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Titre: CONTINUOUS AIR RENEWAL MEASUREMENTS IN AN OCCUPIED SOLAR OFFICE BUILDING

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CONTINUOUS AIR RENEWAL MEASUREMENTS IN AN OCCUPIED SOLAR OFFICE BUILDING

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Introduction

The Solar Energy Laboratory LESO is an experimental passive building, caracterised by low thermal losses and high solar gains (1,2).Accounting for this fact, energy balance calculation of its different solar South rooms needs an accurate determination of their air renewal rate.

A Compact Equipment for Survey of Air Renewal (CESAR) has been developed at the Ecole Polytechnique Fédérale de Lausanne (5,6). The device has been designed for simultaneous analysis of up to ten inhabitated rooms, over extended periods of time (days or weeks). Tracer gas techniques has been usedfor this purpose. Three operating modes can be anticipated : the "decay" and the "continuous flow" methods, and more recently the "constant concentration" method (3,4). This last approach shows serious advantages when compared to the others : measurement of air infiltration can be carried through, even in inhabitated rooms. By use of a non toxic tracer gas very low level (< 100 ppm N20), compatibility of the measurements with normal use of the building is achieved.

Air infiltration surveys have been started on the LESO building during 83/84 heating season. Comparison of 2 methods ("decay" and "constant concentration"), applied to 8 different "solar rooms" has been effectuated. First evaluation of user's influence over some particular convective exchange fluxes (mainly infiltration form the rest of the building) has been done.

Description of the apparatus

CESAR device has been designed as a compact and mobile installation for "in situ" measurements (see figure 1). It can be runed under the 3 operating modes mentionned above.

The equipment is composed of 4 main components :

- A monitor micro-computer
- An infrared N_2O/H_2O spectroanalyser
- A 10-channel sampling unit
- A 10-channel injection programmable unit

Data acquisition is made on a magnetic support (floppy disc).Analysis of data is automatically done by micro-computer at the end of the survey. Air infiltration rates and flowrates as well as statistical parameters are displayed after each analysis. (9 - 12).

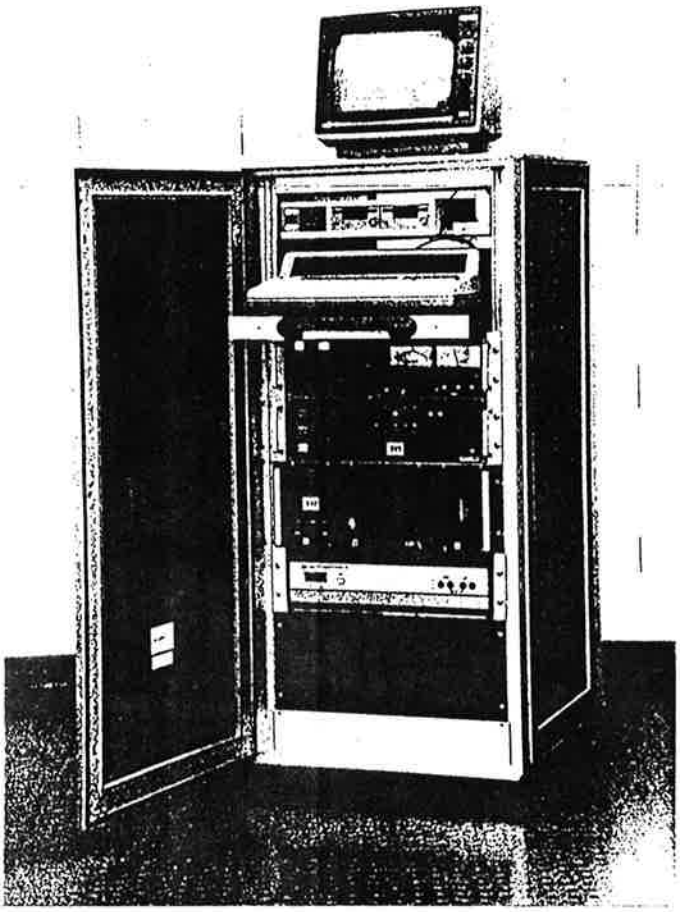


Figure 1 :

View of Compact Equipment for Survey of Air Renewal (CESAR)

Typical air infiltration analysis

In a first step, determination of air change rate in empty rooms is effectuated. "Decay" measurement technique is used for this purpose. Air infiltration analysis in inhabitated rooms is effectuated using the "constant concentration" method. Air change rates, obtained in the first "decay" experiment, are used as input parameters of gas level regulation. N_2O mandatory concentration in the 0 - 200 ppm range is choosen by the operator. Very low tracer gas level insures extended periods of analysis with no disturbances for building inhabitants (8).

Figure 2 : "Constant concentration" analysis effectuated on a LESO solar South room (inhabited room)

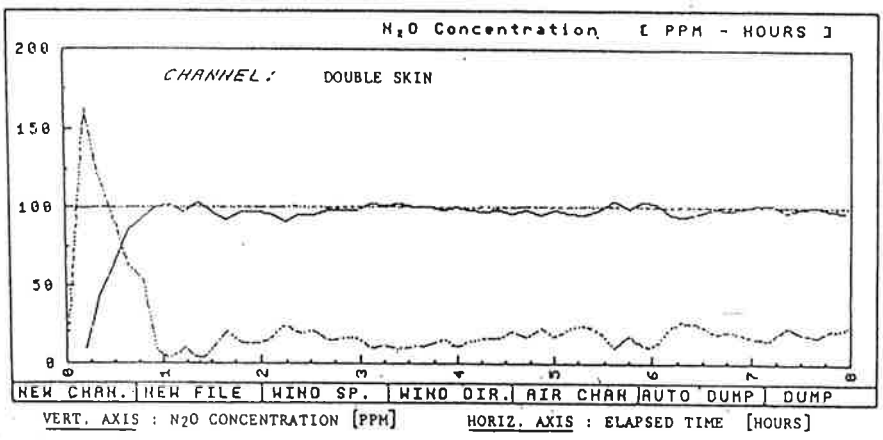


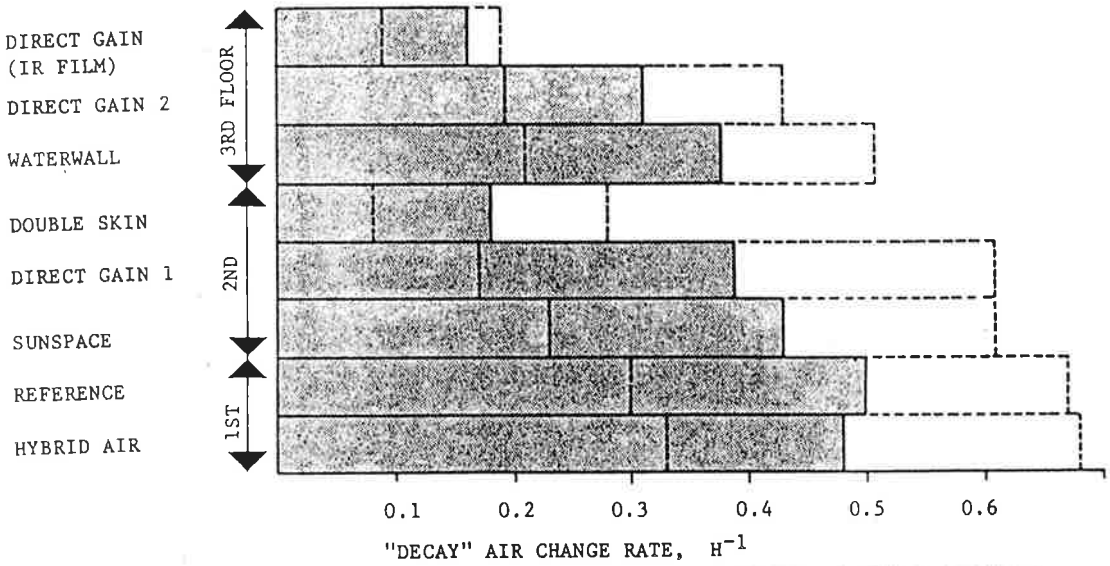
Figure 2 shows a typical "constant concentration" analysis, realised simultaneously over the 8 different LESO solar South rooms. All rooms are inhabited. N_2O concentration level is maintained within a 4 to 8 % interval around choosen mandatory level (100 ppm). N_2O concentration level is shown by a continous curve. Dotted curve shows the N_2O injected flow rate, proportional to air infiltration. (7)

LESO experimental survey

A first air infiltration survey has been done on LESO building during 83/84 heating season. South solar rooms of the building, distributed over 3 floors, have been investigated.

Mean "decay" air change rates have been determinated for the 8 different solar South rooms. Figure 3 shows these measured values obtained over the 1 to 29 February 84 period. Minimal and maximal values over the same period are also reported on the same figure. Name of the passive solar systems, setted up on the South solar room's façade, are reported from bottom to top of vertical axis in the same order they are distributed on the building.

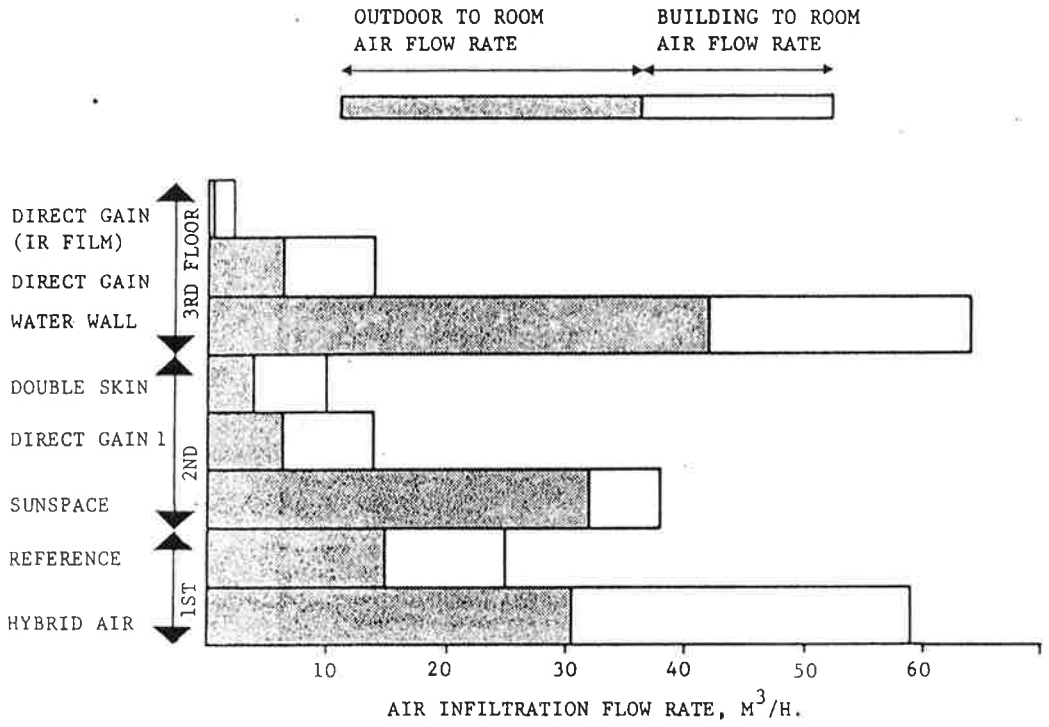
Figure 3 : Minimal, maximal and mean air change rates, measured on the 1 to 29 February 84 period at LESO (Name of the passive system are reported in the same order they are distributed on the floors of the building).



Global infiltration flow rates have been measured simultaneously for every investigated South room using "constant concentration" technique (N_2O constant level is imposed only in the solar rooms). Outdoor to room air infiltration flow rates in every South rooms have been determined, imposing a same N_2O mandatory concentration all over the building (including South rooms and the rest of the building). Mean outdoor to room air infiltration flow rates substracted to mean global infiltration flow rates gives us the mean building to room infiltration flow rates.

Figure 4 shows outdoor to room infiltration fluxes lying within 1 to 40 m^3/h interval. Outdoor to room fluxes are shown in grey. Building to room air fluxes of 5 m^3/h have been measured in empty rooms, for every room having only one communication door with the rest of the building. Same repeated measurements of 84/85 heating season, shows an 11 to 45 % increasing of building to room air fluxes for inhabitated rooms, when compared to empty.

Figure 4 : Outdoor to room and building to room air infiltration flow rates experienced at LESO on the March to end of May 84 period.



Conclusions

- Developed apparatus (CESAR) allows simultaneous air infiltration analysis of up to 10 different rooms, under 3 operating modes.
- "Constant concentration" mode is adequate for purpose of air infiltration measurements in inhabited rooms over extended periods (days or weeks).
- Detail of outdoor to room and building to room air infiltration fluxes can be obtained by this method for every investigated room.
- Mean "decay" air change rates, within the 0.16 to 0.50 h^{-1} range have been experienced for 8 different LESO "solar South rooms".
- Outdoor to room (1 to 40 m^3/h) and building to room (5 m^3/h per door in an empty room) air infiltration flow rates have been measured for the same investigated rooms.
- Increasing building to room air fluxes, within the range of 11 to 45 %, can be expected from inhabitant's influence.

References

(1) A. Faist and al, "The passive solar energy building LESO, a new tool for passive and hybrid systems investigations", Proc. of the 2nd International Congress on Building Energy Management - Ames, Iowa (USA) 30th May - 3rd June 1983.

(2) J.-L. Scartezzini et coll., "Laboratoire d'énergie solaire LESO" Projet NEFF 110, Rapport intermédiaire 83-03-01, GRES-EPFL, Lausanne 1983.

(3) M.Liddament and C. Thompson, "Techniques and instrumentation for the measurement of air infiltration in buildings - a brief review and annotated bibliography , AIC Technical note 10, Bracknell (UK), 1983.

(4) -, "Air infiltration instrumentation and measuring techniques", Proc. of 1st AIC conference, Windsor (UK), 6-8 October 1980.

(5) "CESAR" : Compact Equipment for Survey of Air Renewal", communication to ISO "On-site measurement" meeting, Washington DC, (USA), 4-6 April 1984.

(6) -, "CESAR" : Descriptif de l'installation", rapport interne du GRES-EPFL, Lausanne 1984.

(7) C.-A. Roulet et J.-L. Scartezzini, "Mesure du taux de renouvellement d'air dans la villa Roulet à Apples", Rapport 84-01-10 du GRES-EPFL, Lausanne, novembre 1984.

(8) Sharer and al, "Effects of chronic exposure to nitrous oxyde on Methionine synthase activity", British Journal of Anaesthesia, 55, 693-701, 1983.

(9) P.-F. Collet, "Continuous measurements of air infiltration in occupied dwellings", Proc. of 2nd AIC Conference, Sweden, 21-23 September 1981.

(10) L. Lundin and al, "An automated air infiltration measurement system - its design and capabilities : preliminary experimental results", Proc. of CIB Congress, Stockholm (Sweden), 1983.

(11) P.E. Condon and al, "An automated controlled - flow air infiltration measurement system", Proc. fo Symposium on Air infiltration and Air change rate measurements, ASIM, Washington DC (USA), March 1978.

(12) D.T. Harrje, "Automated instrumentation for air infiltration measurements in buildings", Center of Environmental Studies - Report No 13, Princeton University (USA), April 1975.

SUMMARY

J.-L. Scartezzini, C.Roecker,D. Quévit : Continuous air renewal measurements.
A Compact Equipment for Air Renewal Survey (CESAR) has been developed by the Ecole Polytechnique Fédérale de Lausanne. The device has been designed for simultaneous analysis of up to 10 different inhabitated rooms over extended periods of time (days or weeks). "Constant concentration" tracer gas technique has been used to reach this goal. A first air infiltration survey has been doneat LESO South rooms. Thanks to "constant concentration" method, mean outdoor to room flow rates between 1 an 40 m^3/h have been measured. Building to room air infiltration fluxes of 5 m^3/h have been found, as a mean value, for every room with only one communication door with the rest of the building. Following the 84/85 similar survey, increasing of the building to room air fluxes, within the range of 11 to 45 %, can be expected from inhabitant's influence.

RESUME

J.-L. Scartezzini, C.Roecker, D.Quévit : Continous air renewal measurements.
Un dispositif compact et mobile de mesures de renouvellement d'air (dispositif CESAR) a été développé à l'Ecole Polytechnique Fédérale de Lausanne. L'équipement permet l'analyse simultanée de 10 locaux distincts durant des périodes de mesure pouvant s'étendre à plusieurs semaines. Grâce à l'une des méthodes utilisables sur cet appareil ("concentration constante" de gaz traceur), les mesures peuvent être effectuées en présence d'occupants: Une première campagne de mesure a été effectuée sur 8 "unités solaires" du LESO, durant l'hiver 83/84. Des valeurs moyennes de taux de renouvellement d'air situées entre 0.16 et 0.50 h^{-1} ont été mesurées. A l'aide de la méthode à concentration constante, des valeurs moyennes de flux d'air extérieur, situées entre 1 et 40 m^3/h, ont été déterminées. Un valeur moyenne de 5 m^3/h a été obtenue pour les flux intérieurs (provenant du reste du bâtiment), et pour les "unités" munies d'une seule porte de communication avec le reste du bâtiment. Suite aux mesures semblables de l'hiver 84/85, une augmentation de 11 à 45 %, due à l'effet de l'occupant, a été mesurée pour les flux intérieurs.

KURZFASSUNG

J.-L. Scartezzini, C.Roecker, D.Quévit : Continuous air renewal measurements.
Die Eidgenossische Technische Hochschule - Lausanne hat einen neueun Apparat zur Messung des Luftwechsels entwickelt (CESAR Anlage). Mit dieser Anlage kann man bis zu 10 verschiedene bewohnte Räumen, während mehreren Wochen, analysieren. Man wendet die "Konstant Spurgas Konzentration" Methode an. Eine erste Mess-Reihe wurde während 83/84 Heizungs periode am LESO gemacht. Es wurden mittlere Luftwechsel Werte vom 0.16 bis 0.50 h^{-1} für 8 verschiedene LESO Südenräumen ermittelt. Mittlere äussere Luft-eindringungen, vom 1 m^3/h bis 40 m^3/h konnten dank der "Konstant Konzentration" Methode festgestellt werden. Für den mittlere innere Luftaustausch (mit dem Rest des Gebäudes) wurden Werte von 5 m^3/h gemessen. Diese letzten gemessenen Werte sind nur für Räumen mit einer Türe gültig. Neuere Messungen (1984/85) zeigen eine benutzerabgängige Vergrösserung des inneren Luftaustauschen zwischen 11 und 45 %.