressure distribution and air flow.
PROJECT DETAILS
(1) Apartment buildings (5-18 storey). (2) Concrete and mineral wool. (3) Natural and mechanical ventilation, and water heating system. (4) Surface pressures, pressurization, thermography, experimental set-up for measuring air leakage rate through building components. (5) Fluid multimanometers, thermal sensor, pressure transducer recorder, etc. (6) Occupied and unoccupied buildings.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Inside/outside temperature differences, wind velocity and direction,
size/shape/siting/orientation of buildings, distribution and position of leakage.
START DATE 01:01:1983
END DATE 31:12:1985
BIBLIOGRAPHY
Nantka, M.B. Heat consumption and heat losses of pre-fabricated blocks and possibilities of its reduction. Management of Fuel and Energy (in press).

Nantka, M.B. Measurement of thermal insulation and air infiltration in suburban housing. Polish Acad. Scient., 1983.

Nantka, M.B. Relationship between air leakage, infiltration, ventilation action, thermal insulation, energy consumption and indoor air quality in apartment buildings. Report S.T.U.. 1982/3.

#REF PL2 A method for the removal of exhaust air by means of a central supply air and exhaust air system
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
Reduction of noxious substance concentrations in ventilated rooms by a central supply air and exhaust air system.
PROJECT DETAILS
The method for the removal of polluted exhaust air and for ventilation, uses a central supply air and exhaust air system and eliminates the problem of secondary penetration of pollutants into industrial buildings due to emission from nearby sources situated at a lower level. The principle of this method consists of aspiring the external air instead of the weather-side air, since the aspiration aperture is stationary and is situated above the exhaust air aperture which itself is directed to the lee-side.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air pollutants concentration, wind velocity, relative air humidity, air temperature, specific enthalpy.
START DATE 01:01:1977
END DATE 31:12:1983
APPROX NO MAN HOURS 11,000
BIBLIOGRAPHY
Trojanowski, T.J. Verminderung der Schadstoffkonzentration in belufteten Raumen durch eine zentrale Zu-und Fortluftanlage. Staub und Reinhaltung der Luft, 42, nr.5, 1982

Trojanowski, T.J. Methode zur Entfernung verunreinigter Fortluft mit einer zentralen Zu-und Fortluftanlage. Staub und Reinhaltung der Luft, 41, nr.4, 1982

Trojanowski, T.J. Individuell nach der Windrichtung steuerbare zentrale Zuund Fortluftanlage. Staub und Reunhaltung der Luft, 40, nr.12, 1980

SOUTH AFRICA

#REF SA1 Cape low energy experimental housing project
PRINCIPAL RESEARCHER(S)
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SPECIFIC OBJECTIVES
The current project is aimed at assessing the viability of five passive solar heating technologies in low cost housing in the Western Cape winter rainfall climatic area.
PROJECT DETAILS
The test houses are typical low cost units of 85 m2 floor area that are being built in large numbers. Construction is double leaf masonry with facing brick and concrete block with truss roof and cement tile roof. Natural ventilation with optional air vents is used and heating is solar with radiant electrical backup. A locally made automated SF6 tracer gas system is being used in concert with an Autodata 10/10 logger which provides weather and building data. The buildings are at present not occupied but an occupied phase of one year is planned to commence in late 1984. No theoretical models are currently being developed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Infiltration vs air velocity, wind direction, temperature difference and later, if time permits, building pressure gradient.
START DATE 01:01:1981
END DATE 31:12:1985
APPROX NO MAN HOURS 8000
BIBLIOGRAPHY
Two local reports were issued, written for a

non-technical audience, concentrating on the passive solar design of the houses.

SWEDEN

#REF SE1 A wind tunnel study of effects of surrounding buildings on wind pressure distributions and ventilation losses for a single family house, detached 1.5 storey houses and 2 storey terrace houses.
PRINCIPAL RESEARCHER(S)
B.G. Wiren
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The National Swedish Institute for Building Research
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S-801 29 Gavle
Sweden
Telephone: (026) 100220
Telex: 47396 BYGGFO S
SPECIFIC OBJECTIVES
Use of scale models to provide input data for calculation of heat losses due to uncontrolled ventilation of buildings.
PROJECT DETAILS
Model scale 1:100. Measurement of time-mean pressures at 122 locations on walls and roof of a house surrounded by identical houses in regular arrays. Calculations of air change rates and corresponding ventilation losses. Presentation of a dimentionless heat loss reduction factor as a function of a Froude Number based on free-stream wind speed and internal/external temperature difference.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Relative leakage area, wind speed (u between 0 and 8 m/s), temperature difference (between 5 and 35 K)
START DATE 01:05:1982
END DATE 01:10:1983
APPROX NO MAN HOURS 1500
BIBLIOGRAPHY
Wiren, B.G. Effects of surrounding buildings on wind pressure distributions and ventilation heat losses for a single family house. Paper presented at Sixth International Conference in Wind Engineering, Gold Coast, Australia, 21-25 March 1983.

#REF SE2 Heat recovery from exhaust air
PRINCIPAL RESEARCHER(S)
A. Svensson
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SPECIFIC OBJECTIVES
To investigate the energy savings for different kinds of heat recovery units in different single family houses.
PROJECT DETAILS
44 single family houses with 130 m2 living area. 14 are provided with mechanical exhaust air system (F). 15 are provided with mechanical exhaust and supply air system with heat recovery (FTX). 15 are provided with mechanical exhaust air system combined with heat pump for recovery of heat from exhaust air to hot water (FVP).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather (temperature and wind), installations (pressure difference inside/outside).
START DATE 01:01:1982
END DATE 30:06:1984
APPROX NO MAN HOURS 4000 (incl. development of measuring equipment)
BIBLIOGRAPHY
Heat recovery from exhaust air. National Swedish Institute for Building Research, Bulletin M81:23 and M82:15

Svensson, A. Efficiency of air-to-air heat exchangers in occupied houses. Presented at 3rd AIC Conference, London, UK, September 1982.

Good economy of heat recovery installations require well balanced systems and tight houses. 9th CIB Congress, Stockholm, 1983

#REF SE3 Ventilation (air diffusion) efficiency in dwellings
PRINCIPAL RESEARCHER(S)
M. Sandberg
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Box 785
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Sweden
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SPECIFIC OBJECTIVES
The principal aim is to develop design guidelines for establishing an efficient ventilation in multi-room applications.
PROJECT DETAILS
Measurements in an indoor full-scale test house with one facade exposed to the outdoor environment. Mechanical extract and combined supply/extract ventilation. Electrical heating. Air movements in door opening are visualized by smoke. Pressure and temperature are measured in each room. Ventilation (air diffusion) efficiency is measured by tracer gas technique.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Lay-out of ventilation, air flow rate, temperature difference, indoor air quality.
START DATE 01:01:1983
END DATE 31:12:1986
BIBLIOGRAPHY
Sandberg, M. Definition of ventilation efficiency and the efficiency of mechanical ventilation systems. 3rd AIC Conference, London, UK, Sept.1982

Freeman, I. Gale, R., Sandberg, M. The efficiency of ventilation in a detached house. 3rd AIC Conference, London, UK, September 1982

Sandberg, M. Ventilation efficiency as a guide to design. ASHRAE Trans., Volume 89, Part 2, 1983.

#REF SE4 Low energy houses in Skultorp - performance monitoring and evaluation
PRINCIPAL RESEARCHER(S)
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National Testing Institute
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Telephone: 033 165174
Telex: 36252 TESTING S
SPECIFIC OBJECTIVES
To monitor and evaluate a calculated energy saving and to study space-heating with forced air. The ventilation efficiency and the thermal efficiency will be studied.
PROJECT DETAILS
Two unoccupied identical houses built by Rockwool AB will be monitored. They are identical in every respect except for the level of insulation. One house is very well insulated, and the other is super-insulated. The floor area is 108m2. The

houses are heated by a heat pump and equipped with a forced air system. Tracer gas measurements will be made on several occasions using the constant concentration technique and the decay technique. Pressurization test will be made on several occasions. A modified version of the Lawrence Berkeley Laboratory air infiltration model will be used. The houses are monitored continuously (hourly averages of temperature, etc.)
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, performance of building components, simulated occupancy.
START DATE 01:07:1982
END DATE 01:12:1984
APPROX NO MAN HOURS 1300
BIBLIOGRAPHY
Final report , Swedish Council for Building Research, 01.12.1984.

#REF SE5 Microclimate - the influence of wind pressure distribution on air infiltration through building structures.
PRINCIPAL RESEARCHER(S)
K. Handa, J. Gusten
ADDRESS
Division of Structural Design
Chalmers University of Technology
S-412 96 Goteborg
Sweden
Telephone: 46 31 810100
SPECIFIC OBJECTIVES
In the field of energy-related problems, the influence of wind pressure distribution on low-rise buildings is studied. Project details: Some single-family houses are instrumented, and mean and fluctuating pressure and permeability characteristics of the houses are investigated. The test houses are selected in order to represent different surface roughness conditions. The study has shown the importance of the wind-related flow studies and the inadequacy of the existing models for calculating the rate of air infiltration.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1981
END DATE on-going
BIBLIOGRAPHY
Handa, K. Gusten, J. Pressure distribution around low rise buildings. Proceedings, Designing with wind, Nantes, 1981

Handa, K. Gusten, J. Vindtrycksfordelning pa smahus. Division of Structural Design, Chalmers University of Technology, 1981:9, (in Swedish)

Handa, K., Gusten, J. Estimation of rate of air infiltration based on full-scale wind pressure measurements.Proceedings, 3rd AIC Conference, London, 1982

#REF SE6 Radon from soil - field test of cost effective remedial actions in existing buildings.
PRINCIPAL RESEARCHER(S)
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AIB - Consulting Engineers
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Sweden
Telephone: 08 630020
Telex: 17195 AIB STH S
SPECIFIC OBJECTIVES
To test and evaluate different technical remedial actions to prevent infiltration of radon with soil gas into buildings.
PROJECT DETAILS
Infiltration of soil gas through cracks and holes in existing buildings, even if the radon-222 concentration of the soil gas is normal, may result in unacceptable indoor radon concentrations. Problems occur when the radon concentration of the soil gas is high. Effective methods can be to seal basement or slab floor with radon-tight materials or achieve a pressure difference to prevent soil gas from infiltrating. We are presently in the beginning of evaluating 30 remedial actions. Some preliminary results are positive.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Pressure difference, occurence of cracks and holes in basement or slab. Radon concentration of soil gas. Indoor ventilation rate.
START DATE 01:07:1983
END DATE 31:12:1984
APPROX NO MAN HOURS 8,000
BIBLIOGRAPHY
Eriscon, S-O. Radon i bostader Literature study for research scheme, Swedish Council of Building Research, R128:1981 (in Swedish).

Clavensjo, B., et al Radon i bostader Soil influence on indoor radon concentrations and gamma-radiation Swedish Council of Building Research, R9:1983 (in Swedish)

Radonutredningen SOU 1983:6 (in Swedish)

#REF SE7 Air infiltration compared to energy consumption in small houses
PRINCIPAL RESEARCHER(S)
Civ.Eng. U. Bergstrom
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Swedish Foundation of Research of Woodworking Industries (TTC)
Box 43200
S-100 72 Stockholm
Sweden
Telephone: 08 231525
SPECIFIC OBJECTIVES
To find correlations between tightness of small houses and energy consumption, and to compare with calculation theories.
PROJECT DETAILS
Small houses with wooden structure, insulated according to Swedish Standard SBN 1980. Some groups of occupied single and detached houses with electrical heating will be followed for at least one year (total electrical energy consumption). In each group a number of houses will be pressurized and tests of ventilation-standard will be carried out. The results will be compared to theories of calculation of the importance of airtightness.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Tightness, normal ventilation, family structure, total water and energy consumption.
START DATE 01:05:1981
END DATE 30:11:1983
BIBLIOGRAPHY
Bergenstjerna, A. Energiforbrukning i smahus 1975-77 TFB 1970

#REF SE8 SPARSAM - Energy efficient single family houses
PRINCIPAL RESEARCHER(S)
A. Elmroth and G. Granberg
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Dept of Energy Conservation in Buildings
Royal Institute of Technology
S-100 44 Stockholm
Sweden
Telephone: 46 8 7877000
Telex: 10389 KTHB S
SPECIFIC OBJECTIVES
To build energy efficient houses (total energy consumption for heating, ventilation, hot water and household electricity less than 10.000 kWh/year in Stockholm climate) which can be produced in long series.

PROJECT DETAILS
Well insulated airtight envelope, passive solar design, mechanical ventilation with an exhaust air heat pump for preheating supplied air and for producing hot water, water conserved by using water saving system, comparison between light and heavy structure on energy consumption and installed effect.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Long time measurements of ventilation and air infiltration by using continuous tracer gas technique and a new passive technique. Air distribution in the houses. Indoor and outdoor climate.
START DATE 30:04:1982
END DATE 31:12:1984
APPROX NO MAN HOURS 8,000
BIBLIOGRAPHY
(not yet decided)

#REF SE9 Air pollutants inside dwellings - medical, environmental, hygienic and chemical aspects of air quality.
PRINCIPAL RESEARCHER(S)
Prof. T. Lindvall
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The National Institute of Environmental Medicine
Box 60208
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SPECIFIC OBJECTIVES
This study aims to make precise statements as to the functional demands posed by environmental, hygiene and medical considerations on the air quality inside dwellings. These findings will then be used as a basis for setting up requirements concerning material, building design and ventilation systems.
PROJECT DETAILS
Inside an environmental chamber, a room in a dwelling is simulated. Test persons in the chamber are exposed acutely to low concentrations of simple and complex air pollutants. We will determine sensory effects such as odour sensations, eye irritations and subjective airway resistance as well as document early physiological changes in the airways and in the conjunctiva. The project includes (a) construction of an environmental chamber and related equipment as well as the application of techniques to measure sensory and physiological effects of low concentrations of air pollutants indoors, (b) use of these techniques in the environmental chamber to study the effects of building material, ventilation designs and human activities, (c) study sensitivity in limited risk groups, specifically in persons with allergies, (d) study of chemical processes of importance for indoor air quality, e.g. dependence of indoor air on the composition of outdoor air as well as the decomposition, accumulation and interaction of substances in the air of a room and (e) precise comments on the medical and environmental hygiene demands when various groups are taken into consideration.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
This evaluation will be based on the results of this project and findings in other laboratories in and outside Sweden.
START DATE 01:01:1978
END DATE 30:09:1983
BIBLIOGRAPHY
Ahlborg, U. et al Medicinska och hygieniska effekter av formaldehyd i omgivningsluft. Litteratugenomgang och toxikologisk utvardering.

Berglund, B. et al Do 'sick buildings' affect human performance. How should one assess them. 1983.

Berglund, B. et al Characterization of indoor air quality and 'sick buildings'. To be published in ASHRAE, 1983

Berglund, B. et al Sensory reactions to 'sick buildings' In 'Application of environmental psychology: recent research on environmental hazards and infavourable environments' Eds. B. Berglund and C. Leve-Leboyer Sage Publications, London, 1983 (in press)

Bylin, G. et al Pulmonella och sensoriska effekter av korttidsexposition for kvavedioxid.

Camner, P. et al Luftfororeningars effekter pa luftvagana.

Guhl, A. et al Forstudie av luftvalitet i EKONO OY's kontorsbyggnad i Helsingfors. Rapport fran Stockholm Universitet (Psykologiska Institutionen), 1981.

Johansson, I. Kemiska kartlaggningar av inomhusluft. Skall publiceras VVS Special, September 1983

Knox, S.S. Light air ions and human psychophysiology. Report from National Institute of Environmental Medicine, Stockholm, No.1, 1983

Lindvall, T. Health effects of nitrogen dioxide and oxidants.A document on health criteria to serve as a basis for the establishment of Swedish air quality standards.

Malmsjo, M. et al Ett dynamiskt spadsystem for framstallning av standardgasblandningar. Presenterat som poster vid Svenska kemistsamfundets Analysdagar i Lund, 14-17 Juni 1982 (abstract finns)

Rondahl, L. Medicinska och hygieniska effeckter av toluen och xylen i omgivningsluft. Litteraturgenomgang och toxikologisk utvardering.

Sigtryggsson, P., och Rondahl, L. Diisocyanater i omgivningsluften. Riskidentifiering och riskuppskattning.

Sodergren, D. and Punttila, A. A CO2-controlled ventilation system. Pilot study. Swedish Council for Building Research, D7:1983. (Thomas Lindvall has ingatt i arbetsgrupen for projektet och aktivt medverkat vid skrivning av rapporten)

#REF SE10 Influence on the function of a ventilation system according to the leakage of the building.
PRINCIPAL RESEARCHER(S)
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Royal Institute of Technology
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Telephone: 46 8 7877000
Telex: 10389 KTHB S
SPECIFIC OBJECTIVES
PROJECT DETAILS
A mathematical model for air infiltration in buildings is determined. The model is used for predicting the way different ventilation systems are influenced by inside/outside temperature difference and wind velocity. The influence of retrofitting is also calculated.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Inside/outside temperature difference, wind velocity.
START DATE 01:07:1982 END DATE 01:10:1984
APPROX NO MAN HOURS 8,500

SWITZERLAND

#REF CH1 Real airtightness of residential buildings
PRINCIPAL RESEARCHER(S)
U. Steinemann and A. Haerter
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Switzerland
Telephone: (01) 201 29 00
SPECIFIC OBJECTIVES
The measurements shall give a better knowledge of the real airtightness of typical different constructions, which is the base to calculate natural ventilation.
PROJECT DETAILS
During three winters, a number of residential buildings of typical construction will be tested by pressurisation and supplementary measurements to determine the real airtightness of the whole facade. The project is supported by the Swiss Energy Foundation.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Main parameter - performance of building components.
START DATE 01:01:1982
END DATE 31:12:1985

#REF CH2 Compact equipment for survey of air renewal (Project CESAR)
PRINCIPAL RESEARCHER(S)
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Federal Institute of Technology
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SPECIFIC OBJECTIVES
Measurement of mean and instantaneous air renewal in multi-chamber dwellings using N2O as tracer gas.
PROJECT DETAILS
Using continuous flow and decay methods, measurements of instantaneous air renewal rate will be possible. Using constant flow and constant concentration methods, precise measurement of air renewal will also be possible, over period of days or weeks. The apparatus, designed for both field and laboratory survey, is compact and easily movable.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Infiltration value will be correlated with effects of occupation as well as house tightness and meteorological conditions.
START DATE 01:01:1983
END DATE 31:12:1983
APPROX NO MAN HOURS 2000

#REF CH3 Radiation dose and effects from radon and its progeny in indoor air.
PRINCIPAL RESEARCHER(S)
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Switzerland
Telephone: (056) 99 23 38/99 21 11
Telex: 537 14 EIR CH
SPECIFIC OBJECTIVES
Assessment of weatherstripping/insulation on indoor radioactivity (radon and daughters). Resulting annual dose to general public.
PROJECT DETAILS
Measurements in single family homes. Regional differences: sediment vs granite/gneiss all construction types. Natural ventilation. Passive radon dosemeters (track etch). Occupied buildings. Concept: pairs of dwellings matched for underground/ bedrock (main source of radon).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, weatherstripping, ventilation behaviour of occupants.
START DATE 01:09:1982
END DATE ongoing
APPROX NO MAN HOURS 1200
BIBLIOGRAPHY
Burkart, W. Assessment of radiation dose and effects from radon and its progeny in energy-efficient homes. Nuclear Techn., Vol.60, pp114-123, January 1983.

Burkart, W., et al Energy conservation: increased health impacts despite source.Proceedings of Annual Congress SFRP 'Comparisons of Risks Resulting from Major Human Activities'.

Brunner, H.H., et al Le radon dans les habitations: resultats d'une etude preliminaire en Suisse. Proceedings of 'Societe Suisse de Radiobiologie et Radiophysique', Epalinges, 30 October 1982, pp131-139.

Internal reports.

#REF CH4 Indoor pollutants emitted by building materials
PRINCIPAL RESEARCHER(S)
H.U. Wanner
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Swiss Federal Institute of Technology
Institute for Hygiene and Workphysiology
CH 8092 Zurich
Switzerland
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SPECIFIC OBJECTIVES
Investigation of pollutants emitted by building materials.
PROJECT DETAILS
(1) Review of relevant literature. (2) Studies in living rooms and in a climatic chamber. (3) Elaboration of standards or guidelines to minimize the emissions of gaseous compounds.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Ventilation, temperature, humidity
START DATE 01:04:1980
END DATE 30:06:1983
BIBLIOGRAPHY
Kuhn, M. Verunreinigung der Raumluft durch Materialien. Dissertation. Swiss Federal Institute of Technology, 1983

Kuhn, M., Wanner, H.U. Verunreinigung der Raumluft durch Materialien. Sozial- und Praventivmedizin, Vol.27, pp260-261, 1982

Huber, G., Wanner, H.U. Indoor air quality and minimum ventilation rates. Environment International (accepted for publication).

#REF CH5 Energy auditing: evaluation and development of specific audit procedures.
PRINCIPAL RESEARCHER(S)
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Switzerland
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SPECIFIC OBJECTIVES
Evaluation of air infiltration rate, evaluation of energy consumption due to air infiltration, quantification of effects of wind velocity and direction.
PROJECT DETAILS
Applied to apartment houses with natural and mechanical exhausts, and heated with oil, gas or electricity. Determination of air infiltration rate by component categories, e.g. windows, walls, doors, etc. Measurement of differential surface pressure. Instrumentation: special device for measuring air infiltration coefficients for differential pressure between 0 and +/- 500 Pa, differential pressure manometers.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Indoor and outdoor temperatures, wind direction and velocity, shape of building.
START DATE 01:05:1982
END DATE 31:12:1984
APPROX NO MAN HOURS 500
BIBLIOGRAPHY
Reports on energy auditing methods (to be published)

#REF CH6 Air leakage measurement methods for the building shell
PRINCIPAL RESEARCHER(S)
P. Hartmann and H. Muhlebach
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EMPA
Section 176
Ueberlandstrasse
CH-8600 Duebendorf
Switzerland
Telephone: 01 823 4276
Telex: 53817
SPECIFIC OBJECTIVES
To evaluate advantages of different techniques of static and dynamic measurements of building leakage, for different types of building with the scope of a national standard.
PROJECT DETAILS
To carry out a literature survey on existing methods, especially other than pressurization technique. To develop measurement kits for methods which seem interesting for an application in Swiss buildings. To evaluate these methods by measurements in different buildings. To issue a national standard which should be based on international standards.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
This project is connected with the evaluation of reference values for CH buildings.
START DATE01:07:1983
END DATE 30:03:1985
APPROX NO MAN HOURS 1200
BIBLIOGRAPHY
Baumgartner, Hartmann, Muhlebach Luftun sverluste - wie sind sie messtechnisch erfassbar Heizung und Luftung Nr 2/981

(this publication will be "retrofitted by this new project")

UNITED KINGDOM

#REF UK1 Improvement in the working environment
PRINCIPAL RESEARCHER(S)
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University of Manchester
Oxford Road
Manchester
M13 9PL
United Kingdom
Telephone: (061) 273 3333
SPECIFIC OBJECTIVES
Ventilation-based studies of work spaces to secure improvement in air quality and thermal comfort.
PROJECT DETAILS
Instrumented studies of various work spaces where problems have been reported and assessment of causative factors and remedial measures, e.g. airborne particulates, air change rates, air temperature and movement, air humidity, surface temperature, gaseous contaminants, ventilation rates, etc.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air change rate and thermal comfort (air movement, temperature, radiation, etc.) and energy factors.
START DATE 01:01:1974
END DATE on-going
BIBLIOGRAPHY
Winch, G.R., Tuxford, A.F. A study of the working environment in animal houses.Proceedings of Int. Environment and Safety Conference, Wembley, London, 1980, 1981 and 1982

Tuxford, A.F., Winch, G.R. Improving the working environment.Proceedings of Int. Environment and Safety Conference, Wembley, London, 1980, 1981 and 1982

Winch, G.R., Tuxford, A.F. A base study of working conditions in the pharmaceutical industry. Proceedings of Int. Environment and Safety Conference, Wembley, London, 1980, 1981 and 1982

#REF UK2 An investigation of the air infiltration characteristics of windows
PRINCIPAL RESEARCHER(S)
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Paisley College of Technology
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United Kingdom
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Telex: 778951 PCT LIB G
SPECIFIC OBJECTIVES
To assess the air infiltration characteristics of different types of windows under laboratory conditions
PROJECT DETAILS
Equipment - pressure chamber test rig (3m x 3m max.) Measurements - air leakage, pressure difference, temperature using standard instrumentation. Calculations - statistical analysis of tests on approximately 600 windows, correlation of results and comparison with existing data, e.g. CIBS Guide.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air infiltration rate, pressure difference, dimensionless parameters
START DATE 01:05:1983 (data in existence + additional)
END DATE 01:06:1984
APPROX NO MAN HOURS 500
BIBLIOGRAPHY
Provan, T.F., Younger, J.D. Air and water penetration through windows.Society of Chemical Industry Symposium "Rain Penetration into Buildings", London, March 1979

Provan, T.F., Younger, J.D. Water penetration through windows and door joints.Seminar on Weathertightness of Buildings, MACDATA, Paisley, 1980

Provan, T.F. Keeping the elements at bay,Building, June 1979

#REF UK3 Ventilation of buildings
PRINCIPAL RESEARCHER(S)
Dr. D.W. Etheridge
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British Gas Corporation
Watson House
Peterborough Road
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United Kingdom
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Telex: 919082
SPECIFIC OBJECTIVES
To develop and use theoretical and experimental methods for determining ventilation
PROJECT DETAILS
(a) (i) Dwellings and small commercial buildings. (ii) Conventional and new construction types. (iii) Natural and mechanical systems. Gas heating. (iv) Constant concentration. Pressurization. Wind tunnel. (v) Automatic ventilation monitoring. (vi) Unoccupied. (b) Multi-cell and single-cell versions of "VENT". Quadratic flow equation. Validation described in reference 5 below.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, leakage, simulated occupancy dwellings, commercial, pressurization, tracer gas, mathematical models
BIBLIOGRAPHY
Build. and Env., 12, pp181-189, 1977

The prediction of ventilation rates in houses. Proc. of CIB S17 Meeting, Holzkirchen, West Germany, September 1977.

Experimental techniques for ventilation research, Proc. 1st AIC Conference, Windsor, UK, October 1980.

ASHRAE Trans., Vol. 86, Pt. 2, 1980.

J. App. Energy, 10, 1982.

#REF UK4 The measurement of air infiltration rates in large enclosures and buildings.
PRINCIPAL RESEARCHER(S)
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Telex: 848288 BSRIAC G
SPECIFIC OBJECTIVES
(a) To develop and validate a method of measuring air infiltration rates in large single-cell buildings. (b) To derive from site measurements data suitable for validation of predictive models.
PROJECT DETAILS
The experimental programme involves the development and proving of an instrumentation system suitable for the measurement of air infiltration rates in single-cell (of approximately 1000 m3 volume) industrial buildings. Subsequently, it is envisaged to carry out infiltration rate measurements in a minimum of six suitable buildings covering a variety of types and reflecting differences in structure, location and usage. Finally, the results of the test programme will be used as a foundation for a numerical database.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Will include wind speed and direction, inside and outside temperatures
START DATE 01:10:1981
END DATE 30:04:1984
APPROX NO MAN HOURS 7390
BIBLIOGRAPHY
Dewsbury, J., Jones, T.J., Potter, I.N. The measurement of air infiltration rates in large enclosures and buildings.Proceedings of 4th AIC Conference, Elm, Switzerland, September 1983

#REF UK5 Ventilated containers (naturally ventilated freight containers for carriage of perishable cargoes)
PRINCIPAL RESEARCHER(S)
R.D. Heap
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Shipowners' Refrigerated Cargo Research Association
140 Newmarket Road
Cambridge
CB5 8HE
United Kingdom
Telephone: (0223) 65101
Telex: 81604
SPECIFIC OBJECTIVES
1. Determination of effects of wind on ventilation. (2) Relation between vent design and pressure drop at low Reynolds Numbers.
PROJECT DETAILS
Wind velocity and direction effects will be studied under controlled conditions in a test chamber. Vent design parameters will be related to discharge coefficients, using both theoretical and experiemental methods. This project follows previous work which measured overall ventilated container performance.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind velocity, temperature difference
START DATE 01:07:1983
END DATE 31:03:1986
APPROX NO MAN HOURS 1120
BIBLIOGRAPHY
Heap, R.D. Naturally ventilated containers for the carriage of hygroscopic cargoes.International Institute of Refrigeration, International Congress of Refrigeration, Paris, September 1983

#REF UK6 Low energy housing: ventilation.
PRINCIPAL RESEARCHER(S)
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Telex: 627124
SPECIFIC OBJECTIVES
To assess the ventilation pattern in low energy houses which contain controlled mechanical ventilation.
PROJECT DETAILS
Four low energy masonry houses have been instrumented to record energy consumption, temperatures and ventilation. The ventilation factors are monitored by continuously recording the operating conditions of the fan and by recording open doors and windows
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Pressurisation tests are used to check the consistency of the houses over time. Decay techniques were used to calibrate the houses.
START DATE 01:01:1981
END DATE 31:12:1984
APPROX NO MAN HOURS 7000

#REF UK7 Multi tracer gas techniques
PRINCIPAL RESEARCHER(S)
J.G.F. Littler

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Building Unit
Polytechnic of Central London
35 Marylebone Road
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SPECIFIC OBJECTIVES
Development and evaluation of a 4+ gas tracer system
PROJECT DETAILS
The prototype system uses four different gases simultaneously. It will be used to examine zone-to-zone air movement in three low energy houses designed by Polytechnic of Central London and built by Peterborough Development Corporation.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Heat movement by zone-to-zone air movement
START DATE 01:10:1980
END DATE 30:06:1984
APPROX NO MAN HOURS 4 person years
BIBLIOGRAPHY
Prior, J., Littler, J., Adland, M. Development of a multi tracer gas technique for observing air movement in buildings.Air Infiltration Review, Vol.4 No.3, p9, 1983

Littler, J., Prior, J. Final report to Science and Engineering Research Council, GR/R50768, 1983

#REF UK8 Determination of air-flow in occupied buildings using metabolic carbon dioxide
PRINCIPAL RESEARCHER(S)
J.M. Penman
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South-West Energy Group
Physics Department
The University
Exeter
EX4 4QL
United Kingdom
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SPECIFIC OBJECTIVES
To investigate the practicality of determining air exchanges in occupied buildings by recording the CO2 concentration in the internal air and relating this to the number and level of activity of the occupants
PROJECT DETAILS
Successful trials of the method have been made in naturally and mechanically ventilated areas at Exeter University. A year's data have been collected from a naturally ventilated school and this information is now being analysed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind speed, outdoor temperature, occupant behaviour
START DATE 01:03:1979
END DATE 01:01:1984
BIBLIOGRAPHY
Penman, J.M. An experimental determination of ventilation rate in occupied rooms using atmospheric carbon dioxide concentration.Building and Environment, Vol.15 No.1, pp45-47

Penman, J.M., Rashid, A.A.M. Experimental determination of air flow in a naturally ventilated room using metabolic carbon dioxide.Building and Environment, Vol.17 No.4, pp253-256

#REF UK9 Energy efficiency in a new traditional school
PRINCIPAL RESEARCHER(S)
Dr A Hildon
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City of Birmingham Polytechnic
Perry Barr
Birmingham
B42 2SU
United Kingdom
Telephone: (021) 356 6911
SPECIFIC OBJECTIVES
To demonstrate through monitoring the viability of incorporating various energy conservation measures within a new school of traditional design and costing.
PROJECT DETAILS
School - 2000 m2. Age range - 5 to 13. Highly insulated "brick" construction. Predominantly naturally ventilated but with winter mechanical ventilation incorporating recirculation and heat recovery under automatic control. Performance monitored by in-situ microcomputer data logger. Air infiltration/ventilation monitoring by BRE pressure and tracer gas.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, window use (which is logged), user response.
START DATE 01:01:1979
END DATE 31:12:1983
BIBLIOGRAPHY
Hildon, et al Walmley - an energy efficient school. International Congress in Building Energy Management, Pavoa de Varzim, Portugal, May 1980

Hildon, et al The design and construction of a low energy school within conventional constraints. CIB 3rd International Symposium on Energy Conservation in the Built Environment, Dublin, May 1982.

#REF UK10 Energy improvement kits
PRINCIPAL RESEARCHER(S)
Dr. A. Hildon
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United Kingdom
Telephone: (021) 356 6911
SPECIFIC OBJECTIVES
To establish methodologies for local authorities intending to (a) identify energy characteristics of, and (b) evolve energy retrofit programmes for, their housing stock.
PROJECT DETAILS
Phase 1: Analysis of deduced energy data. Phase 2: Field trials of energy retrofits to 25 representative dwelling types. All naturally ventilated. "Before" vs "after" pressurization testing.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather. Energy energy signature.
START DATE 01:01:1979
END DATE 31:12:1983
BIBLIOGRAPHY
Reports to sponsor Dept of the Environment
Contact: T. Field, Dept HB7

Hildon, A., et al EIK Int. Congress for Building Energy Management, Pavoa de Varzim, May 1980.

Hildon, A., et al A statistical survey of a large large housing stock, CIB 3rd International Symposium on Energy Conservation in the Built Environment.

Hildon, A., et al Case studies of energy retrofits to typical dwellings, CIB 3rd International Symposium on Energy Conservation in the Built Environment.

#REF UK11 Experiments with a passive ventilation system

PRINCIPAL RESEARCHER(S)

K.A. Johnson (in conjunction with T.R.A.D.A.)

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L40 5UF
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SPECIFIC OBJECTIVES

Test feasability of a simple passive ventilation system for domestic property. Continuation of work reported at 3rd AIC Conference (see reference below).

PROJECT DETAILS

Timber framed house, 2 storey (but applicable to masonry construction also). Natural system using "chimneys" from ridge to kitchen and bathroom, inlets via window slot vents and door vents or just natural infiltration. Heating (temporary) by fan heaters. Measuring flows in "chimneys", i.e. ducts by thermister bead, CO2 concentration reduction and CO2 timed release. Correlating flows with inside/outside temperature difference. Unoccupied building. Also some CO2 decay tests.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

Mainly inside/outside temperature difference, and any other parameters which become appropriate.

START DATE 01:01:1981

END DATE 31:08:1983

APPROX NO MAN HOURS 800

BIBLIOGRAPHY

Johnson, K.A., Pitts, G. Experiments with passive ventilation system.Proceedings 3rd AIC Conference, London, UK, 20-23 September 1982

Johnson, K.A., Pitts, G. Further experiments with a passive ventilation system.Preprint August/September 1983.

#REF UK12 Design of low air speed and air direction instrument using corona discharge.

PRINCIPAL RESEARCHER(S)

A.G. Campbell

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SPECIFIC OBJECTIVES

Characterisation of instrumentation parameters and finally to have dedicated microprocessor system

PROJECT DETAILS

Use of corona discharge to pick up electrodes in quadrature. Pick up voltage directed to multiplexer and to 1502 microprocessor.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

Air speed, air direction

START DATE 01:10:1981

END DATE on-going

APPROX NO MAN HOURS 200

#REF UK13 Air infiltration through building entrances

PRINCIPAL RESEARCHER(S)

S. Macloughlin

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SPECIFIC OBJECTIVES

Review the mechanisms of infiltration and the results of others who have tried to establish the relationship between infiltration and traffic rate through various forms of building entrance.

PROJECT DETAILS

Field tests were carried out in the School of Civil Engineering, University of Liverpool. The measured infiltration rate due to the use of entrance doors was compared with that predicted by theory and the work of others. It is a 7-storey reinforced concrete framed building with brick and glass block infill panels. The foyer, where the tests were carried out, had no mechanical ventilation and was heated by oil-fired central heating system. Measurements of internal and external temperatures, pressure difference across entrance, traffic and wind speed were made. It is an occupied building. The concentration of CO2 was measured and its rate of decay calculated.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

Wind speed, traffic (rate and pattern), temperature difference and pressure difference were correlated with air change rate. The infiltration component due to the passage of real people through doors was established.

START DATE 12:01:1983

END DATE 22:04:1983

#REF UK14 Leakage and frictional characteristics of Kleeneze Superseal

PRINCIPAL RESEARCHER(S)

A.F. Railton and R.S. Clough (Supervisor: P.W. Fitt)

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Queen's Building
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Telex: 444174

SPECIFIC OBJECTIVES

To establish the relationship between mechanical resistance to motion and sealing quality of typical brush strip seals

PROJECT DETAILS

A third stage undergraduate project is under way in which a range of straight brush strip seals will be investigated to determine how their sealing quality varies with interference with a range of surface materials. Sealing qualities tested using an airtight box with a metered air supply. Over the same spectrum of interferances and surfaces, the mechanical force required to move the strip linearly, laterally and rotationally will be investigated.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

(as above)

START DATE 01:10:1982

END DATE 30:04:1983

#REF UK15 CO2 infiltration control

PRINCIPAL RESEARCHER(S)

(not known)

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Telephone: (01) 486 4222

SPECIFIC OBJECTIVES
Study of CO2 infiltration control
PROJECT DETAILS
7000 m2 office building for the National Farmers Union in Stratford-upon-Avon. Building to be completed early in 1984. Monitoring planned, but not yet funded.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 16:06:1978
END DATE on-going
BIBLIOGRAPHY
(not known)

#REF UK16 Radon in buildings - assessment of exposure, models and remedy.
PRINCIPAL RESEARCHER(S)
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OX11 ORQ
United Kingdom
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Telex: 837124
SPECIFIC OBJECTIVES
To assess the mean and general distribution of exposures to radon decay products in the UK, to identify areas and circumstances in which high exposures occur, to study the properties of a building and the methods of building that affect exposures, to develop models for the ingress of radon produced in the ground to dwellings and to study the effectiveness of methods of limiting radon decay product levels in indoor air.
PROJECT DETAILS
(1) A postal survey of about 2000 UK homes selected in a representative way will be completed by the end of 1984. The living area and bedroom of each home is monitored with passive integrating devices for a whole year. Participants are asked to complete a questionnaire the answers to which will be used to interpret the measurement results. (2) Surveys are being carried out in homes and workplaces in regions where above average radon levels might be expected. Measurements are made of radon and radon decay product concentrations and ventilation rates using nitrous oxide as a tracer gas. Passive monitors measure the long term average radon concentration. (3) Measurements of radioactivity of building materials and radon exhalation from them are being made in the laboratory. (4) Models are being developed for the ingress of radon from the ground. These will be tested experimentally in the laboratory and in the field. (5) A study of the effectiveness of methods of reducing radon decay product concentrations will be undertaken in a home with above average levels.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Radon gas and decay product concentrations, building materials and construction, weather conditions, local geology, window and door opening habits of occupants
START DATE 01:01:1980
END DATE 31:12:1984
BIBLIOGRAPHY
Brown, L., Cliff, K.D., Wrixon, A.D. Natural radiation exposure indoors.Rad. Prot. Bull., Vol.41, pp9-13, July 1981.

Miles, J.C.H., Driscoll, C.M.H. Passive monitoring of radon-222 and gama-ray exposures in houses.ibid, Vol.42, pp14-19, September 1981

Brown, L., Driscoll, C.M.H., Green, B.M.R., Miles, J.C.H. Pilot study for natural radiation survey, ibid, Vol.52, pp16-20, May 1983

O'Riordan, M.C., Wrixon, A.D., Cliff, K.D., Green, B.M.R. Natural radiation indoors: The problem of high exposures. Proc. of International Symposium on the Dose Limitation System in the Nuclear Fuel Cycle and in Radiation Protection., Madrid, 19-23 October 1981

Cliff, K.D., Wrixon, A.D., Green, B.M.R., Miles, J.C.H. Radon daughter exposures in the UK. Health Physics (in press)

O'Riordan, M.C., James, A.C., Rae, S., Wrixon, A.D. Human exposure to radon decay products inside dwellings in the United Kingdom NRPB R-152 (1983)

#REF UK17 The factors effecting the control of the environment in houses (with special reference to insulation and condensation)
PRINCIPAL RESEARCHER(S)
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Telex: 778951 PCT LIB
SPECIFIC OBJECTIVES
To investigate the impact of recently developed energy conservation measures and produce a clear set of rules for their cost effective and safe application.
PROJECT DETAILS
Dwelling and laboratory tests using varying types of construction with various heating, ventilating and energy conservation regimes in both occupied and unoccupied buildings. Comparison of this with data previously recorded and some form of computer simulation.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, performance of a structure, behaviour of occupants, method of usage of houses and their environment.
START DATE 01:10:1982
END DATE 30:09:1985
APPROX NO MAN HOURS 2000/year
BIBLIOGRAPHY
(not applicable)

#REF UK18 Three-dimensional computations of air flows in buildings.
PRINCIPAL RESEARCHER(S)
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United Kingdom
Telephone: Epsom 26140 ex 2868
Telex: 266701
SPECIFIC OBJECTIVES
To develop and calibrate reliable computer programs to enable parametric and sensitivity studies to be undertaken on air infiltration and ventilation of buildings.
PROJECT DETAILS
This project is part of a study for the IEA Technical Annex (4) concerning the flow patterns and ventilation of a floor area within a multi-storey building with particular emphasis on prediction of "thermal zones" for comparison with measurements or intuition.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature of walls and windows and effect on flow and temperature patterns caused by positions of internal obstacles.
START DATE 01:05:1983
END DATE 01:10:1983
APPROX NO MAN HOURS 200
BIBLIOGRAPHY
Broyd, T.W., Dean, R.B., Moult, A., Oldfield, S.G. The use of a computational method to assess the safety and quality of ventilation in industrial buildings. Heat and Fluid Flow in Nuclear and Process Plant Safety, Conf. I. Mech. E., C97/83, p65, 1983

#REF UK19 Measurements and computations of air flows in clean rooms
PRINCIPAL RESEARCHER(S)
Dr. D.M. Deaves
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United Kingdom
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SPECIFIC OBJECTIVES
To gain an insight into the nature of clean room flows and to compare predictions with full scale measurements.
PROJECT DETAILS
Measurements were taken of the air flows within a newly installed vertical flow recirculating clean room facility. Air flow measurements were taken, using both vane and hot-wire anemometry, in various flow configurations affected by the presence of obstacles and heat sources. Temperature and concentrations were also taken, the latter in order to assess the dispersion from a simulated particle source.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air speed, obstruction size, heat source, concentration source.
START DATE 17:12:1982
END DATE 31:03:1983
APPROX NO MAN HOURS 350
BIBLIOGRAPHY
Broyd, T.W., Oldfield, S.G. The use of computational modelling techniques for clean room designs. Symposium on Modern Clean Room Technology, Lane End, Bucks., UK, October 1982.

Deaves, D.M., Broyd, T.W., Oldfield, S.G. The use of computational modelling techniques for clean room design. Semicon Europa, Zurich, March 1983.

Broyd, T.W., Dean, R.B., Moult, A., Oldfield, S.G. Safe ventilation of industrial buildings. Int. Conf. on Heat and Fluid Flow in Nuclear and Process Plant Safety, London, May 1983.

#REF UK20 Air and smoke movement in buildings
PRINCIPAL RESEARCHER(S)
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Marlborough House
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United Kingdom
Telephone: (0727) 59111
Telex: 889072
SPECIFIC OBJECTIVES
Development of computer-based models for predicting smoke movement through buildings.
PROJECT DETAILS
This project is concerned with the detailed simulation of air and smoke movement through buildings. The programs take account of wind, stack, mechanical ventilation, and local effects due to the fire itself. Leakage characteristics of building components are fed in as data. The programs can cater for any building from single family dwellings to large commercial premises. The program uses a nodal representation of the flow network and uses a Newton-Raphson iterative technique to solve the flow rates and pressures. The program has been validated against output from similar programs and against known details of a hospital fire at Wythenshawe, near Manchester.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind surface pressures, temperature differences.
START DATE 01:06:1977
END DATE on-going
BIBLIOGRAPHY
Irving, S.J. The computer simulation of smoke movement during building fires.Fire Prevention Science and Technology, No.22, December 1979, pp3-8

Irving, S.J., Wilson, A.P. Validation of smoke movement program.Building Services Engineering Research and Technology, Vol.2 No.4, 1981, pp151-159

#REF UK21 Thermal performance of houses
PRINCIPAL RESEARCHER(S)
Dr D C Spooner
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Telex: 848352
SPECIFIC OBJECTIVES
Measurements of heat losses, heat gains and energy balance in an intermittently heated, high thermal capacity house.
PROJECT DETAILS
The house is well insulated and heated twice each day to 20 degrees C (nominal). Instrumentation enables heat losses through walls, floor and roof to be compared with energy input. Originally the house was sealed but recently tests with automatic door and window opening were completed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Door and window opening regime, temperature difference and local weather records.
START DATE 01:01:1979
END DATE 31:12:1983
BIBLIOGRAPHY
Spooner, D.C. Preliminary measurements of heat losses from an unoccupied house.CIBS Congress, Oslo, June 1980

Spooner, D.C. Heat loss measurements through an insulated domestic ground floor.Building Services Engineering Research & Technology, Vol.3, No.4,1982

#REF UK22 Ventilation in industrial buildings
PRINCIPAL RESEARCHER(S)
Dr J R Waters

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SPECIFIC OBJECTIVES
To measure the air exchange rate within large single-cell buildings, as well as exchange to the outside, and to develop a theory which will enable their exchanges to be expressed in terms of single parameters.
PROJECT DETAILS
This project is a continuation of a pilot study with the same titles. Experience gained in the pilot study is being used to design and build a new tracer dilution measurement system which will then be used in a range of buildings up to 10,000 m3 internal volume. Multi-point sampling will allow the determination of internal air movement patterns. A theoretical model will be developed to enable designers to relate air exchange rates to energy conservation and indoor air quality requirements.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Volume of building, position of major openings, position and type of emitters, position of extract grilles.
START DATE 01:09:1983
END DATE 31:08:1986
APPROX NO MAN HOURS 10,000
BIBLIOGRAPHY
Papers are in preparation for publication in Autumn 1983 and Spring 1984.

#REF UK23 Ventilation of animal houses
PRINCIPAL RESEARCHER(S)
Dr. C.M. Wathes
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University of Bristol
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United Kingdom
Telephone: CHURCHILL 852581
SPECIFIC OBJECTIVES
To measure local ventilation rates in animal houses using N2O as a tracer gas
PROJECT DETAILS
Measurements of local ventilation rates in a mechanically ventilated animal house will be made using the constant rate of emission method with N2O as the tracer gas.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:10:1983
END DATE 31:10:1986
APPROX NO MAN HOURS 3 man years

#REF UK24 Environmental response of flexible structures
PRINCIPAL RESEARCHER(S)
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School of Architecture and Building Science
University of Bath
Claverton Down
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United Kingdom
Telephone: (0225) 61244
SPECIFIC OBJECTIVES
To measure the temperature and air movement patterns throughout the year.
PROJECT DETAILS
Temperature and air velocity gradients have been measured throughout a 1500m3 airhouse during winter through to summer. The results suggest that lowlevel air heating with means for recovering heat from high level are important. Solar heating in summer necessitates skin air jets to collect the heat for use with a heat pump.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:05:1980
END DATE 31:01:1984
APPROX NO MAN HOURS 40
BIBLIOGRAPHY
Articles in preparation

#REF UK25 A study of domestic background leakage paths through the development of a portable pressurization test rig.
PRINCIPAL RESEARCHER(S)
I.C. Ward
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United Kingdom
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SPECIFIC OBJECTIVES
The aim of this project is to develop and validate a field testing facility for quantifying background leakage paths in buildings.
PROJECT DETAILS
The work will be carried out by firstly undertaking a laboratory study of flow characteristics of non-standard cracks (typified by very low height to length ratios). Once a range of portable testing boxes has been proved in the laboratory, they will be evaluated against cracks found between component joins in Local Authority housing to establish repeatability and spread.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:10:1983 (SERC funded)
END DATE 31:10:1986
APPROX NO MAN HOURS 6600
BIBLIOGRAPHY
Ward, I.C. Experiences in air infiltration measurements in domestic dwellings.Presented at 4th AIC Conference, Elm, Switzerland, September 1983

#REF UK26 Infiltration evaluation in an 18-storey, naturally ventilated building.
PRINCIPAL RESEARCHER(S)
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United Kingdom
Telephone: (0742) 78555 ex 4712
SPECIFIC OBJECTIVES
To obtain experimental data on air exchanges due to wind forces and stack effect and to advance the modelling of these phenomena.
PROJECT DETAILS
1. Measurements in buildings. (a) Type and size - an 18-storey, naturally ventilated, occupied, educational building of 47,305m3 volume, mostly office accommodation. (b) Measurements taken - N2O tracer, fan pressurization of components, inside/outside pressure differences, inside/outside and vertical temperatures. (c) Instrumentation details - N2O by gas analyser, pressures by strain gauge bridge transducers, temperatures by thermocouples. (2) Theoretical and model calculations. (a) Comparing results with existing infiltration models.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind velocity and direction, inside/outside and vertical temperature difference, measured component infiltration rates.
START DATE 01:01:1981
END DATE 30:06:1984
BIBLIOGRAPHY
Ward, I.C., Sharples, S. An investigation of the infiltration characteristics of windows and doors in a tall building using pressurization techniques. Internal Report BS 68, Dept of Building Science, Sheffield University.

#REF UK27 The development of a predictive model for air movement and heat distribution in factories.
PRINCIPAL RESEARCHER(S)
Prof. P. O'Sullivan and Dr. P.J. Jones
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SPECIFIC OBJECTIVES
To develop from existing techniques for modelling fluid flow, a model for predicting air flow patterns in large single- volume spaces. To validate the model with 'real' building data. To this end a number of factories will be monitored.
PROJECT DETAILS
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Air movement, stratification, system/building designs.
START DATE 01:11:1983
END DATE 31:10:1986
APPROX NO MAN HOURS 54 man months

#REF UK28 Energy conservation within urban renewal of inner city housing.
PRINCIPAL RESEARCHER(S)
Dr. A. Hildon
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United Kingdom
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SPECIFIC OBJECTIVES
To demonstrate through a monitored field trial the viability of incorporating energy conservation measures within existing housing rehabilitation programmes.
PROJECT DETAILS
Inner city '1890 - 1920' dwellings, solid wall. A sample of 40 dwellings from a programme of improvements to 200 houses are subject to a 'before' vs 'after' monitoring exercise. Energy and temperature monitoring with biannual pressurization testing and occasional tracer gas measurements.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, energy signature.
START DATE 04:01:1982
END DATE 30:06:1984
BIBLIOGRAPHY
(none yet available)

#REF UK29 The development and application of multi-tracer gas analysis of ventilation and internal air movement.
PRINCIPAL RESEARCHER(S)
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Sheffield City Polytechnic
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S1 1WB
United Kingdom

Telephone: (0742) 20911

(b) Department of Building
UMIST
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Telephone: (061 236) 3311
Telex: 666094
SPECIFIC OBJECTIVES
To improve a multi-tracer gas technique for application to air flow measurements in buildings and hence develop an understanding of ventilation and air movement in buildings.
PROJECT DETAILS
The use of gas chromatography is employed to detect variations of concentration of up to three tracer gases simultaneously. Following the release of particular tracers in particular zones, the ventilation rates of each zone and the air movements between them can be evaluated. The emphasis is placed on rapid sampling and portability of equipment.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind speed and direction, constructional details, internal interconnection.
START DATE 01:03:1983
END DATE 30:06:1984
BIBLIOGRAPHY
I'Anson, S.J., Irwin, C., Howarth, A.T. A multiple tracer gas technique for measuring air flows in houses.3rd International Symposium on Energy Conservation in the Built Environment, Dublin, March 1982

I'Anson, S.J., Irwin, C., Howarth, A.T. Air flow measurement using three tracer gases. Building and Environment, Vol.17, No.4, pp245-252.

Howarth, A.T., Burberry, P.J., Irwin, C., I'Anson, S.J. Ventilation and internal air movements for Summer and Winter conditions.Proceedings 3rd AIC Conference, London, UK, 1982.

#REF UK30 Ventilation in housing.
PRINCIPAL RESEARCHER(S)
P.R. Warren
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Telex: 923220
SPECIFIC OBJECTIVES
To develop and validate simple techniques for assessing the ventilation performance of existing and new housing. To produce guidance on the means for ensuring adequate air quality in dwellings, whilst minimising energy consumption.
PROJECT DETAILS
Available data on housing ventilation and air flow paths through the fabric will be reviewed and extended by further measurements. In order to investigate the way in which air moves between zones within a dwelling, appropriate techniques

will be developed and tested. Simple methods, developed for predicting the flow of air through the external envelope of dwellings, will be improved and extended. Data on pressure distribution in relation to building shape, surroundings and exposure will be obtained from wind tunnel studies. Methods for reducing radon levels will be investigated and current research on indoor air pollutants reviewed to provide a basis for ventilation requirements and ameliorative measures.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:10:1982
END DATE on going

#REF UK31 Ventilation in non-domestic buildings.
PRINCIPAL RESEARCHER(S)
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Telephone: (09273) 74040
Telex: 923220
SPECIFIC OBJECTIVES
To establish ventilation requirements in relation to building type and use. To develop and validate methods for measuring the ventilation and infiltration performance of buildings. To identify the factors which determine the magnitude of natural ventilation and hence to develop procedures for predicting infiltration and natural ventilation.
PROJECT DETAILS
The main emphasis of the experimental programme will continue to be on office buildings. Existing measuring techniques will be modified and new techniques developed to enable ventilation rates and the efficiency of ventilation to be measured in complex buildings. Using these techniques, measurements will be made in typical office buildings. Studies will continue, using theoretical models, wind tunnel studies and full scale experiments to establish the mechanisms of natural ventilation and to combine these into prediction methods. The examination of occupant behaviour, particularly in relation to window opening and of fresh air requirements will continue.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:10:1982
END DATE on going

UNITED STATES OF AMERICA

#REF US1 The Brookhaven house
PRINCIPAL RESEARCHER(S)
R.F. Jones, AIA
ADDRESS
Brookhaven National Laboratory
Upton,
New York 11973
USA
Telephone: (516) 282 2052
SPECIFIC OBJECTIVES
To demonstrate the potential of various combined conservation and solar techniques to lower energy requirements.
PROJECT DETAILS
The Brookhaven House is a demonstration project funded by the US DOE. To test the thermal integrity of the building envelope, various infiltration tests were made and compared. These methods were SF6 gas decay, pressurization with blower door and a new PFT tracer gas method being developed currently at Brookhaven. Extensive infra-red tests were also performed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature, wind, humidity, and with furnace fans off and on. In addition to testing with an air-to-air heat exchanger.
START DATE 01:09:1980
END DATE 31:10:1983
APPROX NO MAN HOURS 200 (on infiltration only)
BIBLIOGRAPHY
Ghaffari, H.T., Jones, R.F. Heating and seasonal performance of the Brookhaven House (BNL 31268) for AS of ISES Conference, Houston, Texas, USA.

#REF US2 Infiltration rates in residential type buildings
PRINCIPAL RESEARCHER(S)
V. Goldschmidt
ADDRESS
School of Mechanical Engineering
Purdue University
West Lafayette
IN 47906
USA
Telephone: (317) 494 2132
Telex: 272 396
SPECIFIC OBJECTIVES
(1) Measurement of infiltration rates in mobile homes. (2) Comparative infiltration rates in residences.
PROJECT DETAILS
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE not stated
END DATE on-going

#REF US3 Building outbreak investigation
PRINCIPAL RESEARCHER(S)
Dr. K. Kriess
ADDRESS
National Jewish Hospital and Research Center
3800 East Colfax
Denver
Colorado 80206
USA
Telephone: (303) 398 1525
SPECIFIC OBJECTIVES
Consultation and epidemiological investigation of complaints that appear building-related.
PROJECT DETAILS
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1979
END DATE on-going
BIBLIOGRAPHY
Kreiss, K. Building-associated epidemics.Indoor Air Quality. Boca Raton. CRC Press Inc., 1983 (in press)

Kreiss, K., Gonzalez, M.G., Conright, K.L., Scheere, A.R. Respiratory irritation due to carpet shampoo: two outbreaks. Environ. Int. 1982, 8 (1-6): pp337-342.

#REF US4 Weather Haven indoor air quality analyses
PRINCIPAL RESEARCHER(S)
Dr. L.A. Scott, D. Hoffman, M.G. Scott.
ADDRESS
Superinsulation Ltd.,
RR3
Box 18
Northfield
Minnesota 55057
USA
Telephone: (507) 662 0155
Monitoring of indoor air quality in demonstration superinsulation home (the Weather Haven). Indoor

air quality analysed for alternative mechanical ventilation levels.
PROJECT DETAILS
Northern States Power and Western Wisconsin Technical Institute are jointly co-operating in the construction, demonstration and monitoring of a super-insulated home. The 1500 square foot wood frame structure will install and monitor the performance of several HVAC systems and air-to-air heat exchangers. Several potential pollutants, e.g. radon, sulfur and nitrite oxides, formaldehyde, etc. will be measured using grab bag samples and passive detectors.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Varying alternative rates of mechanical ventilation. Also the impact of different amounts of building materials on air quality will be tested.
START DATE 01:04:1983
END DATE 01:09:1985
APPROX NO MAN HOURS 200
BIBLIOGRAPHY
Scott, L.A., Scott, M.G. Indoor air pollution in passive structures. Proceedings of 5th National Passive Solar Conference, Amherst, USA, 1980, pp966-964.

Test results and methods: residential air-to-air heat exchangers for maintaining indoor air quality and saving energy. Energy and Environmental Div., Lawrence Berkeley Laboratories, 1980 (LBL 10222)

#REF US5 Indoor moisture effects on structure, comfort, energy consumption and health.
PRINCIPAL RESEARCHER(S)
K.M. Kelly
ADDRESS
Jay-K Independent Lumber Corp.
Box 378
New Hartford
New York 13413
USA
Telephone: (315) 797 1914
SPECIFIC OBJECTIVES
To discover the sources of moisture in buildings, reasons for moisture retention and the problems resulting from it. To refine and enhance a Moisture Problem Check List.
PROJECT DETAILS
Investigation of problems possibly caused by moisture in buildings, with the purpose of defining and preventing them.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE not stated
END DATE on-going
BIBLIOGRAPHY
Indoor moisture effects on structure, comfort, energy consumption and health.Presented at ASHRAE conference, Las Vegas, Nevada, USA, December 1982 Publication by ASHRAE, Atlanta, Georgia, USA, June 1983

#REF US6 Performance of solar classroom at Hamilton College.
PRINCIPAL RESEARCHER(S)
J.W. Ring
ADDRESS
Dept. of Physics
Hamilton College
Clinton
New York 13323
USA
Telephone: (315) 859 7510
SPECIFIC OBJECTIVES
The effect of air infiltration on the performance of the solar classroom
PROJECT DETAILS
(i) Classroom (of 1000 sq.ft.) used for astronomy students and as an experimental building. (ii) Concrete block. (iii) Natural ventilation. (iv) SF6 tracer gas (with pressurization). (v) Miran IR spectrometer. (vi) Occupied only for a few hours each week.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
(a) Weather (temperature, wind and humidity). (b) Performance of passive solar building as a whole.
START DATE 01:01:1983
END DATE 01:04:1984
APPROX NO MAN HOURS 350
BIBLIOGRAPHY
Ring, J.W., Hamilton, A.M. The solar classroom at Hamilton College.Conference Proceedings SERI/TP-245-300, 1979

Ring, J.W. Performance of a solar heated building in upstate New York, USA 1977-1981.Proceedings of Solar World Forum, 1981

Hernandez, T.L., Ring, J.W. Indoor radon fluxes: experimental tests of a two-chamber model. Environment International, Vol.8, pp45-57, 1982

#REF US7 Building ventilation study
PRINCIPAL RESEARCHER(S)
Dr. R.L. Peterson
ADDRESS
Northwest Hydraulic Consultants Inc.
22477 72nd Avenue South
Kent
Washington 98032
USA
Telephone: (206) 872 0218
SPECIFIC OBJECTIVES
(1) Determine the best locations for HVAC air intakes so that self-contamination is minimised. (2) Determine stack height for laboratory fume hood exhaust so that the quality of laboratory supply air is maintained.
PROJECT DETAILS
A 1:192 model of existing and proposed laboratory buildings, nearby terrain and other significant buildings was constructed and positioned in Northwest Hydraulic Consultants' environmental wind tunnel. Gas sampling taps were installed at 70 locations on the buildings and at various ground-level locations. A tracer gas was released from a stack atop the laboratory for various wind directions, wind speeds and stack heights. By measuring dilution factors on the roof, walls and at ground-level, the optimum position for HVAC air intakes and the most suitable stack height were determined.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Exhaust stack height, wind speed, wind direction, air intake location
START DATE 01:02:1982
END DATE 01:04:1982
APPROX NO MAN HOURS 500

#REF US8 Rural biomass fuels and air pollution
PRINCIPAL RESEARCHER(S)
K.R. Smith
ADDRESS
East-West Center
Resource Systems Institute and
Environment and Policy Institute
1777 East-West Road
Honolulu
Hawaii 96848
USA
Telephone: (808) 944 7519
Telex: 743 0331 TEWCH
743 0119 EWCAD
SPECIFIC OBJECTIVES
(1) Determine the extent and cause of air pollution

exposures in village homes of the developing world. (2) Measure their health impacts. (3) Evaluate the efficacy of alternative remedies such as improved fuels, stoves and ventilation. (4) Explore policy options.

PROJECT DETAILS

(a) Ventilation and air quality measurements are being made in a simulated village house at the East-West Center, and in rural field studies of village homes in a number of areas of Asia and the Pacific including India, Nepal, Sri Lanka, Fiji and Thailand (12-80 m3). Measurements include use of CO2 and perfluorcarbon as tracers using both battery-operated and passive detectors. Ventilation is mostly natural although driven by gases from open cooking or heating fires. Construction is wood, thatch, brick, mud or mixtures. (b) Simple equilibrium box models, multiple box models, empirical models.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

(1) Weather and climate (temperature, wind, humidity, prevalence of ground-level air inversions. (2) Performance of alternative ventilation arrangements. (3) Fuel type and quality. (4) Stove design and operation. (5) Housing style. (6) Behaviour of cooks and fire tender. (7) Location of stove. (8) Cultural and socioeconomic parameters.

START DATE 01:12:1980

END DATE 31:12:1985

BIBLIOGRAPHY

Smith, K.R., Aggarwal, A.L., Dave, R.M. Air pollution and rural biomas fuels in developing countries: a pilot village study in India and implications for research and policy. Formerly East-West Resource Systems Institute, Working Papers WP-82-17 and WP-83-2. Accepted for publication in Atmospheric Environment, 1983.

Smith, K.R., Colfer, C. Cooks on the world stage: the forgotten actresses/actors. East-West Resource Systems Institute Working Paper WP-83-5, 1983.

Ramakrishna, J. The health status of rural women in India: an annotated bibliography.East-West Resource Systems Institute, research materials (in press) 1983

Smith, K.R. Village cooks and indoor air pollution: the dark side of small is beautiful, Invited paper given at 76th Annual Meeting of the Air Pollution Control Association, Atlanta, Georgia, USA, June 1983

Smith, K.R., Roumasset, J. The economic implications of air pollution from small-scale biomas combustion. East-West Resource Systems Institute Working Paper (forthcoming)

#REF US9 California indoor air pollution program

PRINCIPAL RESEARCHER(S)

J.J. Wesolowski, Ph.D.

ADDRESS

Air and Industrial Hygiene Laboratory
California Department of Health Services
2151 Berkeley Way
Berkeley
CA 94704
USA
Telephone: (415) 540 2476

SPECIFIC OBJECTIVES

To carry out, promote and co-ordinate research to define the nature and extent of the non-occupational indoor air pollution problem in California.

PROJECT DETAILS

This is a permanent program which will stress environmental measurement during the first few years. State-wide surveys will be made of various pollutants. Epidemiological studies will be carried out and an educational outreach programme will be developed to assist local health departments.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

Health effects, building characteristics, outdoor air quality and indoor sources.

START DATE 01:01:1983

END DATE on-going

BIBLIOGRAPHY

The California Indoor Air Pollution Program (to be submitted to the International Conference on Indoor Air Pollution, Stockholm, Sweden, 1984)

Levels of airborne asbestos fibers in residences with asbestos-containing heating systems. The Stockholm Conference

An overview of indoor air pollution: the California program (to be submitted for publication to the Journal of Environmental Health)

#REF US10 Ventilation and exhaust air requirements for hospitals

PRINCIPAL RESEARCHER(S)

Prof. J.B. Chaddock

ADDRESS

Center for the Study of Energy Conservation
Duke University
Durham
NC 27706
USA
Telephone: (919) 684 2832

SPECIFIC OBJECTIVES

(1) Characterization of hospital ventilation parameters. (2) Experimental evaluation of the effect of reduced toilet exhaust.

PROJECT DETAILS

Review of Codes and Standards on ventilation requirements. Literature review of air quality in hospitals including airborne infection and chemical contaminants. Classification of space with respect to ventilation requirements using Duke University Hospital. Odour-exhaust air rate study using college students as panelists in judging odour intensity.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

Ventilation and exhaust air rates.

START DATE 01:01:1982

END DATE 15:05:1983

APPROX NO MAN HOURS 2000

#REF US11 ASTM Standards and related activities

PRINCIPAL RESEARCHER(S)

H.R. Treschel

ADDRESS

E06.41 on Infiltration Performances
American Society for Testing and Materials (ASTM)
1916 Race Street
Philadelphia
Pennsylvania 19103
USA
Telephone: (215) 299 5400
Telex: 710 670 1037

SPECIFIC OBJECTIVES

Continued development of voluntary consensus standards.

PROJECT DETAILS

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

START DATE not stated

END DATE not stated

BIBLIOGRAPHY

Stroik, J. Building security STP 719, ASTM, 1981

Standard practice for measuring air leakage rate by the tracer dilution method E741, 1980.

Standard practice for measuring air leakage by the fan pressurization method E779, 1981.

Standard method for field measurements of air leakage through installed exterior windows and doors E783, 1981.

#REF US12 Calculate maximum allowable pollutant emissions from clean-burning diesel engine forklift trucks
PRINCIPAL RESEARCHER(S)
J.L. Coggins
ADDRESS
Energy Applications Inc.
Long Reach Village Center
Suite 224
Columbia
Maryland 21045
USA
Telephone: (301) 730 0663
SPECIFIC OBJECTIVES
To determine if the use of diesel powered forklift trucks in ammunition storage magazines would result in potential health problems for US Army personnel
PROJECT DETAILS
A single compartment indoor air quality model for typical ammunition storage magazines was used to estimate carbon monoxide (CO) and nitric oxide (NO) levels inside magazines based on CO and NO emissions from forklift trucks. A Runge-Kutta step-wise forward integration method was used to numerically integrate the first order differential equation describing the air contaminant behaviour.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind speed, ambient temperature, magazine type, diesel engine parameters (fuel rate, CO and NO emissions, load factor), loading or unloading magazines.
START DATE 07:09:1982
END DATE 15:03:1983
APPROX NO MAN HOURS 450
BIBLIOGRAPHY
Statt, T.G., Coggins, J.L. Calculate maximum allowable pollutant emissions from clean-burning diesel engine forklift trucks.Final Technical Report prepared for US Army Mobility Equipment Research and Development Command, Ft. Belvoir, Virginia, by Energy Applications Inc., March 1983

#REF US13 Control of natural ventilation for agricultural buildings
PRINCIPAL RESEARCHER(S)
Louis D. Albright
ADDRESS
Dept. of Agricultural Engineering
Cornell University
Ithaca
NY 14853
USA
Telephone: (607) 256 4535
SPECIFIC OBJECTIVES
Develop a means to control the ventilation rate in a naturally ventilated barn or glasshouse
PROJECT DETAILS
Firstly, a model is being developed to predict ventilation rates due to wind and thermal buoyancy. A computer model to simulate a control system will be tested using the airflow model. The control model will be used to develop a "best" strategy (one which could go into a microprocessor controller).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 10:10:1982
END DATE 31:12:1985
BIBLIOGRAPHY
None yet

#REF US14 Brookhaven air infiltration measurement system (BNL/AIMS)
PRINCIPAL RESEARCHER(S)
Dr R.N. Dietz
ADDRESS
Dept. of Applied Science
Brookhaven National Laboratory
Building 426
Upton
NY 11973
USA
Telephone: (516) 282 3059
Telex: 96 7703
SPECIFIC OBJECTIVES
Employ a perfluorocarbon tracer (PFT) system, for which concentrations in air down to parts in 10**15 can be detected, in the form of a miniature tracer source and sampler for infiltration measurements in buildings.
PROJECT DETAILS
The principal of AIMS is based on the applicable steady-state assumption that the average tracer concentration is equal to the emission rate from the miniature source divided by the air infiltration rate. Extended to a multizone concept, in which a different type of PFT source is used in each zone, allows determination of air exchange rates between zones as well as their individual infiltration rates. Since both the PFT source and passive sampler are about the size of a cigarette, inexpensive and re-usable, the BNL/AIMS is the most effective approach to these measurements in occupied buildings of all sizes.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Some measurements will be performed to determine indoor pollutant scavenging rates in conventional homes and the effectiveness of HVAC systems.
START DATE 01:10:1981
END DATE 30:09:1984
APPROX NO MAN HOURS 3400
BIBLIOGRAPHY
Dietz, R.N., Goodrich, R.W., Cote, E.A. Multichamber air infiltration and exchange rate measurements with a multi-perfluorocarbon passive tracer system. Third International Conference on Indoor Air Quality, Stockholm, Sweden, August 1984.

Dietz, R.N., Cote, E.A. Air infiltration measurements in a home using a convenient perfluorocarbon tracer technique. Informal Report BNL 3079R, May 1982, Environ. Int., Vol.8, pp419-33, 1982

Dietz, R.N. Brookhaven air infiltration measurement system (BNL/AIMS) Manual for field deployment. Informal Report BNL 31544, February 1982

Dietz, R.N., Cote, E.A., Senum, G.I., Weiser, R.F. An inexpensive perfluorocarbon tracer technique for wide-scale infiltration measurements in homes. Informal Report BNL 30032, August 1981.

#REF US15 Indoor concentration of radon daughters
PRINCIPAL RESEARCHER(S)
E.L. Geiger
ADDRESS
Eberline Instrument Corporation
PO Box 2108
Santa Fe
New Mexico 87501
USA
Telephone: (505) 471 3232
Telex: 66 0438 EIC SFE
SPECIFIC OBJECTIVES
(1) Develop continuous monitor for radon daughters.
(2) Work with State and Federal agencies to evaluate indoor radon daughter concentrations.

PROJECT DETAILS
A microcomputer-based instrument has been developed to monitor indoor working level (WL) concentrations of radon daughters. It is being used to monitor homes near uranium production areas of the US southwest.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Radon daughter working levels.
START DATE 01:01:1980
END DATE 31:12:1983
APPROX NO MAN HOURS 4000
BIBLIOGRAPHY
Geiger, E.L. Eberline's new microcomputer-based radon daughter instrument.International Symposium on Indoor Air Pollution, Health and Energy Conservation, Amherst, Massachusetts, October 1981.

#REF US16 Latent loads in low humidity rooms due to moisture
PRINCIPAL RESEARCHER(S)
B.W. Jones
ADDRESS
Department of Mechanical Engineering
Kansas State University
Manhattan
Kansas 66506
USA
Telephone: (913) 532 5610
SPECIFIC OBJECTIVES
Moisture infiltration through openings of various geometries for different temperature, humidity and airflow conditions.
PROJECT DETAILS
Measurements were made in a test chamber (2m wide x 2m high x 4m long) divided by vertical partition in the center in which test openings were placed. One chamber was warm and moist, the other cool and dry. Measurements were made with natural and forced convection at the opening. A theoretical model based on static pressure difference as a function of height was used to correlate the experimental data. The results may be extended to infiltration of substances other than moisture.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Inside and outside air temperature and absolute humidity, net air outflow, opening geometry.
START DATE 01:01:1980
END DATE 30:09:1981 (continuing at low level activity)
APPROX NO MAN HOURS 2800
BIBLIOGRAPHY
Jones, B.W., Beck, B.T., Steele, J.P. Latent loads in low humidity rooms due to moisture.ASHRAE Trans., Part 1, January 1983.

#REF US17 Detection of air infiltration leak sites in residential and commercial structures.
PRINCIPAL RESEARCHER(S)
S. Ryan
ADDRESS
Department of Physics and Astronomy
University of Oklahoma
Norman
Oklahoma 73019
USA
Telephone: (405) 325 3961
SPECIFIC OBJECTIVES
To develop a simple, inexpensive, portable electronic instrument for use in energy audits to detect air infiltration sites by sensing air flow through leaks in the building envelope.
PROJECT DETAILS
An inexpensive, hand-held anemometer has been developed to detect air infiltration sites by sensing air flow through the site induced by a pressure differential created by a small window fan or environmental conditions. The anemometer, which requires no adjustment in normal operation, will detect both influx and efflux of air and used a novel configuration to reject the spurious signals caused by motion of the instrument which render a conventional anemometer useless for air infiltration work. The device is suitable for both the homeowner and professional auditor.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Infiltration velocities of less than 5cm/sec can be detected.
START DATE 01:01:1980
END DATE 31:06:1984
APPROX NO MAN HOURS 2000
BIBLIOGRAPHY
(Patent application pending)

#REF US18 Air pollutants, aero-allergens and airway-obstructive diseases.
PRINCIPAL RESEARCHER(S)
Professor M.D. Lebowitz
ADDRESS
Division of Lung Diseases
University of Arizona Health Sciences Center
Tucson
Arizona 85724
USA
Telephone: (602) 626 6379
SPECIFIC OBJECTIVES
To measure micro-indoor and outdoor, and regional air pollutants, aero-allergens and weather, and relate these to daily respiratory symptoms and peak flow.
PROJECT DETAILS
Houses: brick, wood-stucco, trailers (metal-wood). Ventilation: natural, central forced air (incl. heat pumps (electric), furnaces (gas/electric), refrigeration (electric), evaporative coolers (electric-water)).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Internal and external weather sources (temperature, relative humidity, wind speed/direction, precipitation, barometric pressure).
START DATE 01:12:1976
END DATE 30:06:1984
APPROX NO MAN HOURS 73,500
BIBLIOGRAPHY
Lebowitz, M.D. et al The adverse health effects of biological aerosols, other aerosols, and micro-climate indoors on asthmatics and non-asthmatics. Environ. International 8:375-380, 1982 Lebowitz, M.D. The effects of environmental tobacco smoke exposure and gas stoves on daily peak flow rates in asthmatic and non-asthmatic families. Eur. J. Resp. Dis. (Suppl.), 1983 (in press)

Lebowitz, M.D. et al Daily symptoms related to indoor pollution in adult asthmatics and non-asthmatics. (Abst.) Am. J. Epidemiol., 1983 (in press)

Lebowitz, M.D., Holberg, C., Dodge, R.R. Respiratory effects on populations from low-level exposures to ozone. J. Air. Pollu. Control Assc., 1983 (in press).

Lebowitz, M.D. Indoor air pollution monitoring and epidemiology. J. Air Pollu. Control Assc., 1983 (in press).

Lebowitz, M.D. et al Gas stove usage, CO and TSP and respiratory effects. J. Air Pollu. Control Assc., 1983 (in press).

#REF US19 Exposure to nitrogen dioxide of inner city residents of New York City.
PRINCIPAL RESEARCHER(S)
I.F. Goldstein

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Columbia University
630 West 168th Street
New York
NY 10032
USA
Telephone: (212) 928 7674
SPECIFIC OBJECTIVES
To relate indoor levels of NO2 to combustion and to personal exposure measured by personal monitors.
PROJECT DETAILS
Inner city apartments using gas stoves for cooking. Palmes tubes used in four locations in apartment, kitchen, living room and bedrooms. Psalmes tubes are also placed outdoors.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Eventually, health parameters.
START DATE 01:09:1982
END DATE 31:12:1984
BIBLIOGRAPHY
Goldstein, I.F., Cuzick, J. Daily patterns of asthma in New York City and New Orleans: An epidemiological investigation. Environmental Research, 30, pp211-223, 1983.

#REF US20 Chemical evaluation of indoor air quality
PRINCIPAL RESEARCHER(S)
F.J. Berlandi, PhD, CIH
ADDRESS
Touchstone Environmental Consultants Inc
33 Thompson Street
Winchester
MA 01890
USA
Telephone: (617) 729 8450
SPECIFIC OBJECTIVES
To measure the variability of common indoor air contaminants in homes and buildings. On the basis of chemical measurements, assess the overall air quality acceptability.
PROJECT DETAILS
The project will use current available technology to measure typical contaminants such as asbestos, formaldehyde, chlordane, carbon monoxide and carbon dioxide.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Measurements will be related to medical and physical complaints of the occupants.
START DATE 01:01:1983
END DATE 31:07:1985
APPROX NO MAN HOURS 1000

#REF US21 Yale health and heating survey
PRINCIPAL RESEARCHER(S)
J.A.J. Stolwijk and B.P. Leaderer
ADDRESS
John B Pierce Foundation and Yale University of Medicine
290 Congress Avenue
New Haven
CONN 06519
USA
Telephone: (203) 562 9901
SPECIFIC OBJECTIVES
To assess exposure to the relevant air contaminants associated with indoor sources. Emphasis was placed on emissions from unvented kerosene space heaters.
PROJECT DETAILS
(1) Initial questionnaire to assess sources, building characteristics and health status of 321 households. (2) 12-week field study during which 2-week samples of NO2 were taken in each home. Source, use and health symptoms reported every 2 weeks. (3) 2-week samples of NO2, HCHO, SO2 and infiltration taken in 35 homes with detail, source, use. (4) Continuous monitoring in 14 homes in 3 locations for CO, CO2, NO, NO2, SO2 and infiltration (continuous source method).
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Verification of chamber model results and development of model to assess exposure from kerosene heaters. Verification of infiltration models.
START DATE 01:10:1982
END DATE 06:04:1983
BIBLIOGRAPHY
Leaderer, B.P. Air pollutant emission from unvented kerosene space heaters.Science, 218, pp1113-1115, 10 December 1982

#REF US22 Hospital ventilation requirements research project
PRINCIPAL RESEARCHER(S)
M. Gough, J. Zang
ADDRESS
American Hospital Association
840 North Lake Shore Drive
Chicago
IL 60611
USA
Telephone: (312) 280 6141 or 6145
SPECIFIC OBJECTIVES
To improve indoor air quality in health care facilities while simultaneously increasing their energy efficiency
PROJECT DETAILS
Phase I: Obtain and review currently available data and information regarding indoor air quality in hospitals. Determine research agenda for conducting air quality tests in hospitals. Develop testing protocol and equipment specifications for air quality sampling in hospitals.

Phase II: Will involve on-site air quality sampling in hospitals.

Phase III: Will analyse Phase II data to determine extent to which ventilation requirements can be relaxed in certain functional areas of the hospitals.

Phase IV: Will involve the manipulation of ventilation rates under very close supervision, monitoring and recording changes in energy use and indoor air quality, and developing a set of recommended changes in ventilation rates.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Sources of pollutants, dilution of pollutants, occupancy levels, pressure relationships and/or directional air flows for infection control. Air handler unit equipment performance.
START DATE 01:04:1983
END DATE 30:06:1984 (Phase I)
BIBLIOGRAPHY
Bleckman, J.R. Hospital ventilation requirements update.American Hospital Association, June 1983

Bleckman, J.R. Frequently-cited ventilation codes and standards.American Society for Hospital Engineering, Technical Document 16:5-82, American Hospital Association, May 1982.

#REF US23 The influence of building design and other factors on indoor air quality.
PRINCIPAL RESEARCHER(S)
C.I. Davidson and V. Hartkopf
ADDRESS
Carnegie-Mellon University
Dept of Civil Engineering
Pittsburgh
PA 15213
USA
Telephone: (412) 578 2951

SPECIFIC OBJECTIVES
To determine relationships between factors such as source emissions, air exchange rates and outdoor pollution levels on indoor air quality.
PROJECT DETAILS
Several single family residences in Pittsburgh will be instrumented for measurement of airborne particles, CO, SO2, O3, NOx, formaldehyde and trace organics. Emissions from stoves, furnaces, water heaters and other sources will be measured. Mathematical models relating sources, air exchange rates and indoor airborne concentrations will be developed and tested.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Source emissions, outdoor pollution levels, outdoor weather, opening/ closing of windows and doors, ventilation system parameters.
START DATE 01:01:1983
END DATE 30:06:1984
APPROX NO MAN HOURS 5000
BIBLIOGRAPHY
Manuscripts in preparation.

#REF US24 Monitoring of active/passive solar house.
PRINCIPAL RESEARCHER(S)
V. Hartkopf, V. Loftness and C. Davidson
ADDRESS
Institute of Building Sciences
Carnegie Mellon University
Pittsburgh
PA 15213
USA
Telephone: (412) 578 3716
SPECIFIC OBJECTIVES
Measure systems performance of inhabited passive/active solar home.
PROJECT DETAILS
An intercity experimental house in Pittsburgh, Pa is being monitored to establish: (1) Overall energy performance. (2) Performance of components (active/passive). (3) Inter-relationship to home use. (4) Comparison of actual performance to simulated performance.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, construction, inhabitants.
START DATE 01:09:1982
END DATE 30:06:1984

#REF US25 Air-to-air heat exchanger product development
PRINCIPAL RESEARCHER(S)
Dr L C Hoagland
ADDRESS
Airchange Inc.
30 Pond Park Road
Higham
MA 02043
USA
Telephone: (617) 749 8440
SPECIFIC OBJECTIVES
Develop, manufacture and market a low cost residential air-to-air heat exchanger for energy efficient ventilation
PROJECT DETAILS
Heat exchanger developed and tested is a rotary type with plastic heat wheel matrix. Package includes rotary heat wheel, integral fans and air filters for both exhaust air and fresh air streams. Heat exchange effectiveness is 75
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:08:1980
END DATE not stated
BIBLIOGRAPHY
Product literature and technical notes on energy savings and moisture exchange.

#REF US26 Study of potential energy savings through CO2 sensing automatic ventilation control in the Minnesota State Capital Building
PRINCIPAL RESEARCHER(S)
J.E. Janssen, P.E.
ADDRESS
Honeywell, Inc
TSC
1700 West Highway 36
St Paul
MN 55113
USA
Telephone: (612) 378 4937
SPECIFIC OBJECTIVES
To demonstrate energy saving potential of CO2 controlled ventilation.
PROJECT DETAILS
Measurements of CO2 levels and infiltration rates were made in the Security Department office area of the State Capital Building. A methane tracer was used for infiltration measurements. Results showed that leakage through the outside air dampers provided adequate outside air. Ventilation efficiency was high (approximately 100 'plug flow' which allowed the supply air to sweep contaminated air from the space.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
In this case infiltration was due to leakage from a connecting hallway and was not influenced by weather conditions.
START DATE 01:03:1983
END DATE 15:07:1983
APPROX NO MAN HOURS 125
BIBLIOGRAPHY
Janssen, J.E. Ventilation for control of formaldehyde in mobile homes ASHRAE paper AC83-10 No.5, Vol.89 Pt.1, ASHRAE Trans. 1983

#REF US27 Air infiltration in industrial buildings
PRINCIPAL RESEARCHER(S)
C.F. Sepsy
ADDRESS
Dept. of Mechanical Engineering
Ohio State University
206 West 18th Avenue
Columbus
Ohio 43210
USA
Telephone: (614) 422 6898
SPECIFIC OBJECTIVES
To measure air infiltration in industrial buildings
PROJECT DETAILS
A tracer gas technique was used to determine infiltration rates in several industrial buildings. The tracer gas was SF6. Studies were made with the building empty and the industrial processes shut down. Data was also collected during normal working periods. A mathematical model was developed and verified by field measurements.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind velocity, temperature difference between inside/outside the building as well as exhaust fan operating/non-operating.
START DATE 03:01:1983
END DATE 30:09:1983
APPROX NO MAN HOURS 600
BIBLIOGRAPHY
Air infiltration in residential structures Presented at ASHRAE Semi-Annual Meeting in Philadelphia, USA

#REF US28 Air infiltration modelling.
PRINCIPAL RESEARCHER(S)
M.P. Modera, M. Sherman
ADDRESS
Bldg. 90, Rm. 3074
Lawrence Berkeley Laboratory

Berkeley
CA 94720
USA
Telephone: (415) 486 4678
Telex: 910 366 2039
SPECIFIC OBJECTIVES
1. To model residential air infiltration. 2. To verify and refine the assumptions in the LBL single-zone infiltration model. 3. To extend the single-zone model to a multi-zone model.
PROJECT DETAILS
Single-zone model - compare predictions with measurements made in the Mobile Infiltration Test Unit (MITU) and with predictions made without various simplifying assumptions. Make measurements in MITU of combined natural and system-induced infiltration. Multi-zone model - model problem as in single-zone but including effect of flow resistances between zones within the structure. Make measurements with multiple tracer gases in test structure and in multi-unit residences.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Leakage area (exterior envelope and between zones), wind speed and direction, temperature differences, ventilation and heating systems.
START DATE 01:01:1978
END DATE on-going
BIBLIOGRAPHY
Modera, M.P., Sherman, M.H., Levin, P.A. A detailed examination of the LBL infiltration model using the Mobile Infiltration Test Unit.Presented at ASHRAE Meeting, Washington DC, USA, June 1983

Sherman, M.H., Grimsrud, D.T. A comparison of alternate ventilation strategies.LBL Report LBL-13678, presented at 3rd AIC Conference, September 20-23 1982

(see AIRBASE for earlier reports)

#REF US29 Natural ventilation
PRINCIPAL RESEARCHER(S)
M. Sherman, D. Dickerhoff
ADDRESS
Bldg. 90, Rm. 3074
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley
CA 94720
USA
Telephone: (415) 486 4022
SPECIFIC OBJECTIVES
To study effects of natural ventilation in warm climates and wind-driven infiltration in all climates
PROJECT DETAILS
(a) Measure buildings in hot, humid climates that can make use of natural ventilation for cooling. This involves the use of simplified comfort algorithms. (b) Study usefulness of wind tunnel measurements in the prediction of infiltration for both open and closed window configurations.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind and pressure coefficients/leakage area.
START DATE 01:06:1982
END DATE on-going
BIBLIOGRAPHY
Ashley, S., Sherman, M. Natural ventilation in hot, humid climates.Submitted to ASHRAE

Sherman, M. A simplified model of thermal comfort (draft)

#REF US30 Air leakage in buildings
PRINCIPAL RESEARCHER(S)
M. Sherman, M. Modera
ADDRESS
Bldg. 90, Rm. 3074
Lawrence Berkeley Laboratory
1 Cyclotron Road
Berkeley
CA 94720
USA
Telephone: (415) 486 4022
SPECIFIC OBJECTIVES
To study air leakage through building envelopes
PROJECT DETAILS
(a) Develop instrumentation for measurement of air leakage. Currently developing acoustic version of AC pressurization which will allow simple real-time monitoring of building leakage. (b) Measurement and cataloging of leakage sites within structure. Component leakage measurements and prediction of total leakage therefrom
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Relating component leakage to total measured leakage.
START DATE not stated
END DATE on-going
BIBLIOGRAPHY
Sherman, M., Grimsrud, D., Sonderegger, R.C. Low pressure leakage function of a building.LBL Report No.9161, 1979

Dickerhoff, D., Grimsrud, D.T. Component leakage testing in residential buildings.LBL Report No. 14735, July 1982

Reinholt, C., Sonderegger, R. Component leakage areas in residential buildings.Proceedings of 4th AIC Conference, Elm, Switzerland, 1983

#REF US31 An indoor air quality study of 40 East Tennessee homes
PRINCIPAL RESEARCHER(S)
Dr. A. Hawthorne, et al
ADDRESS
Instrumentation and Measurements Group
Health and Safety Research Division
Oak Ridge National Laboratory
Oak Ridge
Tennessee 37830
USA
Telephone: (615) 574 6246
SPECIFIC OBJECTIVES
For one year, measurements of indoor air pollutants were made in 40 East Tennessee homes. The houses were of various ages with different types of insulation and heating. In 30% of the houses, the annual indoor guideline for radon, 4 pCi/L was exceeded. The mean radon level in houses built on the ridgelines was 4.4 pCi/L, while half of the houses exceeded the indoor ceiling guidelines of 0.1 ppm for formaldehyde on at least one occasion. Over the duration of the study, older houses averaged 0.04 ppm of formaldehyde while houses less than 5 years old averaged 0.08 ppm. The highest concentration of formaldehyde measured was 0.4 ppm. Diurnal and seasonal fluctuations in levels of formaldehyde were as much as twofold and tenfold, respectively. The highest levels of formaldehyde were usually recorded during summer months. The concentration in indoor air of other hydrocarbons was at least tenfold higher than in outdoor air. Gasoline vapors from automobiles and stored gasoline/oil were responsible for most of the persistent, highly volatile hydrocarbons. Carbon monoxide and nitrogen oxides were usually less than 2 and 0.02ppm respectively, except when gas stoves or kerosene space heaters were operating, or when a car was running in the garage. The factor having the most impact on ventilation was operation of the central duct fan of the heating, ventilation and air conditioning system. The mean rate of air

exchange increased from 0.38 to 0.72/h when the duct fan was operated.
PROJECT DETAILS
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE not stated
END DATE not stated
BIBLIOGRAPHY
ORNL/5965 NTIS, Springfield, VA, USA, 1983

#REF US32 Formaldehyde from pressed wood products (PWP)
PRINCIPAL RESEARCHER(S)
F. Brauer
ADDRESS
US Consumer Product Safety Commission
Washington DC 20207
USA
Telephone: (301) 492 6508
SPECIFIC OBJECTIVES
To provide mechanism for predicting effects of PWP leading on indoor formaldehyde levels.
PROJECT DETAILS
Development of characterization technology, secure cross-section of currently sold PWP, develop/refine computer model to predict ACR based on temperature, loading of sources/sinks in 2-compartment model including gypsum walls.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Temperature, PWP loading, sink loading, inter-chamber air change, inside/outside air exchange, emission rate/product.
START DATE 01:01:1980
END DATE 31:12:1985
APPROX NO MAN HOURS 30,000 (direct and under contract)
BIBLIOGRAPHY
Matthews, Formaldehyde measurements from pressed wood products 17th Annual Symposium, Proceedings of International Particleboard/ Composit Materials

#REF US33 Home weatherisation project
PRINCIPAL RESEARCHER(S)
(a) J. Quackenboss and J. Flickinger (b) J.D. Spengler and W. Turner
ADDRESS
(a) University of Wisconsin
Room 102
Preventative Medicine Department
Madison
WI 53706
USA

Telephone: (608) 263 6928

(b) Havard University
Dept of Environmental Science and Physiology
Boston
MA 02115
USA

Telephone: (617) 732 1255
SPECIFIC OBJECTIVES
Document ventilation rates and pollutant levels in 50 homes before and after energy conservation retrofits.
PROJECT DETAILS
50 homes have had fan pressurization tests and tracer decay measurements along with respirable particle and NO2 levels.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Energy consumption, operation habits, sources, before/after retrofits, SF vs perfluorocarbon tracers, LBL model predictions.
START DATE 01:11:1982
END DATE 31:03:1984
APPROX NO MAN HOURS 4 man years
BIBLIOGRAPHY
Turner, W.A., Bearg, D.W. A superinsulated retrofit in Maine: theory and reality. Presented at ACEEE 1982 Summer Study 'Energy Efficiency in Buildings - what works ?', Santa Crus, California.

#REF US34 Properties and dynamics of indoor radon progeny aerosols
PRINCIPAL RESEARCHER(S)
E.A. Martell, PhD
ADDRESS
National Center for Atmospheric Research
PO Box 3000
Boulder
Colorado 80307
USA
Telephone: (303) 494 5151
Telex: 45 694
SPECIFIC OBJECTIVES
To determine the properties of indoor radon progeny aerosols and their synergistic interactions with cigarette smoke.
PROJECT DETAILS
Experimental chamber studies are carried out using radon progeny and thoron progeny - tagged smoke particles and other combustion product particles. The size distributions of radon progeny aerosols are determined using multi-stage impactors, low-level beta-counting, etc. Variations of size distribution vs age and other factors are determined.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
The influence of indoor airborne particle concentration on the attached fraction, the size distribution and other properties.
START DATE 01:07:1980
END DATE on-going
APPROX NO MAN HOURS
BIBLIOGRAPHY
Martell, E.A. Alpha-radiation dose at bronchial bifurcations of smokers from indoor exposure to radon progeny Proc. National Academy of Science, USA, Vol.80, 1285-1289, March 1983

Martell, E.A., Sweder, K.S. The roles of polonium isotopes in the etiology of lung cancer in cigarette smokers and uranium miners. M. Gomez, Ed., AIME, Chapter 61 in Radiation Hazards in Mining, NY, 1981

#REF US35 362-RP Predicting energy losses due to infiltration in refrigerated warehouses
PRINCIPAL RESEARCHER(S)
H.Z. Jackson
ADDRESS
Administrative Building
Georgia Institute of Technology
Atlanta
Georgia 30332
USA
Telephone:
SPECIFIC OBJECTIVES
Phase I - Conduct literature search into the topic of the research and condense findings into a final report. Identify mathematical models for field test verification.
PROJECT DETAILS
This work was sponsored by ASHRAE Technology Dept., 1791 Tullie Circle NE, Atlanta, Georgia 30329, USA.
Telephone: (404) 636 8400
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:04:1983
END DATE 31:10:1983 (Phase I)
APPROX NO MAN HOURS 600

#REF US36 352-RP Analysis of indoor air acceptability data collected in TRC/LBL project on energy conservation.
PRINCIPAL RESEARCHER(S)
Dr. A. Dravnieks
ADDRESS
Institute of Olfactory Science
211 Tampa Street
Park Forest
Illinois 60466
USA
Telephone:
SPECIFIC OBJECTIVES
To correlate and analyse the air acceptability data collected in connection with an energy study carried out earlier.
PROJECT DETAILS
Measured were: overall air acceptability as judged by occupants and visitors, acceptability with respect to odour, odour intensity per butanal scale, odour threshold, concentrations of various pollutants (particulate matter, carbon oxides, nitrogen oxides, etc.), physical factors such as temperature and humidity and actual ventilation rates.

This work was sponsored by ASHRAE Technology Dept., 1791 Tullie Circle NE, Atlanta, Georgia 30329, USA. Telephone: (404) 636 8400.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:06:1982
END DATE 31:1:1983
APPROX NO MAN HOURS
BIBLIOGRAPHY
No. 2774. Analysis of indoor air acceptability data from a public buildings ventilation study. ASHRAE Trans., Vol.70, Pt.2

#REF US37 Air leakage properties of insulation
D. Harrje, G. Dutt and D.Jacobson
ADDRESS
Center for Energy and Environmental Studies
Princeton University
Engineering Quadrangle
Princeton
NJ 08544
USA
Telephone: (609) 452 5190
SPECIFIC OBJECTIVES
To assess the air leakage properties of various types of commonly used insulation both in a laboratory situation and in actual buildings.
PROJECT DETAILS
A laboratory set-up involving a simulated ceiling section is used to measure the air flow passing through the insulation at various induced pressure differences. In the field, homes are pressure tested before and after insulation is blown into walls and/or ceilings and the relative flows at specific pressures are noted. The reduction in air leakage due to the addition of insulation is noted.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:02:1981
END DATE 30:06:1984
APPROX NO MAN HOURS 2000

#REF US38 Dual infiltration reduction experiment
PRINCIPAL RESEARCHER(S)
G.S. Dutt and D. Jacobson
ADDRESS
Center for Energy and Environment Studies
Princeton University
Princeton
NJ 08540
USA
Telephone: (609) 452 4684
SPECIFIC OBJECTIVES
To compare different methods of reduction of pressurization data with tracer gas measurements in order to determine the quickest, most accurate way to assess air infiltration reduction during a specific building tightening activity.
PROJECT DETAILS
Pressurization and tracer gas measurements were obtained before and after retrofit measures for five 900 ft2 attached, single storey apartment units in Eastern Pennsylvania. Comparisons were made between 50 Pa air change rates, 4 Pa flow rates (converted to equivalent leakage areas (ELA)), and tracer gas decay measurements. Additional detailed data of the same type will be collected in the second half of 1983.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, pressurization measurements.
START DATE 01:11:1982
END DATE 30:04:1984
APPROX NO MAN HOURS 1000

#REF US39 Energy use, infiltration and indoor air quality in tight, well insulated residences.
PRINCIPAL RESEARCHER(S)
(a) N. Nagda, (b) D.T. Harrje and (c) B. Karpay
ADDRESS
(a) Geomet
1801 Research Blvd.
Rockville
MD 20850
USA

Telephone: (301) 424 9133

(b) Center for Energy and Environment Studies
Princeton University
Engineering Quadrangle
Princeton
NJ 08544
USA

Telephone: (609) 452 5190

(c) Applied Management Sciences
962 Wayne Avenue
Silver Spring
MD 20910
USA

Telephone: (301) 585 8181
SPECIFIC OBJECTIVES
To evaluate indoor air quality as building tightness is increased, and to evaluate the IAQ benefits of air-to-air heat exchanger use.
PROJECT DETAILS
Two side-by-side houses have been newly built to the tightness typical of houses 10 years old (10 ach at 50 Pa). One has since been retrofitted to 6 ach at 50 Pa. Indoor pollutant levels are being measured in a series of experiments. Envelope tightness over time is checked by pressurization. The two-chamber flow in each building is being monitored by SF6 tracer gas.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather, local infiltration rates, pollution sources and movement through the houses, building tightness.
START DATE 01:07:1982
END DATE 31:08:1984
APPROX NO MAN HOURS 12,500
BIBLIOGRAPHY
Nagda, N.L. et al Study design to related residential energy use, air infiltration and indoor air quality. Paper No. 83-29.3, Proceedings of 76th Annual Meeting of the Air Pollution Control Association, Pittsburg, USA.

#REF US40 Indoor air pollution: an annotated bibliography
PRINCIPAL RESEARCHER(S)
E. Kundidzora
ADDRESS
Bendix Environmental Research
1390 Market Street
Suite 902
San Francisco
CA 94102
USA
Telephone: (415) 861 8484
SPECIFIC OBJECTIVES
A current, annotated bibliography useful to both laymen and scientists interested in indoor air pollution.
PROJECT DETAILS
12-page bibliography printed in March 1983 to be updated periodically.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1982
END DATE ongoing
BIBLIOGRAPHY
Bendix, S., Kundidzora, E. Indoor air pollution: an annotated bibliography March 1983

#REF US41 Comparison of models for residential air infiltration
PRINCIPAL RESEARCHER(S)
V. Goldschmidt
ADDRESS
Herrick Laboratories
Purdue University
West Lafayette
Indiana 47907
USA
Telephone: (317) 494 2130
SPECIFIC OBJECTIVES
Determine which of the current models for air infiltration provide the best correlation with measured data and are most useful in predicting infiltration of given structures
PROJECT DETAILS
Data from various projects are being collected and compared on a point-to-point basis in an attempt to isolate which tendances are being modelled with success and which models are successful in general, while noting the applicability of these models to existing structures.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Varies with model
START DATE 01:05:1983
END DATE 31:01:1984

#REF US42 Expert system for diagnosing air infiltration problems in buildings.
PRINCIPAL RESEARCHER(S)
G. Wolton and J. Barnett
ADDRESS
Thermal Analysis Group
Bldg. 226, Rm. B114
National Bureau of Standards
Washington DC 20234
USA
Telephone: (301) 921 3501
Telex: 89 8493 GARG
SPECIFIC OBJECTIVES
To use the concepts of artificial intelligence to develop an expert system to diagnose air infiltration problems.
PROJECT DETAILS
This project will use the concept of artificial intelligence to develop an expert system to analyse ventilation system designs and air infiltration problems in buildings. It is intended to develop a simple expert system to demonstrate the feasability of these concepts to building applications.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:01:1983
END DATE on-going
APPROX NO MAN HOURS 1 man year
BIBLIOGRAPHY
Technical report on feasability of expert system for diagnosing air infiltration problems in ventilation systems, September 1984

#REF US43 Air infiltration in passive solar buildings
PRINCIPAL RESEARCHER(S)
A.K. Persily
ADDRESS
Building Physics Division
Bldg. 226, Rm. B114
National Bureau of Standards
Washington DC 20234
USA
Telephone: (301) 921 3501
Telex: 89 8493 GARG
SPECIFIC OBJECTIVES
To evaluate the air infiltration characteristics of passive solar dwellings in US demonstration project
PROJECT DETAILS
Air infiltration tests were performed using the tracer container method in about 60 passive solar dwellings. Pressurization tightness tests were also performed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather data, building tightening.
START DATE 01:09:1981
END DATE 31:12:1983
APPROX NO MAN HOURS 1 man year
BIBLIOGRAPHY
Persily, A.K., Grot, R.A. Air infiltration and air tightness in passive solar dwellings. ASME Proceedings of Conference on Passive Solar Design, April 1983.

Persily, A.K. Air infiltration in passive solar dwellings. ASTM Special Publications on Air Infiltration Measurements, April 1983

#REF US44 Air infiltration and ventilation in large buildings.
PRINCIPAL RESEARCHER(S)
ADDRESS
Thermal Analysis Group
Building 226, Room B114
National Bureau of Standards
Washington DC 20234
USA
Telephone: (301) 921 3501
Telex: 89 8493 GARG
SPECIFIC OBJECTIVES
To develop data and measurement techniques useful for analysing air infiltration and ventilation in large buildings.
PROJECT DETAILS
The project developed an automated air infiltration system to measure the air infiltration and ventilation in large buildings. To present data which has been collected on 12 office buildings. Fan pressurization tests have also been used in 7 of those buildings. Research is beginning on developments to determine the ventilation efficiency in office buildings.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Weather data, building tightness, building operation.
START DATE 06:09:80
END DATE on-going
APPROX NO MAN HOURS 2 man-years per year
BIBLIOGRAPHY
Grot, R.A., Hunt, C.M., Harrje, D.T. Automated air infiltration measurements in large buildings Proceedings 1st AIC Conference, Windsor, UK, 1980

Grot, R.A. Air infiltration and ventilation in two large office buildings.ASHRAE Publication, 1984

Hunt, C., Treado, S. Air infiltration in large office buildings.ASHRAE Publication

Grot, R.A., Persily, A.K. Factors that determine air infiltration and ventilation in large buildings. December 1983

#REF US45 Multi-cell thermal modelling for buildings
PRINCIPAL RESEARCHER(S)
G. Wolton
ADDRESS
Thermal Analysis Group
Building 226, Room B114
National Bureau of Standards
Washington DC 20234
USA
Telephone: (301) 921 3501
Telex: 89 8493 GARG
SPECIFIC OBJECTIVES
To develop research thermal anaylsis computer models for analysing multi-cell buildings
PROJECT DETAILS
This project has developed a research computer program (Thermal Analysis Research Program - TARP) to model heat transfer in multi-cell buildings. Part of this program is a multi-cell air flow model based on the simultaneous solution of the pressure-flow equations between the cells. Contaminant + propagation of smoke movement has been added to this model. The air flow part of the program has been implemented as a separate program and it has been demonstrated that this program can be run on the new generation of 16-bit microcomputer with math processor.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:09:1981
END DATE on-going
APPROX NO MAN HOURS 2 man-years per year
BIBLIOGRAPHY
Wolton, G. Thermal Analysis Research Program (TARP) Users' Manual NBSIR Wolton, G. A program for predicting air flow in multi-cell buildings NBSIR

#REF US46 Convection modelling
PRINCIPAL RESEARCHER(S)
R. Grot
ADDRESS
Thermal Analysis Group
Building 226, Room B114
National Bureau of Standards
Washington DC 20234
USA
Telephone: (301) 921 3501
Telex: 89 8493 GARG
SPECIFIC OBJECTIVES
To develop analytical models and small scale experimental models for convection-induced air movement and heat transfer in buildings.
PROJECT DETAILS
Finite difference of computer models will be evaluated to determine their usefulness for simulating convective air movement. These models will be used to predict circulation patterns in rooms in order to evaluate ventilation efficiency, to evaluate the effect of convection in insulation systems and to evaluate surface film coefficiency. Small scale test methods for these phenomena will also be examined.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
START DATE 01:10:1983
END DATE on-going
APPROX NO MAN HOURS 1 man year
BIBLIOGRAPHY
Barnett, J., Wolton, G., Grot, R. Evaluation of convection models for building application September 1984

#REF US47 Diagnostic procedures for verifying the thermal integrity of building envelopes
PRINCIPAL RESEARCHER(S)
R.A. Grot
ADDRESS
Thermal Analysis Group
Building 226, Building B114
National Bureau of Standards
Washington DC 20234
USA
Telephone: (301) 921 3501
Telex: 89 8493 GARG
SPECIFIC OBJECTIVES
To develop in-situ inspection techniques to determine thermal performance of office buildings.
PROJECT DETAILS
Development of such measurement techniques as infra-red thermography, air infiltration measurements using tracer gas, fan pressurization testing of large buildings, component tightness tests and in-situ U-value measurement. Case studies of office buildings to show the usefulness of this technique and to develop test procedure specification are being undertaken. Training programme and material on useful methods will be developed.
PARAMETERS RELATED TO INFILTRATION/AIR QUALITY
Wind speed and direction, internal and external temperature, building operation, building design, building tightness.
START DATE 01:06:1981
END DATE 31:12:1986
APPROX NO MAN HOURS 2.5 man-years per year
BIBLIOGRAPHY
Grot, R.A., Burch, B.M., Silberstein, S.S. Measurement methods for evaluation of thermal integrity of building envelopes NBSIR 82-2605

Grot, R.A., Chong, Y., Persily, A.K., Fong, J.B. Data from NBS thermal intensity tests on eight GSA Federal office buildings NBSIR 83

Chong, Y., Grot, R.A. The assessment of Federal office buildings using infra-red thermography Proceedings of Thermalsense VI, SPIE, 1983

Fong, J.B., Grot, R.A. Heat loss from thermal bridges.Proceedings of Thermalsense VI, SPIE, 1984

Grot. R.A. Measurement systems for in-situ measurement of U-value.ASTM Special publication on heat flow sensors, 1984

Grot, R.A., Persily, A.K. Air infiltration and air tightness tests in eight U.S. office buildings Proceedings 4th AIC Conference, Switzerland, 1983

Persily, A.K., Grot, R.A. Fan pressurization testing of office buildings.ASTM Special publication on air infiltration measurements, April, 1984

Grot, R.A., Persily, A.K. Air infiltration and ventilation in office buildings.ASTM Special publication on air infiltration measurements, April, 1984

YUGOSLAVIA

#REF Y1 Energy saving by improved building characteristics in relation to indoor air quality.

PRINCIPAL RESEARCHER(S)

K. Sega

ADDRESS

Institute for Medical Research and Occupational Health
Mose Pijade 158
POB 291
41000 Zagreb
Yugoslavia
Telephone: (41) 274 911

SPECIFIC OBJECTIVES

Exposure assessment, determination of (a) indoor/outdoor air pollution relationships, (b) air quality in modern office buildings, (c) influence of construction materials in IAQ.

PROJECT DETAILS

(1) Modern office buildings. (2) Concrete, metal, glass, plywood, plastics and textiles. (3) Mechanical ventilation sometimes in combination with natural, district or central heating (gas). (4) TSP, RP, smoke, CO, SO2, NH3, HCHO, phenol. (5) Low volume pumps with fibreglass filters (TSP, smoke) proceeded by cyclone (RP) and determination of mass concentration, wet chemical methods for SO2, NH3, HCHO and phenol, Ecolyzer for CO2. (6) Occupied buildings.

PARAMETERS RELATED TO INFILTRATION/AIR QUALITY

(a) Temperature and humidity outdoors and indoors. (b) Real behaviour of occupants. (c) Sources of pollution.

START DATE 01:09:1982

END DATE 30:06:1984

APPROX NO MAN HOURS 1200

BIBLIOGRAPHY

GEMS Human exposure to carbon monoxide and suspended particulate matter in Zagreb, Yugoslavia EEP/82/33, WHO, Geneva, 1982

Eugas, M., Sega, K., Sisovic, A. Study of personal exposure to airborne respirable particles and carbon monoxide. Environmental Monitoring and Assessment, Vol.17, pp157-170, 1982

Sisovic, A., Eugas, M. Exposure to CO of urban population groups.Poster presented at 6th World Congress on Air Quality, Paris, 1983.

Sega, K. Indoor air quality.Accepted for publication in Arh.hig.rada i toks. (review in Croatian)

Sega, K. Indoor/outdoor relationship for RP, TSP and smoke concentrations in modern office buildings. Paper submitted to IAQ Conference, Stockholm, 1984

Appendix 1 - Contributing Countries

APPENDIX 1 - Contributing Countries

Country	Identification Letters	Number of Replies
Australia	AU	1
Belgium	BE	2
Canada	CA	37
Czechoslovakia	CZ	1
Denmark	DK	4
Finland	FI	4
France	F	1
Germany	DE	8
Hungary	H	1
Italy	IT	2
Japan	J	6
Netherlands	NL	18
New Zealand	NZ	1
Norway	NO	2
Papua New Guinea	PNG	1
Poland	PL	2
South Africa	SA	1
Sweden	SE	10
Switzerland	CH	6
United Kingdom	UK	31
United States of America	US	47
Yugoslavia	Y	1
	Total	187

Appendix 2 - Survey Form

Air Infiltration Centre's Survey Form for

Current Research into Air Infiltration and Related Air Quality Problems in Buildings

For office use only	
££T #REF	Title of project _____
££N CONTACT ££T ££N ADDRESS	Principal researcher _____ Organisation _____ Address _____ Telephone _____ Telex _____
#infodate	Date survey form completed _____ <
££N DESCRIP	**Description of Project** Specific objectives _____
££P <	Project details _____
££P <	Parameters with which infiltration and indoor air quality will be related _____ <
#startdate	Date project began _____
#endate	Expected termination date _____
#time	Estimated number of man hours _____
££N KEYWORDS	_____
££N BIBLIOG	Important reports and publications, both past and future, (titles, authors, publishers, dates of publication)
££A	***Please return completed form to:*** ***The Air Infiltration Centre, Old Bracknell Lane, Bracknell, Berkshire, RG12 4AH, Great Britain.***

Appendix 3 - Index of Principal Researchers

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#REF CA9 Study of health status of residents in homes insulated with urea formaldehyde foam (UFF) before and after remedial measures are undertaken.

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#REF CA10 An infiltration model for a one-storey house based on the Encore- Canada simulation
#REF CA37 Airtightness tests and occupant effects on energy conservation

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#REF CA19 Determination of air leakage characteristics of residences and development of means of reducing air leakage.

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#REF CA8 Radon in housing, commercial and public buildings.

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#REF CA17 Short-circuiting between fresh air intakes and exhausts of buildings as source of indoor air pollution

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#REF CA5 The effect of indoor relative humidity on survival of airborne micro-organisms and the related absenteeism in schools and hospitals.
#REF CA6 Air infiltration in greenhouses

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#REF CA29 Builders' guidelines for controlled ventilation in new houses

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#REF CA13 Seasonal influence and comparison of measurement techniques for radon and radon daughter concentrations in energy efficient homes.

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#REF CA3 Building modification study

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#REF CA33 Alternative approaches to improving the airtightness of existing and new houses.

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#REF CA4 Evaluation of major residential energy conservation retrofits

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#REF CA22 Indoor air pollution and housing technology
#REF CA23 Updating health standards for residential construction.
#REF CA24 Radon gas (Problem Land series of publications)
#REF CA25 Instrumentation for detection of radon at potential building sites.
#REF CA26 Hazardous heating and ventilation conditions in housing.
#REF CA27 Biomethylation of arsenic in preserved wood foundations
#REF CA28 Strategies for healthy residential environments
#REF CA31 Upgrading residential forced air filtration

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#REF CA1 Environment survey of 1106 office, professional and clerical workers
#REF CA2 Building information system

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#REF CA11 Full-scale measurements of air infiltration and ventilation in houses.

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#REF CA14 Pressure pulse infiltration meter

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#REF CA7 Weatherization

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#REF CZ1 Air infiltration in a school building

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#REF DK2 Measurements of ventilation in retrofitted multi-storey houses
#REF DK3 Suspended particulate matter (SPM) in airtightened buildings, human exposure and health effects
#REF DK4 Health and comfort changes among tenants after draught proofing of their flats.

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#REF DE6 Draught problems in air conditioned rooms

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#REF DE3 Demonstration project "Landstuhl": Energy-saving and the use of solar energy within one and two family houses.

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#REF DE7 Air ventilation in buildings
#REF DE4 Comparative measurements of ventilation systems on one-family twinhouses

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#REF H1 Calculation of air circulation by the flow-in-networks method

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#REF J3 Natural ventilation of dwellings
#REF J4 Ventilation design of dwellings concerned with airtightness

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#REF J5 Personal exposure to nitrogen dioxide in ambient air

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#REF J1 Research on airtightness of various types of houses
#REF J2 Validation of several predicting methods of air infiltration using three types of test houses, the airtightness of which are different from each other.

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#REF J6 Air infiltration calculation method in multi-rooms

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#REF NL9 Infiltration rates in dwellings and their effect on radon
#REF NL12 Ventilation in dwellings with sound attenuated ventilation provisions.
#REF NL13 Heat recovery and warm air heating systems in relation to infiltration
#REF NL15 Pressurization tests in dwellings in relation to natural ventilation
#REF NL16 Air leakage of houses

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#REF NL8 Dutch standard for heatloss calculations for buildings

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#REF NL14 Occupants' behaviour and motivation in relation to natural ventilation

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#REF NL7 Short reference year for weatherdata (SRY)

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#REF NO1 Survey of tracer gas in single family houses

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#REF PL1 Air change rates of typical Polish buildings (Silesia) and the influence of specially tight outer walls and windows on infiltration and energy consumption.

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#REF PL2 A method for the removal of exhaust air by means of a central supply air and exhaust air system

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#REF SA1 Cape low energy experimental housing project

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#REF SE10 Influence on the function of a ventilation system according to the leakage of the building.

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#REF SE7 Air infiltration compared to energy consumption in small houses

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#REF SE4 Low energy houses in Skultorp - performance monitoring and evaluation

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#REF SE8 SPARSAM - Energy efficient single family houses

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#REF SE6 Radon from soil - field test of cost effective remedial actions in existing buildings.

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#REF SE5 Microclimate - the influence of wind pressure distribution on air infiltration through building structures.

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#REF SE9 Air pollutants inside dwellings - medical, environmental, hygienic and chemical aspects of air quality.

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#REF SE3 Ventilation (air diffusion) efficiency in dwellings

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#REF SE2 Heat recovery from exhaust air

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#REF SE1 A wind tunnel study of effects of surrounding buildings on wind pressure distributions and ventilation losses for a single family house, detached 1.5 storey houses and 2 storey terrace houses.

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#REF CH3 Radiation dose and effects from radon and its progeny in indoor air.

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#REF CH6 Air leakage measurement methods for the building shell

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#REF CH2 Compact equipment for survey of air renewal (Project CESAR)

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#REF CH1 Real airtightness of residential buildings

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#REF CH4 Indoor pollutants emitted by building materials

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#REF CH5 Energy auditing: evaluation and development of specific audit procedures.

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#REF UK12 Design of low air speed and air direction instrument using corona discharge.

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#REF UK19 Measurements and computations of air flows in clean rooms

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#REF UK24 Environmental response of flexible structures

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#REF UK4 The measurement of air infiltration rates in large enclosures and buildings.

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#REF UK6 Low energy housing: ventilation.

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#REF UK9 Energy efficiency in a new traditional school
#REF UK10 Energy improvement kits
#REF UK28 Energy conservation within urban renewal of inner city housing.

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#REF UK29 The development and application of multi-tracer gas analysis of ventilation and internal air movement.

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#REF UK27 The development of a predictive model for air movement and heat distribution in factories.

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#REF UK25 A study of domestic background leakage paths through the development of a portable pressurization test rig.
#REF UK26 Infiltration evaluation in an 18-storey, naturally ventilated building.

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#REF UK31 Ventilation in non-domestic buildings.

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#REF US36 352-RP Analysis of indoor air acceptability data collected in TRC/LBL project on energy conservation.

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#REF US46 Convection modelling
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#REF US40 Indoor air pollution: an annotated bibliography

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