GUIDE FOR RESIDENTIAL INDOOR AIR QUALITY INVESTIGATIONS

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July 1995

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This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the External Research Program (CMHC CR File 6585-V17-2). The views expressed are those of the authors and do not represent the official views of the Corporation.

NOTE: LE RÉSUMÉ EN FRANÇAIS SUIT IMMÉDIATEMENT LE RÉSUMÉ EN ANGLAIS.

DISCLAIMER

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STATEMENT OF PART IX FUNDS

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the Corporation has interests in all aspects of housing and urban growth and development.

Under part IX of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has statutory responsibility to make widely available, information which may be useful in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

ACKNOWLEDGEMENT

The authors wish to thank Jim White, Virginia Salares, Don Fugler, Ray Merrill, and the homeowners who participated in the project, for their contributions.

FORWARD/CAUTION

This guide should be seen as a resource document, and is a first attempt at producing a protocol to help lead an investigator through the steps needed to determine the urgency, extent and severity of reported indoor air quality problems.

The Guide may not be sufficient, on its own to help an investigator, particularly an inexperienced and untrained person, to carry out a competent investigation. Although it provides useful guidance, it should be always supplemented by training. A field investigator should have extensive experience in indoor air quality investigations, a thorough understanding of building science, and some understanding of the health problems and symptoms that could occur in houses with indoor air quality problems.

This and other studies are being used by CMHC in the development of a training course for Indoor Air Quality Investigators. Training is considered essential for all those whose activities involve indoor air quality investigations in housing.

Should you have comments on this Guide please pass them on to Jim White, CMHC, National Office, 700 Montreal Road, OTTAWA, Ont., K1A 0P7 (Fax 613-748-2402) and reference file number CR #6585-V017-2. Your input will be carefully considered during development of a consensus Guide that will be produced under the auspices of ASTM.

NOTE

The complete research report consists of Part I, Short Guide and Reference Guide, and Part II, Summarized Test Results and Detailed Test Results.

Avant-propos

Il faut percevoir le présent Guide comme un document de référence et comme première tentative d'élaboration d'un protocole pour aider l'enquêteur à suivre les étapes nécessaires en vue de déterminer l'urgence, l'étendue et la gravité des problèmes signalés de qualité de l'air intérieur.

Il se peut qu'en lui-même, le Guide ne suffise pas pour aider l'enquêteur à effectuer une enquête compétente, surtout s'il s'agit d'une personne sans expérience ni formation. Même s'il donne d'utiles orientations, le Guide devrait toujours être accompagné d'une période de formation. Un enquêteur sur le terrain devrait avoir beaucoup d'expérience en matière d'enquête sur les problèmes de qualité de l'air intérieur, une connaissance exhaustive des sciences de la construction et une certaine connaissance des problèmes de santé et des symptômes qui peuvent se présenter dans les maisons ayant des problèmes de qualité de l'air intérieur.

La présente étude et d'autres recherches sont utilisées par la SCHL pour élaborer un cours de formation à l'intention des enquêteurs en matière de qualité de l'air intérieur. La formation est considérée essentielle pour toutes les personnes qui s'occupent d'enquêtes sur la qualité de l'air intérieur des habitations.

Si vous avez des commentaires au sujet de ce Guide, veuillez les faire parvenir à Monsieur Jim White, SCHL, Bureau national, 700 chemin de Montréal, Ottawa ON K1A 0P7 (Télécopieur 613-748-2402) et le numéro de dossier étant le 6585-V017-2. Nous tiendrons compte de vos observations au moment de l'élaboration du Guide définitif qui sera produit par ASTM.

Note

Le rapport consiste d'une première partie, soit «un guide abrégé et un guide de référence», et d'une deuxième partie, soit «un résumé des résultats du test et un rapport détaillé des résultats du test».

TABLE OF CONTENTS

List of Tables

List of Figures

List of Flowcharts

Abstract

A Guide for Residential Indoor Air Quality Investigations presents a proposed series of steps that should be followed by trained specialists for identifying and determining the urgency, severity, cause and possible remedial actions needed when a possible indoor air quality problem is reported.

It starts with questions that can be given over the phone to occupants and includes steps, questions, and observations for a field visit and a written report, if considered necessary. The Guide is a useful resource for those considering the causes of indoor air quality problems in residences, and can be used to improve an investigator's understanding of some of the issues and procedures.

1.0 SUMMARY/RESUME

Protocols, Standardized Procedures or Guides are being developed to investigate environmental health complaints in office and highrise buildings, schools and hospitals. These instruments systematize the investigation of air quality complaints, and provide the owner or building manager with the tools he needs to act on and resolve problems. No protocols have been developed to assist in home investigations.

A review of the housing literature indicated that there were many research publications and reports which would provide the home investigator with useful guidance. This information was widely dispersed and difficult to use in a practical manner and the first task was to abstract these articles and determine with the assistance of experts in the field, the types of information and experience that may be of use in the Guide. It was quickly noted that the resulting document may be impractically large and too cumbersome for field use and as a result two documents were developed; one simplified document for field use which is a Short Guide highlighting aspects of the investigation, and a second Reference Guide which parallels the first and provides in depth information when needed.

The next task was to establish a logical investigation strategy for the Guide. Of necessity, the strategy would be limited to general indoor air quality investigations since it would be difficult if not impossible to address the specific practical needs of the many diverse groups such as furnace contractors, hypersensitive individuals, or engineers. The specific protocols required by these groups would be developed at another time and serve to supplement the Reference Guide rather than replace it. In addition, the Guide should be simple enough to be employed as a self help tool by the non-technical user or homeowner.

A stepwise investigation strategy was eventually adopted, following the approach of previous office and highrise protocols, in an effort to reduce costs and improve investigation efficiencies. The five step strategy (Table 1) emphasizes a trial and error approach which relies heavily on observation. Simple non-measurement tests are recommended for the early stages of the investigation and hypotheses are evaluated as these are formed. The objective is to resolve the problem without making expensive measurements, although the procedure still encourages the measurement of simple parameters such as humidity, temperature, air movement, and carbon dioxide: these can greatly assist the investigator. The five step procedure increases in complexity and in expense as one proceeds through the sequence and the intent is to resolve the problem at an early stage to keep costs down.

The First Step reviews the situation over the phone, determines whether an emergency exists, and may follow-up with a visit. If

an emergency does not exist, the investigator will attempt to collect enough additional information over the phone to form a hypothesis and make suggestions (Step Two). The Short Guide can be used to help standardize the interview and to begin a written reference/report for the homeowner (or for later review by the investigator during his walkthrough).

Once the interview is completed the investigator will review the information gathered and try to form a hypothesis. He may suggest possible steps that the homeowner can take to resolve the problem, or proceed to Step Three which is the walkthrough.

In Step Three, the investigator proceeds to the site to verify the information gathered and to review the situation in more detail. The investigator is provided with a list of non-measurement tools to be employed when needed. He may also make a few simple measurements to characterize conditions. Thus practical methods for conducting a chimney safety test, and making in-duct air flow measurements have been included as appendices. Locations for possible chemical, physical or biological measurements are identified during the walkthrough.

There may be an opportunity at this time to do some immediate modifications/tests in an effort to isolate/identify/remediate sources. This is considered to be a normal part of the investigation strategy which goes through cycles of information gathering, hypothesis formation and testing to systematically narrow down the range of possible causes. The investigator must search through clues carefully to solve the problem, realizing that many problems can be handled on site by a person who is familiar with the house as a system.

In Step Four the gathered information is reviewed and possible courses of action established. This procedure may be carried out on site and the occupant given a quick verbal report. A written report will usually follow to formalize the procedure. The route to take at this stage will depend on available resources, the severity of the problem and the probability of resolving the problem. In some cases rather than go on to Step Five and make measurements the occupant will prefer to spend the money on remediation in the hope that the measures adopted will resolve the problem. This may often be the cheaper or more reliable route to take since measurements are often inconclusive anyway and remediation may still have to be done. The building may need obvious work and this is the time to do it.

In the event that the problem remains unresolved the investigator may decide to proceed to Step Five. He and the occupant should be aware of the potential costs involved of making measurements or remediation, and estimates will have been prepared for discussion.

The final Step involves making measurements of physical, chemical and biological parameters. Measurement kits have been defined in the Reference Guide and graded in terms of cost and complexity. The investigator is provided with the background needed to set up an effective sampling program and to make measurements; location, timing, frequency of measurements, measurements to be made, equipment and manufacturers, standards and guidelines for interpreting results, and pertinent facts on sources and equipment summarized to assist in the evaluation of the sources. The investigator is also provided with information on source evaluation, useful air quality relationships are described, and typical remediation recommendations are listed. This information should help resolve technical problems.

Interpretation of measurements is often a difficult process, particularly if the sampling program has not been well defined with later interpretation in mind. The potential effects of single contaminants and mixtures of contaminants on the health of individuals is unclear and the numbers generated by a measurement program may have little meaning even when compared to existing guidelines. Often non-measurement tests, such as when or where the occupant feels better or worse, or where odours occur, are more effective indicators. The investigator will develop these tests as his experience increases.

The Short and Reference Guides were submitted to different experts for evaluation. Suggestions were made: to include an emergency section; to include more information relating to the resolution of non health and safety problems; and, to emphasize non-measurement methods to help reduce costs. The resulting guide is our attempt at incorporating these features. Some detailed technical procedures have been included because they are a good coverage of the practical aspects, and others included because they are indispensable tools. These technical procedures tend to increase the document size, but do not affect the usability because they are included as appendices. Bringing these procedures together in one location should increase the value of the Reference Guide.

The suggestion was made to make the Reference Guide self-contained in nature and, to the best possible extent, we have attempted to do this. The document grew in size as the interests of each individual were incorporated, and, as a result, the Short Guide was developed. The Short Guide is useful as a field tool since it is a point form summary of the Reference Guide. In practice, it was difficult even to follow the order in the Short Guide because of the complexity of most situations and the occupants interest in directing the investigation. In general, however, most relevant aspects of the Reference Guide were eventually covered and some areas were covered more than once. This repetition was not considered to be a problem at the time since it ensures completeness and does not detract from the

thrust of the investigation.

Specialized Guides, following a similar format, will eventually be required for specific situations, but are beyond the scope of this research. In a separate project, a protocol for investigating IAQ problems in the housing of the hypersensitive is also being developed at CMHC.

The ASTM format adopted for the Guide, is a contract requirement and this document will form the basis for a future ASTM Guide. A version was given to members of the ASTM D22 sub-committee on indoor air quality for comments. This final report includes their comments to date.

The Guide was evaluated by investigating four problem houses and the detailed reports for these investigations are included in a separate report (Part II). The test houses were not selected specifically for this study but rather originated as complaints to CMHC and were taken when found. The complaints received however, were typical of those often reported to CMHC.

The problems in three of the four houses were easily identified without any in-depth testing. The exceptional house is being investigated by a contractor and our research was discontinued. The Guide was found to be repetitive and in all cases there was some difficulty in following the stepwise strategy at the test site. The occupants and the layout of the house often affected the sequence of the investigation, but this did not seem to alter the fact that much of the Guide was eventually covered and found useful. The repetition found in the document tended to reinforce earlier observations and helped ensure completeness.

The reported problems were moisture and mould (1), dust (2), moisture and spillage (3), and allergies (4). The evaluation pointed out many problems which required attention and/or pointed out areas which needed improvement.

It was not possible to carry out an in-depth investigation over the phone in any of the cases, and a walk-through the site was necessary before any suggestions could be made. The phone conversation was, however, a useful preparation for the site visit. The investigator was able to evaluate the emergency status of the situation, characterize or review the problem and focus or limit the task. The equipment requirement was easily defined, the occupant was informed of the probable strategy that would be employed, as well as the time involved, and the investigation proceeded quickly or efficiently. The investigator/occupant were both better prepared as a consequence to explain/understand details as the investigation proceeded. The occupant not only had a better understanding of the process, but was able to provide some useful input, and was better able to act on the recommendations. There may be some value in asking the occupant

to complete or review the Short Guide in preparation for the walkthrough to help reduce investigation costs.

With practice and use of the Guide, the investigation became more systematic and refined. The Guide is therefore a significant educational tool and would be of value to most inspectors and homeowners.

«Guide des enquêtes sur la qualité de l'air intérieur des habitations»

1.0 RÉSUMÉ

On élabore actuellement des protocoles, des méthodes standardisées ou des guides pour étudier les plaintes concernant la santé environnementale des occupants des immeubles à bureaux, des tours d'habitation, des écoles et des hôpitaux. Ces instruments systématisent les enquêtes qui font suite aux plaintes touchant la qualité de l'air et donnent au propriétaire ou au gestionnaire de l'immeuble les outils nécessaire pour agir et résoudre les problèmes. Aucun protocole n'a été élaboré pour orienter les enquêtes effectuées dans les maisons.

L'examen des publications sur le logement révèle l'existence de nombreux comptes rendus et rapports de recherche qui offriraient une orientation utile à l'enquêteur sur la qualité de l'air des maisons. Ces renseignements sont très dispersés et difficiles à utiliser en pratique; la première tâche a donc été de résumer ces articles et de déterminer, avec l'aide d'experts en la matière, le genre de renseignements et d'expérience qui pourraient servir à l'élaboration du Guide. Après avoir rapidement constaté que le document ainsi créé pourrait être trop gros et peu pratique sur le terrain, on a préparé deux documents : d'abord un document simple à utiliser sur le terrain, soit un Guide abrégé présentant les principaux points de l'enquête, puis un Guide de référence qui suit le premier et qui donne des renseignements détaillés lorsque le besoin s'en fait sentir.

La deuxième tâche a été d'élaborer une stratégie d'enquête logique en vue de la préparation du Guide. Il a fallu limiter la stratégie aux enquêtes générales sur la qualité de l'air intérieur puisque qu'il serait difficile, voire impossible, de répondre aux besoins pratiques des nombreux et divers groupes d'intéressés tels que les entrepreneurs en chauffage, les personnes hypersensibles à l'environnement, ou les ingénieurs. Les protocoles particuliers nécessaires à ces groupes seraient élaborés plus tard et viendraient s'ajouter au Guide de référence plutôt que le remplacer. En outre, le Guide devait être assez simple pour qu'un utilisateur ou un propriétaire-occupant sans connaissances techniques puisse s'en servir.

Une stratégie d'enquête par étape a éventuellement été adoptée, en suivant la méthode d'élaboration des protocoles d'enquête sur la qualité de l'air des bureaux et des tours d'habitation, afin de diminuer les coûts et d'améliorer l'efficacité des enquêtes. La stratégie en cinq étapes (tableau 1) met l'accent sur une démarche par tâtonnements qui s'appuie principalement sur l'observation. Aux premières étapes de l'enquête, on recommande des essais simples sans mesures et une évaluation des hypothèses au fur et à mesure de leur élaboration. L'objectif est de régler le problème sans se livrer à ces opérations coûteuses de mesure, bien que la méthode encourage quand même la mesure de paramètres simples tels que l'humidité, la température, le déplacement de l'air et le gaz carbonique, mesures qui peuvent être très utiles à l'enquêteur. La méthode à cinq étapes devient plus complexe et plus coûteuse en passant d'une étape à l'autre, et le but visé est de régler le problème aux premières étapes pour limiter les coûts de l'enquête.

La première étape consiste à examiner la situation lors d'un entretien téléphonique afin de déterminer si c'est un cas d'urgence, et l'appel pourra être suivi d'une visite des lieux. S'il ne s'agit pas d'une urgence, l'enquêteur tentera de recueillir assez de détails supplémentaires au téléphone pour pouvoir élaborer des hypothèses et proposer des élément de solutions (deuxième étape). Le Guide abrégé pourra servir à normaliser l'interview et à commencer un rapport écrit à l'intention du propriétaire-occupant (ou en vue d'un examen ultérieur par l'enquêteur au cours de sa visite des lieux).

Une fois l'interview terminé, l'enquêteur examinera l'information recueillie et tentera d'élaborer une hypothèse. Il pourra suggérer au propriétaire certaines mesures à prendre pour régler le problème, ou encore passer à la troisième étape, c'est-à-dire la visite.

À la troisième étape, l'enquêteur se rend sur les lieux pour vérifier les renseignements obtenus et examiner la situation de plus près. L'enquêteur a à sa disposition une liste de méthodes sans mesures, qu'il pourra utiliser au besoin. Il peut aussi effectuer quelques mesures simples pour décrire la situation. C'est pour cette raison que le Guide contient en annexe des méthodes pratiques pour vérifier la sécurité d'une cheminée et pour mesurer le débit d'air dans les conduits. La visite sert aussi à repérer les endroits où se feront d'éventuelles mesures chimiques, physiques ou biologiques.

Cette étape peut être l'occasion d'apporter des modifications ou de procéder à des essais immédiats afin d'isoler, de cerner et/ou de corriger les sources du problème. Ce travail est considéré comme une partie normale de la stratégie d'enquête, qui passe par des cycles de collecte d'information, d'élaboration d'hypothèses et d'essais afin de circonscrire systématiquement l'ampleur des causes possibles du problème. L'enquêteur doit examiner attentivement les indices en vue de régler le problème, en étant conscient que plusieurs problèmes peuvent être réglés directement par une personne connaissant la maison en tant que système.

À la quatrième étape, on examine les renseignements recueillis et on détermine des solutions éventuelles. Cela peut se faire sur les lieux et s'accompagner d'un bref rapport oral à l'occupant. Un rapport écrit suivra habituellement afin de rendre la méthode d'enquête plus officielle. À cette étape, la solution à adopter dépendra des ressources disponibles, de la gravité du problème et de la probabilité de pouvoir le régler. Dans certains cas, plutôt que de passer à la cinquième étape et de procéder à des mesures, l'occupant mettre dépenser son argent à remédier à la situation en espérant que les moyens choisis régleront le problème. C'est souvent la solution la moins coûteuse et la plus fiable puisque souvent, les mesures ne mènent pas à des conclusions sûres, et qu'il faut alors quand même apporter un remède au problème. L'immeuble peut clairement avoir besoin de travaux et c'est maintenant qu'il faut les faire.

Si le problème ne trouve aucune solution, l'enquêteur peut décider de passer à la cinquième étape. L'enquêteur et l'occupant devraient être bien conscients de ce qu'il pourra en coûter pour procéder à des mesures ou remédier aux problèmes, et on préparera des estimations qui seront ensuite examinées.

La dernière étape consiste à mesurer des paramètres physiques, chimiques et biologiques. Le Guide de référence contient la description de trousses de mesure qui ont été cotées selon leur coût et leur complexité. On fournit à l'enquêteur l'information nécessaire pour mettre en place un plan d'enquête efficace et pour procéder aux mesures, soit : l'endroit, le moment et la fréquence des mesures, les mesures à prendre, l'équipement et ses manufacturiers, les normes et directives pour l'interprétation des résultats et le résumé des faits pertinents sur les sources du problème et sur l'équipement afin d'aider à l'évaluation des sources. L'enquêteur a aussi à sa disposition de l'information sur l'évaluation des sources, la description de paramètres utiles de la qualité de l'air, et une liste des solutions couramment recommandées. Ces renseignements devraient aider à régler les problèmes techniques.

L'interprétation des mesures est souvent un processus difficile, surtout si le plan d'enquête a été mal défini sans tenir compte de l'interprétation à venir. Les effets possibles de contaminants individuels et de mélanges de contaminants sur la santé des personnes sont mal connus et les chiffres produits par un programme de mesures peuvent avoir peu de sens même lorsqu'on les compare aux ligne directrices existantes. Souvent, les essais sans mesures, par exemple

déterminer où l'occupant se sent mieux ou moins bien, ou l'endroit où il y a des odeurs, sont des indicateurs plus efficaces. L'enquêteur élaborera ces essais à mesure qu'il acquiert de l'expérience.

Le Guide abrégé et le Guide de référence ont été soumis à l'évaluation de différents experts. Voici certaines de leurs suggestions : inclure un chapitre sur les urgences; inclure plus d'information sur le règlement des problèmes qui ne menacent ni la santé ni la sécurité; et mettre l'accent sur les méthodes sans aucune mesure pour aider à diminuer les coûts. Le présent Guide constitue notre meilleur effort pour suivre ces suggestions. Certaines techniques détaillées ont été incluses parce qu'elles donnent une bonne description des aspects pratiques de telles situations, et d'autres figurent au Guide parce qu'elles sont des outils indispensables. Ces techniques gonflent un peu le document, mais sans en limiter l'utilisation parce qu'elles sont présentées en annexe. Le regroupement de ces techniques sous une même couverture devrait accroître la valeur du Guide de référence.

On nous a suggéré de présenter le Guide de référence sous une seule couverture, et c'est ce que nous avons tenté de faire dans la mesure du possible. Le document a pris du volume lorsque nous avons inclus les sections concernant chacun des intéressés et c'est pour cette raison que nous avons préparé le Guide abrégé. Le Guide abrégé est utile sur le terrain puisqu'il résume point par point le contenu du Guide de référence. En pratique, il a été difficile de suivre le même ordre dans le Guide abrégé à cause de la complexité de la plupart des situations et de l'intérêt des occupants à garder le contrôle de l'enquête. Cependant, les aspects les plus pertinents du Guide de référence ont en général été décrits et certains domaines sont traités plus d'une fois. Cette répétition n'a pas été perçue comme un problème, car elle permet de s'assurer que le Guide est complet et elle ne détourne pas l'attention de l'objectif premier de l'enquête.

Il faudra éventuellement élaborer des guides spécialisés pour des situations particulières en suivant la même présentation, mais ils dépassaient la portée de la présente recherche. Dans le cadre d'un autre projet à la SCHL, on élabore un protocole pour l'étude des problèmes de QAI dans les logements des personnes hypersensibles à l'environnement.

La présentation ASTM adoptée dans le présent Guide était exigée dans le contrat et le présent document servira de base à un Guide ASTM futur. Une version a été soumise à l'examen des membres du sous-comité D22 de l'ASTM sur la qualité de l'air intérieur. Ce rapport final comprend les commentaires que les membres du comité ont fait jusqu'à maintenant.

Le Guide a été évalué en menant enquête dans quatre maisons à problème et les rapports détaillés de ces enquêtes sont incluses dans un rapport distinct (Partie II). Les maisons mises à l'essai n'ont pas été spécifiquement choisies pour cette étude mais plutôt en raison de plaintes reçues par la SCHL, et elles ont été acceptées là où on les a trouvées. Les plaintes reçues étaient cependant typiques des plaintes souvent présentées à la SCHL.

Les problèmes ont facilement été cernés dans trois des quatre maisons sans avoir à procéder à des mesures poussées. La maison faisant exception est en cours d'examen par un entrepreneur, ce qui a mis fin à notre recherche. L'essai a permis de constater que le Guide était répétitif, et dans tous les cas, il a été difficile de suivre la stratégie par étapes sur les lieux. Les occupants et la disposition des maisons ont souvent perturbé le déroulement de l'enquête, mais cela n'a pas semblé changer le fait qu'une grande partie du Guide a été utilisée et qu'il s'est révélé utile. Les répétitions que contient le Guide ont eu tendance à renforcer les premières observations et à aider à ce que l'enquête soit bien complète.

Les problèmes signalés étaient les suivants : humidité et moisissures (1), poussière (2), humidité et déversements (3) et allergies (4). L'évaluation a cerné plusieurs problèmes demandant de l'attention et/ou a signalé des endroits nécessitant des améliorations.

Il n'a pas été possible d'effectuer une enquête en profondeur au téléphone dans un seul de ces cas et il a fallu une visite sur place avant de proposer toute mesure corrective. La conversation téléphonique a cependant été une préparation utile à la visite des lieux. L'enquêteur pouvait évaluer l'urgence de la situation, décrire ou examiner le problème, et concentrer ou limiter les travaux. Il a été facile de définir les besoins de matériel, l'occupant a été informé de la stratégie qui serait probablement utilisée et du temps que le travail prendrait, et l'enquête s'est faite rapidement et efficacement. L'enquêteur et l'occupant étaient ainsi mieux préparés à expliquer et à comprendre les détails de l'enquête pendant son déroulement. L'occupant a non seulement mieux compris le processus mais il a pu fournir des renseignements utiles et il était mieux en mesure d'agir en se fondant sur les recommandations. Il y aurait peut-être une certaine utilité à demander à l'occupant de remplir ou d'examiner le Guide abrégé, en préparation à la visite des lieux, afin d'aider à réduire les coûts de l'enquête.

Avec la pratique et en utilisant le Guide, l'enquête est devenue plus systématique et plus raffinée. Le Guide est donc un bon outil de formation et il serait utile à la plupart des inspecteurs et des propriétaires-occupants.

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2.0 SHORT GUIDE

Refer to the Reference Guide for additional information.
Try to quantify information where possible.

Initial Contact by Phone

File
Date
Location

Identify caller/age/occupancy

Describe problem and any action/results

- Health problem
- House problem
- Outdoor problem
- other

Remediation attempted by occupant

Anyone contacted by occupant for assistance

Assess urgency and document occupant health information

- Describe complaint/magnitude/timing
- Occupant opinion about urgency
- Combustion, gas, biological, chemical odours
- Symptoms severity, duration and suddenness of onset
- Association of odours/locations/symptoms
- Hypersensitivity
- Review of family medical history (short)
- Review of work environment and exposure to sources

Assessment of urgency and need for immediate walkthrough

Dangerous Situation

a n/a

Instruct client to leave and/or reduce hazard

Contact health services

Contact gas/furnace company

Contact family members/responsible person/neighbour

Evaluate need for other professional assistance

Implement

Immediate Visual Inspection to Relieve Danger

a n/a

Emergency equipment needs

Assess hazard ;
CO Level_____,Gas Level_____
Inspect combustion systems

Spillage _____
Gas leaks _____
Venting, chimney and makeup air supply deficiencies;
HDL_____

Check for moisture sources, spills and accumulation; Rh_____%

Chemical and biological hazards;
VOC Level____;Mould_____
Outdoor air sources;
VOC Level____, CO Level_____;
Other

Interview by Phone By Investigator

Additional observations (use Short Guide)

Any tests done by occupant (cleaning, ventilation)

Any odours indoors or outdoors

Recent problems with combustion systems

Excessive moisture, spills

New occupant activities (construction, hobbies)

Outdoor Environment

Note weather

Describe neighbourhood/terrain

Outdoor Source checklist

High road traffic	___	Exhaust from neighbour	
Airport	___	combustion	___
Pollen (plants)	___	dryer	___
Dust	___	Pesticide spraying	___
Smog	___	Near golf course	___
Near stagnant water	___	Near business	
Near polluted		gas station	___
groundwater	___	dry cleaner	___
Near effluent	___	other	___
On problem soil	___	Near industry	___
		smelting	___
Over dumps	___	paper mill	___
Near landfill site	___	other	___
Soil gas	___	Near agriculture	___
Radon hot spots	___	fertilizer	___
Noticeable happenings		pesticide	___
to residents of the area	___	Other	___

Previous use of lot

Describe lot/drainage

Describe house/age/condition

Review building exterior (technology employed, signs of deterioration, damage stains, erosion, leakage, unusual features)

chimney

roof

siding

foundation

backfill

eavestroughs

Vegetation

Driveway

Other

Note that some outdoor measurements may be made for baseline information at this time.

Indoor Environment

Describe house Interior (size, layout, location of appliances, materials employed, unusual features, use of rooms, outside closets, storage of chemicals and materials)

General impression (stuffy, clean, dusty, odorous, humid)

Previous use of house/occupancy

Recent air quality events-renovations, spills

Other

Comment

Occupant Activities and Air Quality

any local exhaust

cooking

hobbies

cleaning

renovations-painting, construction

VOC level____, Rh_____ %, Dust____, Other____

other

Describe crawlspace/basement (as moisture/pollutant source/barrier)

Describe building envelope (technology employed for windows/sealing/insulation/materials employed)

describe envelope;

tightness;
estimate_____; ELA_____
leakage around windows/doors;
flow_____
leakage through cracks/sump/drain;
flow____; odour____; Rh____%
insulation and cold spots; location_____

VOC sources;carpets, building materials, flooring, drapes

level_____
Moisture/radon sources; drains, crawlspace, sump, basement
radon Level_____, Rh Level_____%
Other

Comment

Combustion systems

describe system; age, condition, number, type, size

gas and combustion leaks;
CO level_____; combustion gas_____;fuel gas_____:
venting, chimney and makeup air supply acceptable
safety test_____; depressurization level _____

filter inspection

humidifier connected;
Rh _____%
other

comments

Ventilation/HRV/Air Conditioning/Humidification/Dehumidification

describe system; age, type, model, condition, size

general air quality impression; stuffy, humid, odours
Rh_____%; T (C)_____;CO2_____;flow_____
uncontrolled/controlled

drafts/leaks; smoke pencil_____

air movement and circulation with smoke pencil;
flow_____
stagnant water

filters

depressurization and airflow balance;depressurization_____
flow ___
particulate sources/removal:
particulate level_____
other

Moisture Sources/Condensation

Rh _____%

unvented dryers

unvented bathrooms

humidifiers

unvented cooking

dirt floor crawlspace/damp basement

stored firewood

vegetation

other

comment (look for effects of high humidity)

condensation

potential cold spots

Chemical Sources

odours_____,
level____(qualitative)
chemical type ____

storage areas

use

hobby areas

spills

local exhaust

new materials, furniture, furnishings

other

comments

House Dust Sources

nature _____;
level_____
location (shelves, heating system)

furnace filter

rugs, drapes, hard to clean shelves

other

comment

Air Cleaners

describe; type, age, size, condition

ozone generation;
level____
other

Stored building materials (dust/humidity)

Rh level_____%; particulate level_____

firewood type_____;
quantity_____
construction materials;
type_____; quantity_____
other

Bathrooms

general impression

vented/ventilation

odours;
level_____ (qualitative)
insulation

Rh_____%

condensation/leaks

deterioration

mould/moisture accumulation (toilet, sink, bathtub)

spills

other

comments

Kitchen

general impression

odours;
level____ (qualitative)

venting/ventilation

insulation

condensation/leaks

Rh_____%

moisture/mould (sinks, refrigerator)

deterioration

spills

other

comments

General observations other rooms

general impression;
sources, ventilation, combustion products
living room

bedroom

laundry room

porch

other

Ceilings/attic

general impression

condensation

moisture, leaks

mould

loose insulation

stained ceilings

asphalt shingles

obvious air movement through ceiling fixtures, cracks
(smoke pencil)

Garage/Storage Building

attached

chemicals present

pathways;
flow_____
other

comment

General Review/Summary on Site

Describe/Recommendations

General Review of Chemical/Biological/Physical Measurements

Parameter	ID	Location	Time	Results
CO2				
CO				
NO2				
HUMIDITY				
TEMPERATURE				
AIRFLOW				
PARTICULATES				
RADON				
VOC				
OZONE				
AIR EXCHANGE				
MOULD				
OTHER				

3.0 REFERENCE GUIDE

3.1 Scope

3.1.1 This Guide assists individuals in resolving indoor air quality and comfort problems in residential buildings. The Guide assists in determining the causes of poor indoor air quality, helps define the methods and scope of a particular study, and helps establish the point at which specific professional services are required. It is intended for investigations initiated in response to complaints or perceived problems.

3.1.2 The Guide provides assistance in identifying and resolving residential air quality problems. Residential buildings are enclosed environments where mould, chemical pollutants, particulates, and radon can cause unhealthy or uncomfortable conditions.

3.1.3 The Guide includes a background on pollutant sources and information on instruments and monitoring methods for chemical and biological contaminants, temperature, humidity and air speed.

3.1.4 The Guide also describes or lists a number of simple tools to help in the investigation.

3.1.5 The Guide is intended to formalize many diverse approaches to forensic investigation of ill-defined air quality problems and is not intended to preclude the use of existing methods.

3.1.6 An all-encompassing and precise method for investigating indoor air quality problems is not possible at this time and the proposed strategy must be considered qualitative in nature with the present state of the art

3.1.7 **Caution:** The Guide is a not a tool for personal health diagnosis or a substitute for medical assistance where an expert in environmental medicine may be required.

3.2 Referenced Documents

3.2.1 ASTM Standards

D337 Humidity with a Psychrometer (The Measurement of Wet- and Dry- Bulb Temperatures), Measuring

D1605 Practices for Sampling Atmospheres for Analysis of Gases and Vapours

D1356 Definitions of Terms Relating to Atmospheric Sampling and Analysis

D1357 Standard Practice for Planning the Sampling of the Ambient Atmosphere

D1914	Conversion Units and Factors Relating to Atmospheric Analysis.
D2914	Sulfur Dioxide Content of the Atmosphere (West-Gaeke Method)
D3151	Velocity, Average in a Duct (Pitot Tube Method)
D3162	Carbon Monoxide in the Atmosphere (Continuous Measurement by Nondispersive Infrared Spectrometry)
D3195	Rotameter Calibration
D3249	Standard Practice for General Ambient Air Analyzer Procedures
D3464	Velocity, Average in a Duct Using a Thermal Anemometer
D3608	Nitrogen Oxides (combined) Content in the Atmosphere by the Griess-Saltzman Reaction.
D3670	Determination of Precision and Accuracy of Methods of Committee D-22
D3686	Practice for Sampling Atmospheres to Collect Organic Vapours (Activated Charcoal Tube Adsorption Method)
D3687	Analysis of Organic Vapors Collected by the Activated Charcoal Tube Adsorption Method
D3824	Continuous Measurement of Oxides of Nitrogen in the Ambient or Workplace Atmosphere by the Chemiluminescent Method
D4490	Standard Practice for Measuring the Concentration of Toxic Gases or Vapours using Detector tubes
D4023	Humidity Measurements
D4599	Toxic Gases or Vapours Using Length of Stain Dosimeter, Measuring the Concentration of
D4861	Pesticides and Polychlorinated Biphenyls in Indoor Atmospheres, Sampling and Analysis of
D5014	Standard Test Method for Measurement of Formaldehyde in Indoor Air (Passive Sampler Methodology)
D5110	Calibration of Ozone Monitors and Certification of Ozone Transfer Standards Using Ultraviolet Photometry.
D5197	Formaldehyde and Other Carbonyl Compounds in Air (Active Sampling Methodology),Determination of
D5156	Ozone in Ambient Workplace and Indoor Atmospheres (Ultraviolet Absorption)
D5221	Formaldehyde in Air, Continuous Measurement of
D5280	Evaluation of Performance Characteristics of Air Quality Measurement Methods with Linear Calibration Functions.
D5157	Indoor Air Quality Models, Statistical Evaluation of.
E741	Standard Test Method for Determining Air Leakage by Tracer Dilution
E783	Window leakage test

3.2.2 EPA Standards

Compendium of Methods for the Determination of Air Pollutants in Indoor Air, Report EPA/600/4-90-010

3.3 Terminology

3.3.1 Definitions

For definitions and terms used in this Guide, refer to terminology D1356. For an explanation of units, symbols, and conversion factors, refer to Practice D 1914.

3.3.2 Description of Terms Specific to This Standard

3.3.2.1 **Air exchange rate:** the volume of outdoor air that enters the indoor environment in one hour divided by the volume of the indoor space.

3.3.2.2 **Backdraft:** reversal of airflow direction in a flue or chimney.

3.3.2.3 **Hypersensitive:** individuals with a particularly high sensitivity and reaction to pollutants.

3.3.2.4 **Remediation:** the process by which a problem is corrected

3.3.2.5 **Sinks:** a material; liquid, solid or gas which removes pollutants usually by absorption or chemical reaction.

3.3.2.6 **Sources:** a material, liquid, solid or gas which emits pollutants.

3.3.2.7 **Spillage:** movement of combustion gases into the indoor air because of incomplete removal of exhaust gases by a chimney or flue.

3.3.2.8 **Walkthrough:** process of walking through a house to systematically investigate problems.

3.3.2.9 **Building Envelope:** surfaces enclosing the indoor space and separating it from the outdoors.

3.3.2.10 **Stack/Wind Effect:** building depressurization caused by thermal and wind effects.

3.3.2.11 **Exfiltration/Infiltration:** the movement of air through unintentional openings in the building envelope.

3.3.2.12 **Tight Housing:** housing characterized by low infiltration/exfiltration.

3.3.2.13 **Stressors:** Environmental parameters, such as lighting, noise, vibration, ergonomics and overcrowding, that may result in complaints about air quality, even though these parameters are not related to air quality.

3.3.2.14 **Thermal Comfort;** A state of mind in which a person feels satisfied with the thermal environment. The factors affecting thermal comfort are air temperature, mean radiant temperature, gross air motion and turbulence, relative humidity, activity level, and clothing.

3.4 Summary of Practice

3.4.1 This Guide presents a process of assessment, checking and testing, asking questions, making observations, and gathering and analysing information on sources and the house-as-a-system.

3.4.1.1 The process involves five sequential steps of increasing complexity and cost and relies mainly on observation and analysis rather than measurement. Occupant participation and the avoidance of unnecessary measurements helps reduce costs.

3.4.2 Step One, a phone conversation, is used to document the complaint, the nature and severity of the problem evaluated, and steps taken to protect the client and resolve the problem. An emergency inspection procedure is described.

3.4.2.1 If the situation is not urgent, additional information is systematically gathered on sources and house factors (Step Two) by phone. Some checking and testing by the occupant may be attempted before Step Three.

3.4.3 If a solution is not found, the investigator visits the site to verify the information gathered and investigates in more detail (Step Three). Some remediation may be attempted after a thorough analysis of the data. Some simple measurements (such as humidity, CO or CO2) may be made. Some simple tests may be carried out to evaluate the operation of the ventilation or combustion systems.

3.4.4 The information obtained is analyzed in Step Four, a hypothesis is formed and tested and more complex remediation is attempted. A decision is then made about further investigation which may involve measurements.

3.4.5 Step Five includes chemical, physical or biological testing. It is usually a last resort unless an emergency exists or a contract is developed which specifically directs such testing. The Guide provides information on methods, equipment and on interpretation of such testing.

3.4.5.1 Measurements have been divided into two levels; those which do not require special training and are less expensive (Level One) and those which require the services of an expert (Level Two). A series of test kits have been organized in terms of the complexity of the measurements to be made. A set of tables is provided as sequential checklist for indoor air quality complaints.

3.5 Significance and Use

3.5.1 The health and/or comfort of the homeowner can be affected by poor indoor air quality.

3.5.2 This Guide is intended primarily to assist individuals concerned with resolving indoor air quality problems in residences but may also be of use to the individual who is interested in maintaining a healthy living environment.

3.5.3 A standard methodology for forensic evaluation of indoor air quality problems is not feasible at this time. This Guide presents a logically sequenced strategy which should minimize costs and contains useful background information helpful for identifying causes and possible resolution of indoor air quality problems.

3.6 Background and Tools

3.6.1 **Communication, and courtesy are fundamental tools.**

3.6.2 **Specific pollutant concerns**

Common pollutants, their sources and health effects are introduced in Appendix X4.

3.6.3 **Understand the problem as a system**

The problem to be resolved must be understood as a system with many components (Appendix X5).

3.6.4 **Analysis of indicators, affect and remedy**

Common relationships and solutions to problems are summarized in Appendix X6.

3.6.5 **Flowcharts and visual aids**

The investigator should employ flowcharts, visual aids, checklists (Appendix X7) to systematize the investigation and help reduce oversights. They can be copied, written up on, and used as permanent records or for reporting purposes.

3.6.6 Remediation recommendations

The investigator should be aware of frequently occurring problems and solutions (Appendix X8).

3.6.7 The smell test

Sources are often detectable by smell but the investigator or occupant should frequently leave the house to clear his nose during the investigation. The house should be closed for a brief period before the test to permit pollutants to reach a maximum level. Odours such as auto exhaust, body odour, mustiness, chemical smells, solvents, sewage gas odours are problem indicators.

Caution! Some dangerous pollutants have no odour. Carbon monoxide is one deadly example.

3.6.8 Indicators not based on measurements

Many non-measurement indicators other than odour are useful tools for gauging air quality or for locating sources. Examples are: where and when the occupant feels better; evidence of rotting or deterioration; unsanitary conditions; stains or mould; unusual humidity; condensation or dryness; and, excessive dust.

3.6.9 Chimney safety test procedure

If combustion pollutants are suspected, a standardized combustion systems safety test may be useful (Appendix X1 or (32)). A complete combustion system training course is presented in (21).

3.6.10 Pressure drop test

A micromanometer can be used to measure the pressure drop across the building envelope, or at various points within combustion or ventilation equipment, to provide information on building performance (15,32).

3.6.11 Blower door test

The effective leakage area in a house (house tightness) can be determined following the Canadian General Standards Board Standard, "Determination of the Airtightness of Building Envelopes by the Fan Depressurization Method ", (CAN/CGSB-149.10-M86) or equivalent method (18).

3.6.12 Air exchange test

The rate of air infiltration through cracks and openings (passive or active tracer methods) can be determined by several methods. The AIMS-NAHB passive method is well described in the CMHC publication, "Indoor Air Quality Survey: CMHC IAQ Kit Instructions" (16). An ASTM method (E741) is available. An active tracer method is presented in (Appendix X2) and is derived from (17). A Guide to tracer methods is available from the Air Infiltration and Ventilation Centre (18).

3.6.13 Garbage bag airflow test

This test provides a quick check for air flow into or out of ducts, due to fans and through cracks or openings. The time to inflate or deflate a garbage bag of known volume is determined.

3.6.14 Smoke pencil airflow test

Low airflow rates in a room can be estimated with a smoke pencil by timing the movement of a small cloud of smoke. The smoke pencil can also be employed to evaluate air movement through cracks or openings, between rooms or to evaluate the performance of the combustion and ventilation system (spillage, leakage).

3.6.15 In duct airflow measurements

A thermal anemometer can be used to make in-duct airflow measurements ((Appendix X3), HRV balancing, air circulation)).

3.6.16 Sampling from cracks, openings (sump, drain) or surfaces, and sampling from wall cavities

Some methods for sample collection and measurement from sumps or wall cavities are available. Soil gas entry point containers are described in (19). A modified version of the ASTM in-situ window leakage test is described in (20). Several devices for sampling are described in (26). There may be some advantage to sampling when the building is being depressurized.

3.6.17 Residential Ventilation Guidance

Two publications provide guidance on residential ventilation (30,31).

3.6.18 Short Guide

A Short guide (Section 2.0) is available for field work, to be supplemented by details from the Reference Guide when needed (Section 3.0).

3.6.19 Pollutant measurement guidance/test kits

Guidance is provided on instruments and methods, on making measurements and on interpreting the results (Section 3.7.5). A survey is described in (17), and pollutant measurement methods for microbiological pollutants, VOCs are presented in (28,29) and several other parameters are described (22). A test kit for housing is presented in (16), for office buildings in (23) and for high rise buildings in (24). Many CMHC research publications provide guidance on making measurements. Courses and Workshops are available (27). A house ventilation and air quality reference guide is available (30). A self help guide to identifying and correcting house problems is presented in (33).

Test kits organized in terms of complexity and cost are presented in Table 5 of Section 3.7.5.

3.6.20 Standard equipment

Recommended equipment includes: clipboard; strong flashlight; ladder; face mask (particulates); protective clothing; test kit (CO2 monitor; humidity and temperature monitor); serviceman's mirror; camera with flash; tools (wrench, screwdriver); micromanometer for pressure drop tests (building envelope); smoke pencil for airflow; leakage; or spillage observations; house plan (if available) or drawing; complaint description; and notepad.

3.6.21 Emergency equipment

In emergency situations the following are required: combustion gas meter; CO meter or tubes; spill containment or removal equipment; gas mask (certified for CO and combustion gases); and, a breathable oxygen supply.

3.6.22 Assistance during investigation

An associate, or outside expertise (especially emergencies) may be required and is often desirable.

3.6.23 Reference books, pamphlets

These documents can be used to increase awareness of the homeowner.

3.7.0 The Investigation Method

The investigation method is outlined in Table 1 and a Short Guide is presented in Section 2.0.

3.7.1 Step One; Document and Network the Complaint.

The first steps in the process are to obtain as accurate a description of the complaint as possible, determine whether an emergency exists, and organize effective action.

3.7.1.1 Identify the caller

- Name
- Address and telephone number.
- Location (room, apartment, house, owned/rented, owner details)

3.7.1.2 Describe the Problem and any action/results

The complaint should be described here and if possible classified under the following headings which help focus the enquiry.

- Health related problems (Is the occupants health affected i.e. dizziness, nausea, vomiting?)
- House related problems (Is there a problem with the house i.e. gas or combustion leak?)
- Environment related problems (Does the problem originate from outside the house i.e. fumes, combustion odours?)
- Other problems

3.7.1.3 Remediation attempted

The occupant may have actively attempted to correct the problem. This work should be documented, along with the results obtained to date.

3.7.1.4 Anyone contacted by the occupant for assistance

Any experts, contractors, consultants that have already been used should be identified, along with what was attempted and the results of these efforts. This information should help eliminate

duplication. It may be useful to contact these individuals to clarify/augment information.

3.7.1.5 The nature and urgency of the complaint assessed (by asking key questions and documenting the symptoms/health information of the occupant).

Gas leaks, combustion odours, strong chemical smells and strong allergic reactions are situations where the occupant may be in immediate danger. Such situations usually require prompt action for the health and safety of the occupant. See Section 3.7.1.6 for immediate action and advice. Most other situations do not require an emergency response and can be resolved by less urgent methods (Section 3.7.2).

At this time establish the occupants background, and assess the urgency. Since it may be difficult or impossible to assess the situation with certainty, the investigator is advised to be cautious, to keep an open mind, to inform and/or involve the client in the decision making process and to treat situations where it is difficult to judge the urgency as serious until proven otherwise.

The following key questions/observations provide guidance. The consultant is not limited to any particular sequence. Proceed to the emergency section (3.7.1.6) if the client appears to be disabled:

- Does the occupant feel that the situation is urgent? Ask the caller to describe the problem, its magnitude, any symptoms and timing?

- Are many people affected? When a number of people is involved and there is a sudden onset of symptoms, expressed by the occupant, the problem is serious. The degree of concern will further establish the importance of the symptoms.

- Note whether symptoms are severe, and/or with sudden onset or of long duration; dizziness, impairment or loss of consciousness, vomiting, choking, poisoning, severe allergy. Any of the above indicate urgency.

  Fatigue, eye, nose and throat irritation, headaches, swelling, itching are indicators of irritation and allergy and are probably not life threatening. Note whether the symptoms and/or odours can be associated with a specific location in the house.

  The timing of symptoms (recent, ongoing, recurrent, morning night), location where affected (home, outside, at work, in transit, sports), when worst (spring, fall, heating season,

fireplace on) provide important clues to the nature and seriousness of the problem.

- If the purpose of the call is a complaint about combustion and gas odours (choking, suffocating, rotten egg smell), chemical odours (paint, cleaners, perfumes, new house) or biological symptoms (mould, slime, musty, stuffy, heavy smells) gauge the severity of the problem (odours, duration, intensity). Is there a need for immediate action?

- Define whether there are any unusual or parallel events which may have a strong influence on air quality: floods; spills; hobbies; noises; local construction; new furniture; new carpeting; indoor/outdoor chemical spills; renovations and painting; pest spraying; and/or furnace or ventilation problems. List these and ask the caller to assess his degree of concern.

- The occupant may be sensitive or sensitized (*hypersensitive) to air pollutants if: he or his family suffer from a health problem (allergies, heart problems, asthma, eye/nose/throat irritation, coughing, headaches); the occupant works near sources (solvents, chemicals, copy machines, animals); the occupant is uncomfortable at work (hot/cold, humid/dry, smoky, dusty, drafty); or is suffering from psychosocial conditions (work stress, uncomfortable work environment). List any infectious or respiratory illness, allergies or chemical sensitivities and determine the clients degree of concern.

  As a conclusion assess the urgency and the need for an immediate action and/or walkthrough.

3.7.1.6 The Dangerous Situation

This section is applicable if the situation is urgent. It may not be applicable in other situations.

Combustion and gas leaks, overexposure to a chemical or hypersensitivity, are infrequent but potentially-dangerous situations.

If the client is able to take action he should be instructed to immediately eliminate sources of flame, to contact the furnace company, and/or fuel supplier, or to remove the offending chemicals from the house and to ventilate. He would normally be advised to leave the house to avoid additional exposure.

An appropriate authority should be called in for assistance at this time, particularly for gas or combustion leaks.

If the client is incoherent or unable to proceed, the consultant

should immediately contact an emergency service and have him evacuated. Family members or a neighbour should be contacted and may be able to help.

Inform the landlord of the problem; if the dwelling is owner-occupied, notify the gas or furnace company of leaks and the degree of urgency involved.

Consider including other experts in the investigation, then proceed to the site.

3.7.1.7 Immediate Visual Inspection (Special Step Three)

This section may be applicable if the situation is urgent. Otherwise it is not applicable.

The house and location must be quickly examined for sources or equipment malfunction and the contributing factor identified. Visual observation, smell, breathing or eye discomfort, and common sense checking and testing should provide enough clues to gauge the type and size of the pollutant sources present.

The investigator is advised to proceed with caution since toxic materials may be present. Carbon monoxide can be deadly and has no smell! Some combustion pollutants, gases, and chemicals have characteristic odours which may indicate the presence of danger. The consultant's exposure should be minimized by ventilation and/or through use of a respirator (a combustion gas meter or a CO indicator should be employed if possible).

Fuel odours/combustion odours (pungent, choking or suffocating) and soot, creosote, or smoke in the living space are evidence of spillage and leakage of combustion gases or fuels.

In general look for pathways, and points of entry of combustion gases into and through the house directly from the appliance or from the flue/chimney. A smoke tube can be employed to locate leaks. Take photographs and record observations as the investigation proceeds.

Check to determine that all combustion systems including space heaters, stoves, and water heaters have adequate combustion and makeup air supplies and be properly vented. The chimney must be unobstructed and undamaged as verified by checking indoors and outdoors (a strong flashlight and mirror are helpful). Major spillage is often a result of a blocked chimney.

Check for moisture sources, spills and accumulation of water.

Check for strong chemical and/or biological sources which may also be affecting the health of the occupant. Strong chemical and biological sources often have characteristic odours (except for

carbon monoxide and radon) which can provide a valuable clue to the nature and location of the source. Radon, of course provides no short term health symptoms, only lung cancer due to long term exposure.

Pay particular attention to smoking, mouldy odours/high humidity levels, strong chemical smells from solvents, cleaners, new carpets or furnishings, paints and renovations and excessive dustiness.

Also pay particular attention to high outdoor pollutant levels or events such as spills, recent construction, use of pesticides/ fertilizers.

3.7.2 Step Two; Develop Background by Phone: Proceed to Collect Information by Phone if the Situation is Not Urgent

As much information as possible should be collected by phone before the first site visit to minimize costs. The Short Guide may be employed to focus the interview.

Obvious problems may often be identified and simple remediation suggested without the need for a site visit.

It is difficult to communicate effectively over the phone, and many clients are non technical. As a consequence the investigator usually must limit the interview to simple questions and simple suggestions.

3.7.2.1 Method

- Clarify the occupants view of the problem and document any attempts that have been made to remediate. The occupant is very familiar with his house and the neighbourhood and can often detect even subtle problems.

- Expand as much as possible on the background developed in Step One. Follow the guidance provided there and/or the Short Guide. Repeat questions if necessary since a new perspective may result.

- If the occupant appears willing to participate in the investigation then systematically walk him through the house and neighbourhood.

- Describe simple checks and tests that he can do: remove possible sources such as paints, cleaning materials, carpets, and pets; ventilate by opening windows; testing chimneys for spillage; correcting water leaks and removing moisture sources; measuring humidity levels; cleaning spills, dusty areas, and mould; and, eliminate smoking. Do

the tests provide any further insight and suggest solutions to the problem?

- Determine whether any similar problems have been identified in the neighbourhood and what was done.

3.7.2.2 Analysis

Step Two concludes by evaluating the information gathered, forming and testing a hypothesis, making referrals where necessary, reporting to the client, and planning for Step Three.

Some simple checks, tests, and remediation may have been attempted at this stage.

The investigator should be familiar with typical sources and house systems and guidance is provided in appendices X1 to X8.

3.7.3 Step Three; Walkthrough

This Step is the first visit by the investigator, to verify the data obtained from the occupant, and to inspect in more depth.

The Step will help identify sources in the neighbourhood, pathways to and through the building envelope, indoor sources and/or faulty mechanical systems.

Establish the time and probable duration of the site visit. Indicate that there may be the possibility of a return visit.

Plan everything carefully to minimize any disturbance of the occupant. Determine the equipment and background material needs (neighbourhood maps, house drawings, occupant file and previous history/use of house). A Short Guide is provided for field use (The Reference Guide would then be employed as a reference document).

Professional advice may be sought at this stage. The gas company can check for gas leaks or evaluate the furnace. The construction company or a building inspector can provide information on specific construction details and the building code. A consultant can do an energy efficiency test and check for moisture problems or help with aspects of the inspection.

The occupant may be encouraged to assist. Many aspects/questions may have been overlooked and he may be able to provide immediate background and feedback as the investigation proceeds.

Particular attention should be paid to the three most significant sources of air quality problems; mould, combustion systems and ventilation.

3.7.3.1 The Outside Environment

The investigator should familiarize himself with the neighbourhood, the local climate, and the building exterior prior to entry into the house. The outdoor environment may be a source of pollutants, the climate may direct pollutants from local sources to the house and the building envelope may be leaky. Employ a camera to record problem areas.

Map out potential pollutant sources in the neighbourhood and expand on the information through discussions with neighbours, former owners and the occupant (a checklist is provided for convenience in the Short Guide).

Note the position of neighbouring sources with respect to the house and the prevailing wind. The neighbour/former owner can provide information on the previous history of the house or lot and the neighbourhood, any accidents, fires, floods, or chemical spills.

The house may be located on or near a landfill site or boggy area (methane gas), on contaminated soil (previous gas station), and on or near a radon hotspot. Location near effluents, stagnant water, or polluted groundwater can result in microbiological contamination.

Dust and combustion gas levels may be elevated during nearby construction periods, and during high local road or airport traffic.

Many industries such as smelting or paper manufacturing, businesses such as gas stations and dry cleaners, and pesticide or fertilizer use on nearby farms or lawns can contaminate air, water and soil with heavy metal, complex organic and inorganic pollutants.

The neighbours combustion exhaust systems, dryer exhaust and garden activities are sources of pollutants such as CO, pesticides, and fertilizers.

Note the weather conditions and estimate their potential effect on the indoor pollutant load. Is the current weather typical of the period? Stagnant air, thermal inversions and the local microclimate (temperature, wind speed and direction or weather pattern) may result in pollutant buildup and migration to the house from a distant location.

Winds and low winter temperatures can depressurize the house and increase the infiltration of pollutants. Is the house exposed to direct sunlight and wind? Note that increased infiltration may influence pollutant levels and, as a result, measurements should be made with care.

Describe the house including type, age, condition, and location of garage. The investigator should familiarize himself with the exterior aspects of the building. The roof, and siding should be examined for leakage, deterioration, stains, and quality of construction, the foundation for cracks, sealing and the quality of backfill, the eavestroughs should be positioned away from the foundation, and the surrounding land should be well drained with drainage away from the house, not towards it.

Inspect the chimney for deterioration, damage, staining, signs of leakage or efflorescence and blockage. The chimney should extend well above the roof to improve draft and to reduce the danger of backdrafting. The chimney should be properly capped (A-vent or B-vent) to minimize wind effects.

All exhausts should be located away from air intakes to prevent re-entrainment.

The nature and location of vegetation should be assessed since it can raise indoor pollen, dust or humidity levels or cause foundation damage with subsequent penetration of moisture and pollutants. Vegetation can also act as a wind and solar shield and temper environmental influences.

3.7.3.2 The Indoor Environment

In this section the house interior should be studied (size, layout, location of appliances, building materials employed, combustion systems, ventilation). Any unusual features should be identified, use of rooms defined, outside closets identified, and any chemical or materials stores also be identified.

During the inspection, regard the house as a system where sources, combustion appliances, ventilation, climate and people interact. As many aspects as possible should be assessed, checked and tested in a methodical manner; in order to obtain as clear an understanding of the problem as possible.

If possible, carry out the walkthrough on a relatively calm day, since the wind and stack effect may influence air quality.

Review the previous history/use of the house and try to identify incidents which may have a permanent effect on the air quality.

Start the investigation in the basement and work your way through the house, finishing in the attic. Qualitatively assess the building envelope for tightness; check for sources; evaluate ventilation where possible and conduct simple venting tests if needed. Organize the equipment needed, and place your observations on a drawing of each room as you proceed through the house. Try to involve the occupant in the investigation and ask him/her to fill in details as the investigation proceeds.

Describe the house and obtain a general impression of the layout, finishing, and quality of construction. Note any recent changes or renovations, and look for unusual features such as unvented appliances, absent or poorly located diffusers or return air registers, and locations with poor air circulation, dampness, odours.

Obtain a visual impression (stains, mould, spills, rot, organic residues), a general air quality impression (stuffy), and look for general signs of contamination (unclean areas, condensation, stains, biological sources, evidence of spills). Dust, dirt, odours and signs of deterioration are a cause for concern.

Care is advised when inspecting an area of the house that may contain harmful substances such as lead, asbestos, or mould. Try to leave the area undisturbed. A suitable respiratory protector should be employed in these situations.

The audit should identify possible control and test points for measurements as these may be needed.

House General Impression; The age of the house may help focus the investigation; old houses are often leaky with uncontrolled ventilation, may be poorly insulated, have an old heating system, and may have a damp/mouldy or poorly-sealed basement. Note all examples or exceptions to these expectations and consider them as possible contributors to problems.

New houses may have typical new-house chemical odours, are often tighter than old houses, may have more controlled ventilation, and often have drier basements. Look for exceptions and consider them as likely problems.

Occupant Activities; The most serious source of occupant generated pollution is usually smoking. Cooking, cleaning, and hobbies also generate pollutants (VOCs, particulates, moisture) and these areas must be locally exhausted.

Crawlspace; A dirt floor crawlspace may be a source of radon, moisture and mould, should be isolated (covered with 6 mil polyethylene sheeting, ballasted and sealed) and vented following standard radon remediation practices. A depressurized house (tight with unbalanced ventilation) may draw in pollutants from the surrounding soil through a poorly-sealed ground contact floor.

A musty odour and/or excess humidity may also be a sign of poor local or general ventilation.

Building Envelope; Poor sealing of the building envelope may result in uncontrolled ventilation and in the influx of soil

gases and outdoor pollutants.

The areas around windows and doors, electrical feedthroughs, plumbing feedthroughs and openings in the building envelope are possible pollutant pathways and should be inspected. A smoke pencil will help locate air leaks and air movement through the envelope.

Deficiencies in insulation (particularly at corners), a poor or absent moisture barrier, poor sealing along the floor-slab interface in the basement (and at windows, cracks, unsealed floor drains, open sumps) may result in moisture infiltration, cold spots and condensation, and moisture or mould buildup in and on walls and windows. High humidity levels and dampness can result in peeling paint, rotting window sills, damaged gypsum wallboards, and mould in exterior closets, in the corners of interior surfaces of outside walls, and behind furniture.

Mould may develop on stored clothing, carpets and drapes if damp. These materials are also sinks for VOCs and may act as long term sources of these pollutants.

Describe the construction materials employed, the quality of construction, and list possible problems associated with them.

Carpets, upholstery, drapes, particleboard/exterior plywood, glues, plastics, wall coverings, and new paints, release formaldehyde or VOCs, which can be characterized by odour. The magnitude and location of these sources should be estimated. Many materials may also act as sinks for other pollutants and may release them slowly over time.

Estimates of the size of the polluting material and it's age may provide a useful indicator of source strength.

Note that many contaminants including mould, may also be sources of airborne particulates and house dust.

Combustion heating systems/gas water heater;

The furnace should be described including age, condition, number, type and unusual features.

Spillage, leakage or backdrafting will result in pungent, choking or suffocating combustion gases, and high particulate levels from an oil- or wood-burning appliance, or warmth and humidity from a gas-burning appliance. Soot, creosote, or smoke around the furnace or in the living space is further evidence of spillage and leakage. Note whether there are any odours on startup of the combustion system. If the flame pattern is suspect (offcolour, poorly shaped) suggest a tune up by a qualified technician.

Unvented kerosene or gas heaters will release combustion pollutants directly into the living space. Some people cannot tolerate these products.

Note whether the combustion system is properly vented; Note the presence of elbows or bends that may reduce efficiency or blockage. Check whether the duct work is properly connected.

Check whether the fireplace and other combustion appliances have a proper makeup air supply. Check the air supply ducting for signs of flow reversal. A combustion systems safety inspection will help evaluate performance.

Note any obvious blockage/damage/leakage/staining/poor maintenance of the furnace/chimney which may affect venting. Inspect the chimney from the top and through the ash cleanout. A flashlight and serviceman's mirror are needed. Many clay chips in a masonry chimney means that liner damage is occurring.

If combustion spillage is suspected, leaving a spillage indicator (for gas furnaces) or a fire alarm (for oil or wood appliances) may help to clarify the situation.

Inspect the filters for dirt load and filter quality.

Note whether the humidifier is connected and in reasonable condition.

Ventilation/HRV/Air Conditioning/Humidifiers/Dehumidifiers

Describe the system(s); age, model number, condition, quality of installation.

High moisture levels, odours and stuffiness are signs of poor ventilation/air circulation and/or unvented sources.

Is the ventilation controlled or uncontrolled? An unbalanced ventilation system may depressurize the house and induce pollutant infiltration.

Form an impression of the ventilation and air distribution in each room, particularly where there are sources of moisture and chemicals. Note the location of diffusers and exhaust grills (if any) and any drafts. A smoke pencil may be useful to gauge air movement between rooms and through the building envelope.

The performance of humidistats, thermostats and other control devices should be evaluated in a detailed inspection.

Note the presence of stagnant water and slime in air conditioners, and humidifiers/dehumidifiers which may be a source of microbiological contamination. Humidifiers may generate

aerosols (particulates) and excessively increase humidity levels (>55%). Check for use of tap water in older electronic humidifiers which may result in high particulate levels.

Check any air filters (furnace, HRV, fans including range fans) for cleanliness. Filters may reduce airflow if clogged and an inspection of trapped debris may provide clues to offending particulate.

Moisture Sources/Condensation; Humidifiers, unvented moisture sources (dryers, cooking, cleaning, bathrooms), and basement/crawlspace with moisture problems or dirt floors may excessively increase humidity levels. Look also for backdrafting appliances, a large number of indoor plants, and firewood stored inside. Look for any effects of high humidity such as condensation, peeling paint, and mould growth. Look for potential cold spots and/or concealed condensation.

Chemical Sources; Note any odours and look for chemical storage areas; fuels, solvents, pesticides, hobby materials, paints, cleaning materials, all of which may release organic compounds into the air (VOCs). Look for evidence of recent use, spills and determine whether a local exhaust is present. Occupants will be good sources of information on this.

The release of chemicals is increased during occupant use and may reach significant levels in poorly ventilated areas.

Dust Sources; Dust consists of a variety of organic and inorganic materials, some of which are allergenic. Note the dust level in the house and the state of cleanliness (on shelves, cabinets, in carpets). Fine dust in the air can often be seen in the sunbeams from windows.

Vacuuming will help reduce large particle dust levels, as will a reduction in fleecy (rugs, drapes) surfaces. Central vacuum systems with outside exhausts are especially good since they do not increase airborne dust levels of fine particulates that causes many health problems. Normal portable vacuum cleaners may actually elevate house dust levels since many particulates are not properly filtered. Some vacuums create fine particulates from larger ones.

Check the ductwork, diffusers or return air intakes for dust/dirt and mould buildup. The furnace filter will provide some indication of dustiness and should be inspected.

Pets; Pets are a source of allergenic material (dander, hair) and both the pet and the area must be kept clean. Pet hair in ducting systems can be a problem.

Air Cleaners; Poorly designed, installed or maintained electronic

air cleaners may actually be a source of ozone. Keep the filter clean to prevent arcing and/or replace with HEPA or other high quality filtration system. Note the type, size and condition of any air cleaners or filters present.

Stored building materials; Particleboard, waferboard, plywood, ceiling panels, rubber products, glues, and mortar are sources of VOCs and particulates and should not be stored indoors. Note the quality and type of material present and evaluate its possible influence.

Bathrooms; Form a general impression and note any odours. The bathroom should be vented to reduce moisture buildup and possible mould development. Windows are seldom used during winter in cold climates. Condensation on windows or the toilet tank, rotting of window sills, peeling paint, and musty smells signify excessive condensation and moisture.

The area under the sink, the toilet and around the shower/bathtub should be inspected for leakage, dirt buildup, rotting materials and mould growth.

Personal care products, cleaning materials, and plastics will generate VOCs with characteristic odours.

Kitchen; Form a general impression. Inspect the area for evidence of neglect and deterioration and note any odours.

The kitchen stove must be vented to remove cooking odours, gas fumes or combustion products and moisture.

Condensation on windows, peeling paint, and musty odours may indicate excessive moisture buildup, poorly insulated wall areas and mould growth. The sink area should be inspected for dampness, evidence of rotting and water damage, leakage and mould growth. Check cupboards under sinks. The refrigerator drip pan may hold stagnant water and also be a source of microbial growth if the heater is defective or missing.

Cleaning materials stored in the kitchen may generate VOCs.

Garage; Garages may be a source of VOCs (paints), pesticides, combustion gases (car), and fuels if it is attached and poorly isolated from the house. The smoke pencil will indicate the direction of airflow between the house and the garage and the potential for a hazard. Run all house exhaust fans while performing this check.

General observations other rooms;

The living room, bedroom, laundry room, porch may also contain significant sources. Form a general impression of the area and

characterize odours, note spills, areas of poor air circulation, drafty or overheated locations, new furnishings, furniture.

Ceilings/attic; Form a general impression and note any odours/excessive temperatures/inadequate ventilation. Leakage from the roof, and condensation in the attic may eventually permeate through to the ceiling and produce visible stains, particularly if no moisture barrier is present or attic feedthroughs are not properly sealed. Look for condensation and mould on roof trusses or sheathing, and condensation on vents and waste pipes.

Stack and wind effects may induce the uncontrolled movement of moist air through cracks and openings in the ceiling. Check suspected leakage points with a smoke pencil.

Emissions from asphalt shingles and other roofing materials may enter the house (VOCs). Loose insulation may generate particulates.

3.7.4 Step Four; Analysis and Remediation

Step Four will normally provide additional clues about the air quality problem. The investigator will form and test a hypothesis by means of simple remediation step(s) or tests. The remediation employed should begin with simple small steps (tests) and proceed to more complex expensive methods until a satisfactory solution is achieved. In general, it is less costly to remediate first than to proceed directly to step four and make measurements.

The action to be taken at this stage will depend on the level and type of pollutants present, the ventilation requirements, occupant tolerance and budgetary considerations. The level of ventilation in a space must balance the level of pollutants being generated and the adequacy of any modifications is a subjective decision. Occupant feedback during a remediation process which is done in steps over a period of time will help decide the optimum tradeoff between remediation, occupant satisfaction and budget.

Remediation involves the removal, exhaustion, and sealing of sources; modifications to the ventilation and changes to any occupant activities which may be generating pollutants.

If the problem remains unresolved then the consultant and occupant must determine whether to proceed to Step Five. The various strategies possible, their costs, and the probability of success as a result of this step should be discussed and clarified.

Appendices X1 to X8 contain background information, flowcharts and a table to guide the investigator.

3.7.5 Step Five; Measurements

At the present time many procedures are still under development and the investigator should use standardized protocols from EPA or ASTM to ensure that the best quality results are obtained.

3.7.5.1 Predeployment considerations

Some planning of the strategy to be employed must be carried out before returning to the house to make measurements. Thus the location and pollutant to be monitored may have been established during the walkthrough. The strategy should be based on a comprehensive understanding of the house as a system and be designed for the worst case condition if possible.

The measurement timing is important since pollutant levels are not constant and tend to vary with time. Some pollutants vary more than others and the approach to be taken must be pollutant specific.

The equipment must be selected, be tested and calibrated prior to entry to the house. Measurement methods can be simple, relatively inexpensive and employable by untrained users while others are complex, expensive and require training. For screening purposes, colorimetric sampling tubes and passive samplers may be the preferred choice. A variety of test kits which cover most applications are presented in Table 5 and a brief discussion of source evaluation methods is presented in (Appendices X4 - X7).

For most types of measurements a closed house condition should be established to emulate highest exposure levels. For such sampling periods, doors and windows are kept closed, ventilation systems turned off, and humidifiers or dehumidifiers deactivated, a minimum 12 hour period before the start of the measurement period. Measurements should be made on calm days.

A much better understanding of test information will result if simultaneous air exchange rate or subsequent air-tightness measurements are made (do not perform an air-tightness test before pollutant measurements).

Location considerations;

Measurements must be made at control locations for reference purposes. The easiest control location for house monitoring is outdoors, and upwind if pollutant levels are low.

Results from the test locations will be compared to the control locations and to standards, to evaluate the significance of the contamination present indoors and out.

When testing place the sampler/monitor in an open and

unobstructed position well away from walls, temperature and humidity extremes and where normal air circulation will be encountered.

Timing considerations;

Pollutants which arise from the building structure, furnishings or ventilation (formaldehyde, some VOCs, radon, biological contamination) are not usually time-sensitive and can be monitored under closed house conditions to achieve the maximum levels.

Occupant generated pollutants (such as carbon dioxide), or VOCs (from hobbies, cleaning, or cooking) are best checked at the time of occurrence, if possible.

Combustion backdrafting (colour change sensors are available; smoke alarms and battery cost about $15), spillage, and leakage or ozone generated by electronic cleaners may be occasional events and the optimum time will be difficult to determine. Continuous monitors (expensive) are the only reliable method for this type of measurement. Some tests (combustion, spillage) can induce a problem and indicate the possibility of a problem but not its occurrence.

Some sources are seasonal: pesticides, outside sources in summer; humidifiers, fireplaces, furnaces in winter.

Sampling during the winter months may result in reduced pollutant levels if excessive infiltration or natural ventilation dilutes the sample. Sampling during spring or fall periods, will best characterize the pollutant levels in low-ventilation conditions.

Table 2 is a summary of some of the considerations presented in this section.

3.7.5.2 Overview of Monitoring Methods

Appendices X4 to X7 provide additional background information on source evaluation.

Measurement results can be arranged in terms of skill required, expense and capital costs, whether the methods are passive or active, portability, whether the device is a sampler/analyzer or direct reading, whether measurements are continuous or grab, and whether the procedures are wet or dry chemical.

The colorimetric sampling tube is a simple, low-cost method which will provide on-site spot measurements in some cases (CO, CO2, O3, formaldehyde) but has limited accuracy and sensitivity for the measurement of many other indoor air quality parameters. The sample is taken with a small hand (usually 1 to 10 strokes, with

more strokes increasing sensitivity) or electric pump and the length of stain read from a scale on the tube, usually calibrated in ppm units (these should be corrected for any non-standard number of strokes).

Passive samplers are simple to deploy and relatively inexpensive but require a minimum eight hours to one week to obtain a useful measurement (NO2, formaldehyde, radon, air change). The sampler is deployed in a safe area away from climatic extremes and recovered after a suitable period.

In the case of formaldehyde and radon, the sampler can be read in the field with a small test kit or reader. In other cases the sampler must be sent to a laboratory to be read (radon) or chemically analyzed (NO2, formaldehyde, air change). This procedure may require several weeks.

Passive methods are useful for surveys because the samplers can be easily deployed by the occupant and returned by mail. They are often inconvenient for single-house investigations.

Wet chemical methods are recommended for the accurate spot measurement of many air quality parameters, but extreme care must be exercised in cleaning equipment, sampling and sample handling (formaldehyde, NO2, SO2). This method also has the advantage that the equipment required (bubbler, pump) is readily available in many laboratories.

The sample to be tested is drawn through a bubbler by means of a small pump. The bubbler contains a sorbent/reactant chemical which traps the target material. The solution is then treated chemically and analyzed in a laboratory, usually by a colorimetric procedure.

The wet-process procedure is more complicated than the colorimetric sampling tube, a laboratory facility is needed for sample preparation and analysis and, in addition, wet chemical samples are more difficult to transport.

Active Samplers which employ sorption tubes (VOCs), filters (particulates) or impaction on agar (fungi) are simple to deploy but analysis of the resulting sample is difficult and costly.

In the case of VOCs, an airstream is drawn through a sorbent tube (charcoal, Tenax, Ambersorb, or a mixture of several) by a pump (AC-powered for multisorbent tubes). The sample is then sent to a laboratory for analysis by GC, or GC/MS. Total volatile organic carbons (TVOC), or individual volatile organics can readily analyzed by this procedure. In general the more complex the analysis required, the more expensive the procedure.

Particulates are most commonly determined by collecting a sample

on a preweighed filter then weighing again to determine the mass of material collected. This procedure is simple in principle and provides a sample for analysis. A precision analytical balance is required, however, and the investigator must be aware of the need for buoyancy corrections to the weights obtained.

Mould is commonly determined by impacting the air sample on agar or by swabbing an area. A colony count is obtained after a short period but the results must be interpreted in terms of a very limited guideline. Few persons are adequately trained in mould speciation, an important measurement. Only a few colonies of some moulds is too many, while others are of lesser concern. Results are thus qualitative and difficult to relate to specific air quality problems. If detailed analysis is made for pathogens, an expensive procedure, the results may still be of little assistance to resolving specific health problems.

Direct reading instruments can be employed for spot checks or surveys or be set up for continuous monitoring. Many instruments are capable of logging data for extended periods (more detailed investigations). Some training is required for operation, deployment and interpretation of results.

CO2 (NDIR), CO (electrochemical), humidity (capacitance), temperature (RTD) and air speed (anemometer) are commonly measured by direct reading survey type instruments. VOCs can be measured qualitatively by a photoionization method or quantitatively by a field portable gas chromatograph. Many field portable instruments are available for radon measurement. These are based on ion chambers, alpha scintillation cells and solid state detectors. Instruments for SO2, NO2 and O3 are generally large, delicate and sophisticated and not suited for survey or routine work. Direct reading instruments are available which measure particle numbers, size or mass. The simplest of these are based on the optical interaction between light and the particulates to be measured (scattering).

In all cases the instruments must be properly calibrated and maintained to ensure accurate and reliable operation.

3.7.5.3 Sampling and Equipment Considerations

A summary of test locations and ideal measurement times is presented in Table 2. A summary of pollutants and measurement procedures is presented in Table 3. Guidance on selecting the most appropriate measurement procedure is presented in Tables 4 and 5 and a short list of instruments and manufacturers is presented in Table 6. Measurement results are compared to standards, Table 7, to identify problem areas.

Instruments and methods are divided in table 4 into two levels. Level one is a simple screening or survey method where the

desired result may be qualitative, low-cost or carried out by a non- technical user. A level two procedure is more complicated, expensive, and is employed when accurate results are needed. Continuous monitoring is an objective and training is usually required.

Test kits (Table 5) are organized in terms of complexity and cost to further assist the investigator.

3.7.5.4 How to Make a Measurement (Tables 2 to Table 6.)

The contractor should establish the monitoring times(s) and location by consulting Table 2. During the walkthrough the investigator should have already identified the pollutants to be measured, as well as the sampling and control locations.

Several measurement methods are presented in Tables 3 and 4. The method of choice is often a cost/accuracy tradeoff (level one versus level two). The measurement methods are organized in terms of test kits in Table 5.

Once a method is chosen, the list of manufacturers is available to assist in the purchase of suitable equipment (Table 6). This is a limited list and does not include all manufacturers nor recommend a specific one.

Most equipments are accompanied with operating and measurement instructions and, where possible, recognized measurement standards should be consulted.

Before making measurements, ensure that the instruments are properly setup and calibrated and that closed-house conditions or alternative space optimum conditions have been established at the monitoring site.

3.7.5.5 Measurement Results and Analysis

Results should now be compared to observations and to standards (Table 7). Supplemental background information, flowcharts and a table are provided in Appendices X4 to X7 to assist the investigator.

High test values (compared to standards or other test averages) may indicate that there is an air quality problem or that the potential for one exists. When associated with symptoms, odours and other non-measurement air quality indicators, high results suggest the need for further remediation.

An air quality problem may still exist even if the results are low since the pollutant levels may be low at the time of measurement, or the individual may be hypersensitive. Problems are sometimes attributed to the combined effects of many

pollutants at low concentrations, complicated by other factors such as humidity extremes, poor air circulation, drafts or overheating. Environmental stressors such as noise, workplace problems and lighting may be confused with air quality problems. Psychosocial problems can reduce tolerance to substandard air. It may be the combination of all of these factors that results in a problem, not any single one of them.

The state of the art is such that failure to detect IAQ problems does not mean that a problem does not exist. The measurement method may not be sensitive enough, the measurement may have been made at the wrong time or permissible exposure standards may simply not be low enough.

Table 1 Investigation Sequence and Guide

Step One; Document and network the complaint/assess danger

Document complaint; review complaint and collect occupant information

Assess danger; review causes of concern, combustion systems and gas leaks, chemical/biological hazards, severe and sudden symptoms are causes of concern

Emergency walkthrough; review combustion system, gas leaks and problems of chemical and biological origin

Relieve danger; remove occupant or resolve problem

Step Two; Proceed to collect information by phone if the situation is not urgent

Further discuss problem with client, analyze the information gathered and suggest simple remediation tests.

Step Three; Detailed Walkthrough

A detailed walkthrough is made to verify and supplement the information gathered by phone.

- Review outdoor environment; outdoor sources, pathways and house factors
- Review indoor environment; house factors

Step Four; Analysis and Remediation step

The walkthrough information is analyzed and remediation attempted in a sequential manner proceeding from the simple to the more complex to minimize costs.

Step Five; Measurements Step

This section covers chemical, physical and biological measurements.

Covered are:

- Predeployment considerations; calibration, sampling, location and timing
- Monitoring methods; passive/active instruments, wet chemical methods, direct reading instruments
- Sampling and equipment considerations: temperature,

humidity, airflow, CO2, CO, NO2, O3, particulates, VOCs, formaldehyde, microbials, radon, air change rates

- How to make a measurement; test locations and ideal sampling times, pollutants and measurement methods, guide to selecting a measurement method, test kits, equipment and manufacturers list, standards and guidelines

- Interpretation of results; in terms of standards and guidelines.

Table 2 Source/Test Locations and Ideal Times

Pollutant	Source and/or Test Location	Time
Odours, CO2	General	Closed house conditions, when heavily occupied, combustion systems on, stuffy, humid, odours present
CO, NO2 SO2,	Near source; in garage, near combustion equipment, (stove, water heater, fireplace)	When cooking, combustion systems in use, high traffic levels
Formaldehyde	Building materials, smokers, new furniture, new carpets	Closed house conditions
Particulates	Sources; vacuuming, cleaning, combustion process, housedust, cooking	When suspected
Radon	Basement, living area	Closed house conditions
Biological	Sources; complaint area, damp area, mouldy area	Closed house conditions, musty odours present, other signs of mould
VOC	Sources; hobbies, paints,	Closed house conditions

	storage area, new furnishings	
Humidity	Near sources, complaint areas	Closed house conditions
Air movement	Registers, mid point room	Normal house conditions
Ozone	Near air cleaners	While on
Combustible gas	Combustion systems	Complaint times, inspection times

Table 3 Pollutants, Factors and Measurement Methods

Parameter	Method
Humidity	Sling psychrometer or electronic gauge
Air motion	Smoke tube Katathermometer Thermal Anemometer
Biological aerosols	Impaction/agar, impingers
Carbon dioxide	Colorimetric tubes Diffusion samplers NDIR (infrared) analyzers
Carbon Monoxide	Colorimetric tubes Passive samplers Electrochemical analyzers NDIR (infrared)
Formaldehyde	Colorimetric tube (marginal) Passive sampler Wet chemical
Nitrogen Dioxide	Colorimetric tubes (marginal) Passive samplers Wet chemical Direct reading analyzer (chemiluminescence)
Sulfur Dioxide	Colorimetric tube (marginal) Electrochemical detector Wet chemical methods Analyzer fluorescence
Particulates	Filtration/ weighing Impaction Instrument-optical scanning Instrument-piezoelectric
Ozone	Colorimetric tube Wet chemical methods Instrument-chemiluminescence
VOC	Sorbent tubes-charcoal Sorbent tubes-Tenax Multisorbent tubes GC-FID, MS
Radon	Electret alpha track charcoal alpha scintillation Filtration/alpha counting

Table 4 Guide to Selecting Measurement Procedure

Parameter Method	Source/Application	Level One	Level Two
Humidity	High/Low humidity	Sling psychrometer, Hygrometer	Hygrometer, Recording Instrument
Air Motion in room (low)	Ventilation, Circulation, Drafts	Smoke pencil	Katathermometer
Air Motion ducts ((higher velocity)	Balancing HRV	Garbage bag test	Anemometer, Flow hood
Carbon Dioxide	Stuffiness Body Odour, Spillage, Poor Ventilation	Colorimetric tubes Passive/active sampler	NDIR instrument
Carbon Monoxide	Combustion odour, Combustion leaks,	Colorimetric tubes	Electrochemical instrument
Nitrogen Dioxide	Combustion odour, Spillage	Passive sampler Colorimetric tube*	Wet chemical, Chemi-luminescent Analyzer
Particulate	Combustion leaks, Occupant activity, House dirt Smoking,	-------	Filtration and weighing, Optical scanning instrument, Piezoelectric instrument
Formaldehyde	Particleboard, New carpets, New furniture	Passive sampler	Wet chemical

Ozone	Electrostatic air cleaners, Photocopy machines	Colorimetric tube	Wet chemical, Chemi-luminescent analyzer
VOC	Paints, Solvents, Cleaning Materials, Hobbies,Glues	Sorbent tubes, (sampling)	GC-MS TVOC-instrument Portable gas chromatograph,
Radon	Soil gas infiltration Water supply,	Electret, Alpha track, Charcoal, canister	Alpha scintillation, Ion chamber, Solid state detector
Air change rate, Airtightness	Infiltration of air	--------	Tracers/Active or passive methods, DC/AC pressurization (blower door)
Microbials, Fungi		Swabs (colony count)	Impact/agar plate (sampling) Complex analysis Impinger

* Marginal sensitivity (many strokes required)

Table 5 Test Kits

Parameter	Method
Test Kit 1. Basic Equipment	
Temperature	Thermometer
Humidity	Psychrometer
Air movement	Smoke Tube
Pressure drop	Micromanometer
Test Kit 2. Simple Screening Kit	
Temperature	Thermometer
Humidity	Psychrometer, electronic hygrometer
Air movement	Smoke tube
Pressure drop	Micromanometer
CO2	Colorimetric tube, Low cost CO2 analyzer
Formaldehyde	Colorimetric tube*, Passive sampler
Test kit 3. Intermediate Screening Kit	
Temperature	Thermometer, Electronic instrument
Humidity	Psychrometer, Electronic instrument
Air movement	Smoke tube
Pressure drop	Micromanometer
CO	Colorimetric tube,
CO2	Colorimetric tube, Passive sampler, Low cost CO2 analyzer
Formaldehyde	Colorimetric tube*, Passive sampler
NO2	Colorimetric tube*, Passive sampler
SO2	Colorimetric tube*,
Radon	Passive sampler
Test Kit 4 More Advanced Measurements	
Temperature	Thermometer, Electronic instrument
Humidity	Psychrometer, Electronic instrument
Air Movement	Smoke tube
Pressure drop	Micromanometer
CO	Electrochemical instrument
CO2	NDIR instrument
Formaldehyde	Passive, Impingers + pump
NO2	Passive, Impingers + pump
SO2	Colorimetric tube*
TVOC/VOC	Sorbent tube + pump, Badge
Particulates	Filter + pump
Radon	Passive sampler
Microbials	Swabbing/Water samples
Air Exchange	Passive or active tracer
Infiltration	Blower door

Test Kit 5 Advanced Measurements /Remediation

Temperature	Psychrometer, Direct reading instrument
Humidity	Psychrometer, Electronic instrument
Air velocity	Katathermometer, Thermal anemometer
Pressure drop	Micromanometer
CO	Electrochemical
CO2	NDIR instrument
Formaldehyde	Passive, Impingers + pump, Continuous instrument
NO2	Passive sampler, Impinger + pump, Direct reading instrument
SO2	Impinger + pump, Direct-reading instrument.
TVOC/VOC	Multisorbent tube + GC/MS, Gas chromatograph
Particulates	Filtration, Direct-reading instrument
Ozone	Colorimetric tube, Direct-reading instrument
Combustible Gases	Direct-reading instruments
Radon	Direct-reading instrument
Microbials	Impaction agar
Air Exchange	Passive, Active tracer
Infiltration	Blower door
Loggers	Continuous electronic systems

* Marginal sensitivity (many strokes required)

Table 6 Equipment and Manufacturers*

Parameter	Principle	Manufacturer	Model
Humidity	Hygrometer	Vaisala	HM131,HMP-31UT
	Psychrometer	Cole/Parmer	N-03312-20
Air movement	Kata-thermometer	Cansel	T6405
	Smoke tube	Gastec,Draeger	500
	Thermal anemometer	Kurz, Omega	440 HH-410
Carbon Dioxide	Colorimetric tube	Gastec, Draeger	2LL 0.01%
	Passive	Draeger	1%/A-D
	NDIR	Nova, AECL, Fuji,Horiba	390 Comfocheck
Carbon Monoxide	Colorimetric tube	Draeger, Gastec	2a 1LL
	Passive	Draeger, Gastec	50/a-D 1D
	Electro-chemical	Dynamation	Monogard
		Nova	390
Formaldehyde	Passive	AQRI, ATL	PF1 STC
Particulates	Optical scattering	PPM, MDA	HAM PCD-1
	Gravimetric	Sierra Anderson	241
Radon	Passive	Rad-Elec, Air Chek	E-Perm Charcoal canister
	Active gas	Pylon, Instruscience, Thomson	AB-5 RN2000
	Active progeny	Nielsen, Alphanuclear	TN-WL-02 Alpha Prism

Air exchange	Passive	NAHB/AIMS	PMC-
Infiltration	Blower Door	Retrotec, Minneapolis Blower Door	
NO2	Colorimetric	Gastec	9L
	Passive	AQR, Dupont, MDA	Air Check Pro-Tek Palmes tube
	Active Chemi-luminescence	Scintrex, CSI	LMA-3 2200
Ozone	Colorimetric	Draeger, Gastec	0.05/a LOW
	Active Chemi-luminescence	Scintrex, Columbia Scientific	LOZ-3 CSI2000
Fungi	Active Impaction	Biotest, Anderson	RCS 10-850
SO2	Colorimetric	Draeger, Gastec	0.01/a 51b
	Electro-chemical	Interscan	4240
	Fluorescence	Monitor Lab	8850
VOC	Active PID	Photovac, Foxboro	TIP OVM-88
Combustible Gas	Catalytic	Gastech, Draeger, Draeger	GX-86 Exylarm Triowarn
Pressure Drop	Differential capacitance	Cole-Parmer	L-10400-05 L-10400-21

* The list of manufacturers is not complete and those listed are not necessarily recommended.

Table 7 Summary of Standards and Guidelines

Parameter	ASHRAE (office)	Health Welfare Canada	
Humidity	25-65% RH	30-80% RH Summer 30-55% RH Winter	
Temperature	20-24 C Winter 22-26 C Summer		
Air motion	0.25 m/s Summer 0.15 m/s Winter		
Carbon Dioxide (CO2)	1000 ppm	3500 ppm	Alter
Carbon Monoxide (CO)	9 ppm	11 ppm 25 ppm	Alter Aster
Formaldehyde	0.4 ppm	0.1 ppm 0.05 ppm	action target
Particulates	75 ug/m3 (yr)	100 ug/m3 40 ug/m3	short long
Sulfur dioxide (SO2)		0.38 ppm 0.019 ppm	Aster Alter
Nitrogen dioxide (NO2)	0.55 ppm (yr)	<0.05 ppm <0.25 ppm	Alter Aster
Ozone (O3)	0.05 ppm (cont.)	0.12 ppm	Aster
Microorganisms		Limited guidelines	
Radon		20 pCi/L	

Other Standards and Guidelines

TVOCs	European	0.2 mg/m3
Air Exchange	CNBC	0.3 ACH (dwelling), 1.0 ACH (unventilated room), 0.5 ACH (ventilated room)
Combustibles	EPA	25% LEL (evacuate), 10-25% (caution)

APPENDIX X1 CHIMNEY SAFETY TEST PROCEDURE

APPENDIX X1 CHIMNEY SAFETY TEST PROCEDURE

Step 1: Put building in heating season condition;

- Turn off furnace, turn down DHW
- Close all windows
- Open all interior doors, except those to bedrooms which do not have a bathroom attached

Step 2: Set up the blower door (or just a manometer across the envelope). Make sure the fan opening is blocked so that it does not provide an extra hole for air movement. Zero the gauge.

Step 3: Determine the House Depressurization Limit (HDL). It is generally 5 Pa unless all appliances are sealed combustion (in which case 10 Pa is safe). Any woodstove or fireplace makes the HDL = 5 Pa. Exceptionally good chimneys (eg. new, interior, or well-insulated) can probably tolerate a slightly higher HDL (eg 6-7 PA)

Step 4: Turn on the furnace circulation fan, if it has its own switch. If it causes house depressurization, as measured on the gauge, leave it on. If not, turn it off.

Step 5 Turn on all exhaust equipment, eg bathroom fans, kitchen fans, clothes dryers, workshop exhausts, whole house fans, etc.

Step 6: Use a propane camp stove to heat up the fireplace, if one exists. You will probably have to open a fireplace room window for a couple of minutes to let the fireplace chimney establish draft. Close the window when draft is established

Step 7: Compare the house depressurization shown on the manometer to the HDL. If the reading is way higher than the HDL (usually 5 Pa), the house has problems. If the depressurization is only 1-2 Pa, the house is safe. If the depressurization is around 4-5 Pa, assess the situation (eg how often are the fans used at the same time, how good is the chimney) and investigate some more.

Step 8: With the fans still running, start up either the furnace or water heater and check for spillage with a smoke pencil around the dilution air openings. Spillage longer than 60 seconds probably indicates problems with the appliance or chimney. Investigate.

Step 9: Let the appliance run for five minutes. While the

chimney is heating up, make a small hole for a metal pressure probe in the flue pipe about a foot from the appliance. Insert the probe just inside the hole (so it is measuring the static pressure at the side of the pipe). After five minutes, take a reading. If you have only one or two pascals, your chimney is faulty or there is insufficient heat being supplied to it. More than five Pascals is adequate draft. Between 3-5 Pa, you should probably investigate further.

Step 10: Clean up. Turn off furnace, circulating fan, exhaust fans, propane burner in the fireplace. Reset furnace and hot water thermostats if you changed them. Put metal tape over the hole in the flue pipe.

APPENDIX X2 ACTIVE TRACER METHOD FOR AIR EXCHANGE RATE

APPENDIX X2 ACTIVE TRACER METHOD FOR AIR EXCHANGE RATE

The information presented here has been abstracted from the DBR paper 1165 (Division of Building Research, National Research Council) and from CMHC publication (16)

Dose Preparation

Prepare the tracer gas doses away from the test location. The apparatus referred to in this paper consists of a Matheson Lecture bottle and regulator assembly, standard syringes and 20 ml draw stoppered vacutainers which are ordinarily used for blood sampling in hospitals.

1. Check the dose syringe for leaks by submersing a syringe with the plunger withdrawn and a small rubber stopper on the needle in water. Pressurize the syringe by pushing in the plunger and watch for air bubbles.

2. Purge the regulator and septum chamber assembly on the lecture bottle by following the steps;

    - Locate the apparatus near an exhaust fan or outdoors.
    - with the needle valve closed, adjust the regulator to 10 psi.
    - Insert the syringe into the septum.
    - Open the valve thus allowing the pressure to fill the dose syringe and then expel the gas (20 to 30 cc should purge the system).

3. Fill the dose syringe to the desired volume. This is accomplished by inserting the syringe needle into the septum and allowing the gas pressure to drive the plunger to a point beyond the desired volume. Withdraw the needle from the septum and press the plunger to the desired volume mark. Allow the pressure in the syringe to stabilize for 3 seconds and cap the needle with a rubber stopper.

4. Close the needle valve and turn off the pressure regulator.

    Important; Dose syringes should not be used for sampling. Clearly label syringes as either "Dose Syringe" or "Sampling Syringe".

On Site Preparation and Injection of SF6

1. Immediately upon entering the test site, record the time, date and weather conditions in a log book.

2. Open, then close and lock all doors and windows which are normally closed in the building and turn off all exhaust fans. This is to ensure that all windows and doors are shut tightly.

Note whether or not the pilot light in the furnace is on of off.

3. Drill a small hole (1/16") in the return air duct upstream from the circulation fan. The thermostat should be turned down with the fan still running.

4. Remove the rubber stopper from the needle on the dose syringe and inject the tracer gas into the duct through the hole just drilled.

5. Allow 30 minutes for the tracer gas to mix throughout the building. In this time, prepare 7 vacutainers plus a few back ups for sampling. Preparation involves reinforcing the septum-stopper on the vacutainer with a strong tape (white fabric tape is preferable for labelling purposes). This reinforcing ensures that the septum-stopper does not pop out when the container is pressurized with the gas sample.

   Note: In houses without a central warm air heating system, floor fans should be used to circulate the tracer gas. Sample should be taken at a central location.

Collection of Gas Samples

To obtain good results from a tracer gas test, it is important that the times of sampling are recorded accurately. It is therefore recommended that a stopwatch be used.

1. Prior to sampling, test the sampling syringe on site for leaks, then carefully and gently dry the syringe needle. Do not draw samples with a leaky syringe. Use of a leaky syringe can lead to diluted gas samples and erroneous results.

2. Obtain the first sample from the return air stream through the hole drilled in the return air duct. Start the stopwatch at precisely the time that the plunger on the syringe is withdrawn, Use the following technique for withdrawing each sample:

   a) With the needle of the syringe in the return-air stream, flush the syringe by fully withdrawing and compressing the plunger to its original position at least once. This should be done within the 30-second time interval prior to taking the sample.

   b) At the time of sampling, obtain the sample from the return air stream by steadily withdrawing the plunger to approximately the 60 cc mark on the syringe. Leave the needle in the return air stream for approximately 3 seconds immediately following this procedure, thus allowing for the pressure in the syringe to reach

equilibrium. Push the plunger on the syringe to the 50 cc mark.

c) Immediately insert the needle into the vacutainer through the centre of the taped in place septum/stopper.

d) Check that the plunger is freely drawn into a position between the 30 and 40 cc marks by the vacuum in the sample tube. If this is not observed, the vacutainer is faulty. Replace the vacutainer and repeat steps (a) to (d), recording the new time at which the replacement sample is taken.

e) After allowing the vacutainer to reach equilibrium with the syringe, pressurize the vacutainer by completely depressing the sampling syringe. Hold the syringe in this position for at least 3 seconds before withdrawing the needle.

f) Clearly label the vacutainer with the appropriate information (time location, comments). The time should be recorded relative to the start time. The first sample should be labelled, t=0. The vacutainer label must unambiguously distinguish the test of which its sample is a part. This can be done satisfactorily by including the street address of the house, the date, and the time of the test start on the label.

3. Repeat step 2 for t = 10, 20, 30, 40, 50, 60 minutes. Use the stop watch to obtain samples precisely at these times.

4. When the test is complete, cover the hole with a piece of duct tape and return any thermostat settings, etc. to their original settings. Check to confirm that the pilot light, if lit at the start of the test, is still lit. Re-light according to furnace or water heater manufacturers instructions if it has gone out during the test.

Calculation of Desired Amount of Gas

To conduct the tracer gas test, it is recommended that the initial concentration in the building be approximately 50 ppb. Therefore, it is necessary to obtain a reasonably accurate estimate of the volume of the building. The following equation should be used for determining the volume of tracer gas for each application:

$$V(t) = V(b) * 50 * 10^{-9} * 28317$$

where V(t) = volume of tracer gas in cm*exp3
V(b) = volume of building in ft*exp3
50*10exp-9 = desired initial concentration of tracer gas
28317 = conversion factor (1 ft*exp3 = 28317 cm*exp3)

Shipping Samples for Analysis

The collected gas samples should be shipped to IRC for analysis on a gas chromatograph/electron capture detector.

Institute for Research in Construction
National Research Council, Canada
Montreal Road, M-24
Ottawa, Ontario
K1A OR6

SF6 Lecture Bottle Apparatus

1. Lecture bottle, SF6, Matheson Products Canada
2. Model 3320 Lecture bottle regulator
3. 3/16" I.D., 5/16" O.D., 1/16" wall, clear PVC
4. Package of rubber septums Fisher 02-683-54

Assembly procedures for attaching the regulator to the lecture bottle are listed in the manual which is provided with the Matheson Gas Regulator. Attach a rubber septum to the hose connector on the regulator according to the following procedure:

1. Cut approximately 3/4" of PVC tubing and place it over the hose connector on the regulator. The end of the tubing should be flush with the end of the connector.

2. Place a rubber septum over the PVC tubing on the hose connector.

3. Secure the rubber septum and the PVC tubing to the hose connector by tightly wrapping a fine wire around the septum.

Prior to preparing doses for tracer gas tests, it is recommended that the regulator be set at approximately 10 Pa. Turning the pressure adjusting screw on the regulator counterclockwise will lower the outlet pressure.

APPENDIX X3 CONDUCTING AN IN DUCT AIR VELOCITY TEST; TRAVERSE METHOD

APPENDIX X3 CONDUCTING AN IN DUCT AIR VELOCITY TEST, TRAVERSE METHOD

The air velocity varies across the duct due to drag effects of the duct walls and other inline factors.

To calculate a flow correctly, the average velocity at a selected point in the duct must be determined. To calculate the average velocity, a number of readings are taken across the duct and averaged. Since the ducts are round, measurement points must be selected so that the average velocities correspond to equal areas of the duct (equal area traverse).

Conducting the Air Velocity Test, Traverse Method

With the ventilation system and the air velocity meter operating for a few minutes to stabilize begin the traverse as follows;

1. Place the velocity sensor into the centre of the duct in such a way that the air stream flows directly through the window.

2. Press the MED range button, and wait approximately 30 seconds. The needle will tend to jump. If the needle goes off scale to the left, then press the LOW range button. If the needle goes off scale to the right, while in the MED range, then press the HIGH button. Ensure that the correct range is selected before proceeding.

3. Pull the probe out of the duct. Since the measuring probes are not marked, it will be the testers responsibility to ensure that an equal area traverse is conducted. Proceed in taking the traverse readings as follows:

    - Place the probe to the outer edge of the duct towards you such that a velocity is registering
    - If the duct is insulated, you must either remove the insulation or make a visual adjustment such that the probe marking would be flush with the duct edge
    - Wait for the velocity to stabilize on the meter and record the reading on the data sheet.
    - Move the probe inward to your next selected position
    - Wait until an average reading can be identified and record the next reading.
    - Repeat the procedure as you insert the probe progressively inward (according to the probe shaft markings) towards the duct centre and record each reading on the data sheet.
    - after completing the 5th or 6th velocity measurement, depending upon duct diameter, proceed to take the velocity measurements at each marking again as you pull the probe out towards yourself and record the reading on the data sheet.

4. Seal the test hole with tape,.

Air Flow Calculations

On the field data sheet, measured air velocities are recorded in m/s or ft/min for 6 points in the duct as the probe is inserted and withdrawn.

1. Since two measurements are taken at each point, take a straight average to determine the average velocity at each point of the traverse. This calculation (probe in + probe out/2).

2. Since the 6 points in the traverse represent an equal area, you can calculate a straight average of all the average point velocities to determine the average duct velocity.

3. Now calculate the air flow through the duct by the equation:

   Flow rate = Average Duct Velocity * Duct Cross Section Area

   The duct cross sectional area is as follows:

   4" duct area = 0.0827 ftexp2
   5" duct area = 0.13635
   6" duct area = 0.19635
   9" duct area = 0.34907

   Multiply the average air velocity by the appropriate cross sectional area to get the duct air flow. Duct airflow in cfm/2.118939 = Duct airflow in l/s

APPENDIX X4 SPECIFIC POLLUTANT CONCERNS AND SOURCE EVALUATION

APPENDIX X4 SPECIFIC POLLUTANT CONCERNS AND SOURCE EVALUATION

This section introduces common pollutants, their sources and health effects and briefly discusses measurement methods.

Typical Concerns

- Radon
- Combustion Products/Carbon Monoxide/Carbon Monoxide
- Biological Products/Mould
- Consumer Products/VOCs/Formaldehyde
- Ozone
- Moisture/Temperature
- Dust

The house, particularly in cold climates is an enclosed environment where chemical, or biological pollutants and radon can build up to significant levels. Since the pollutant level varies considerably from time to time, it may be difficult to get a good picture of how strong the source is from a brief visit.

In addition cause and effect may not be obvious and the investigator should be open minded to as many sources and interactions as possible.

Exposure to pollutants can have indirect effects besides those listed here including increased susceptibility to disease from other causes, aggravation of existing disease and sensitization to the same and other environmental agents.

VOCS AND FORMALDEHYDE originate from smoking, new furniture, carpets, glues, and building materials. Look for chemical sources such as paints, solvents, cleaners, fuels, pesticides and hobby areas which are improperly used, stored or vented. Many chemicals have characteristic odours which will help locate and identify them.

Symptoms experienced include coughing, sore throat, nausea, headaches, skin irritation and allergies.

Formaldehyde is a colourless gas. A pungent odour indicates that it is present at concentrations greater than 0.2 ppm. Indoor concentrations are dependent on the age of the source, ventilation or infiltration, indoor temperatures, and humidity. Concentrations can vary by as much as 50% from day to day or from season to season.

Measurement methods include direct reading tubes, chemical analysis, and electrochemical detectors. The direct reading tube employs a hand pump and concentrations are read directly in ppm from the length of a colour stain. This method is only marginally sensitive at indoor air levels and requires an impractical number

of strokes.

In chemical methods; formaldehyde is first collected in a sorption medium, then treated chemically and analyzed to determine its concentration. Passive samplers sample by diffusion, are inexpensive, and require little training to deploy. They are sensitive and provide an average level for the collection period of 8 hours to a week. Active methods employ impingers. Some training is required and care must be exercised in cleaning and sample handling.

The electrochemical detector is a direct reading analyzer with a sensitivity in the range of 0.02 to 0.05 ppm. The unit is quick to respond and can be used for continuous or spot measurements. The unit is expensive and has a sensor with a limited lifetime.

VOCs are compounds containing carbon and hydrogen which are often present at very low levels in indoor air. When a sample is taken up to 50 compounds are frequently present. Indoor levels may range as high as several mg/m3.

Measurement methods include direct reading tubes, passive badges, photoionization sources, flame ionization detectors, infrared detectors, and sorption/chemical analysis.

Direct reading tubes sample air by means of a small hand pump. The length of stain is proportional to the concentration. This method is only suitable for screening purposes since the method was developed for much higher levels than those found in indoor air.

Passive badges sample by diffusion over periods for 8 hours to a week. The sampler is sent to a laboratory for analysis. The sensitivity is in the sub ppm range.

Photoionization detectors (PID) are direct reading instruments which employ a UV lamp to ionize the molecules present. The amount of ionization is proportional to the concentration. The detector is non specific and sensitivities are marginal for materials at typical indoor levels. PIDS are useful screening tools however and can be carried around the building to help locate sources.

Flame ionization detectors (FID) burn chemicals and the amount of ionization produced is proportional to the concentration. The device is non specific but like the PID is a useful screening tool.

Infrared detectors are direct reading instruments suitable for monitoring individual VOC compounds. The sensitivity is in the ppm range but the instrument is not as selective as the GC and is expensive.

Active sorption/chemical analysis methods usually employ charcoal/tenax or ampersorb material and one or more sorbents. An

air sample is collected by means of a sample pump and the sample is later extracted by means of a solvent or heat and analyzed on a GC/MS. Charcoal tubes are useful for non polar compounds. Multisorbent tubes can be used to collect a much wider range of compounds and are more suitable for the measurement of TVOC.

COMBUSTION GASES AND PARTICULATES introduced by smoking, unvented cooking, unvented heaters, leaking chimneys, backdrafting and spillage. Combustion gases include CO, CO2, and NO2. CO is odourless but associated combustion products have a characteristic odour. Combustion gases, particularly CO are toxic and can cause a range of symptoms from headaches and nausea to dizziness, impairment and death.

Signs of venting failure include charred or smoke marked appliances, acrid smells on startup, and warm or damp furnace rooms.

CO2 is a normal constituent of the atmosphere (odour levels are 330-350 ppm). The concentration of CO2 indoors varies according to location, occupancy, time of day, building tightness and air circulation/ventilation.

Measurement methods include direct reading tubes, and infrared analyzers. In the direct reading colorimetric method, a hand pump is used to draw air through a glass tube. The length of stain is proportional to the CO2 concentration which is read from a scale on the tube. The accuracy is +/-25%.

Tubes are also available which sample by diffusion over a 1-8 hour period and provide an average CO2 level.

Infrared analyzers usually employ the NDIR principle of detection and contain sample and reference cells, a detector and a source of Infrared radiation. Direct reading instruments respond quickly and can be used for spot or continuous measurements. The devices must be calibrated before and after measurement with reference gases. They are expensive and delicate but are portable, sensitive and provide a monitoring capability.

CO is a colourless, odourless, toxic gas and is a product of incomplete combustion. The CO level should be measured if there are complaints of exhaust odours or if there is some other reason to suspect a problem.

Measurement methods include direct reading tubes, electrochemical analyzers and infrared monitors. The direct reading tubes are low cost and employed for spot sampling. A hand pump is used and the CO level and can be read directly in ppm from the detector tube. The sensitivity is limited to 5 ppm or more. Long term sampling tubes with a sampling pump can be used to obtain an average concentration over longer periods.

The electrochemical analyzer provides immediate accurate results and are useful for spot or continuous measurements. The monitor employs an electrochemical cell where CO is oxidized to CO2. They are less expensive than infrared analyzers and also require calibration.

Infrared monitors are more expensive direct reading instruments. They usually employ the NDIR principle where a sample and reference cell, detector and source of infrared radiation is employed.

HUMIDITY levels should be between 30 and 55 %. Lower levels can result in respiratory irritation. At higher levels, condensation can occur on cold surfaces such as windows, basement floors, water pipes, in closets and in concealed areas where there is air leakage through walls (holes in building envelope). Prolonged exposure can result in mould growth.

Moisture sources include open sumps and drains, a dirt floor crawlspace, poor drainage around the foundation, humidifiers, unvented dryers, cooking, washing and cleaning activities.
The presence of efflorescence and water damage on the basement wall indicates prolonged or repeated moisture infiltration.

Measurement methods include psychrometers, and electronic hygrometers. A psychrometer uses the difference between a wet and dry bulb thermometer (sensor) and is whirled or an electric fan is employed. They are relatively inexpensive instruments and powering the psychrometers simplifies use.

Hygrometers are small electronic units with a direct digital display. A change in capacitance or resistance is usually employed as the sensing method. Spot or continuous measurements are possible. The instruments are more expensive than psychrometers and require calibration at least once a year (portable kits are available).

MOULD is characterized by a dark brown, black or multicolored material and is often found on materials which have been damp for prolonged periods. Wet carpets, particularly those which are biodegradable or have foam underpads, stagnant humidifier water, floor drains, open sump pits, water leaks, floor joists and areas which have been exposed to a dirt floor crawlspace, spills, dehumidifiers, and areas of dampness or condensation are potential areas of microbiological activity.

Look for signs of periodic wetting or flooding, slime in humidifier water, and a mouldy musty odour.

Mould problems can be found by smell and a noticeable odour will indicate a problem somewhere indoors. Since mould release rates vary over many orders of magnitude with time a visit will not often coincide with the worst case conditions. The investigator must look

for clues as to what has been happening over time or the problem may be misdiagnosed.

Mould growth should be differentiated from rust, burn marks or liquid spills.

Mould besides causing allergic reactions and infections have a potential for causing chronic illnesses (Aspergillus fumigatus, Histoplasma capsulatum, Aspergillus fumigatus, Stachybotrys atra, and some other fungi are dangerous).

Measurement methods include air sampling by means of impactors or centrifugal samplers followed usually by colony counts. Species identification is of critical importance but very expensive. Spore concentrations can vary by an order of magnitude in times of less than a minute. Any pathogens or toxigenic species are considered to be unacceptable.

HOUSE DUST (PARTICULATES) consists of biological materials such as dust mites, animal dander, pollens, bacteria and viruses in addition to non biological particles from combustion processes, from soils, glass fibre insulation, asbestos, natural and synthetic fibres, or plaster. Renovations and outdoor construction can augment particulate problems.

Indoor particles come from indoor sources and can be drawn into the building via infiltration. The size range of concern is from 0.1 to 10 um diameter.

Allergenic reactions are associated with biologic dust from mites, pollens, and animal dander. Symptoms often associated with high particulate levels are non specific but may include dry eyes, nose and throat, coughing, sneezing and respiratory allergies.

Measurement methods usually include the gravimetric method, and optical scattering. With the gravimetric method an air sample is collected on a filter and the difference in weight corresponds to the mass of particulates. Matched weight filters are available to correct for humidity changes. Air samples are usually collected for 8 hours or more at flow rates of 2 l/min. A cyclone or other method can be employed to separate off particles larger than 10 um. Filter methods are simple and low cost but require extreme care and a precise balance. A large air volume must be collected to achieve a sensitivity as low as 5 ug/m3.

In optical devices the amount of scattering is proportional to the dust level. The devices are sensitive, direct reading and fast but are expensive. Optical scattering methods do not provide a sample for later analysis.

RADON, moisture and other soil gases can permeate into the basement through cracks, or holes and via the sump. Radon is a colourless,

odourless gas which is radioactive and naturally present in soil.

Radon may be a problem if the house is located on a radon hot spot, and/or is depressurized.

Radon will not cause any immediate health effects but may be a hazard over the long term.

Measurement methods can be passive or active grab or continuous monitors. Passive devices are integrating low cost methods with a one day to one year deployment period. Charcoal canisters, alpha track and E-perm detectors are common types with different degrees of accuracy, cost and readout methodology. These devices suitable for large scale screening measurements.

Instruments are more expensive but can usually provide more accurate measurement in real time. Instruments usually employ alpha scintillation, ion chamber, or solid state silicon detectors.

OZONE originates from dirty and poorly adjusted high voltage electronic air cleaners. It has a characteristic fresh air odour and can be a significant irritant.

Methods of measurement include chemiluminescence, UV spectroscopy or wet chemical (Iodometric).

Chemiluminescent methods measure the light intensity resulting from the ozone-luminol or acetylene reaction. These devices are very sensitive and accurate but expensive and not considered to be truly portable.

The UV method measures the amount of UV absorption at 254 nm. This is a reference method and is expensive. Lower cost units are now commercially available for routine monitoring.

Wet methods are available as grab or continuous analyzers. The iodometric method has been commonly used for laboratory analysis but is not really suitable for routine indoor air quality measurements by untrained users.

ASBESTOS is used as a high temperature pipe insulator or in older houses, around ducts and furnaces. There is a potential for contamination if the asbestos coverings are torn or degraded, otherwise the material should be left undisturbed.

VENTILATION; STUFFINESS, MOISTURE, AND ODOUR; together may indicate a general ventilation or circulation problem. The CO2 concentration or rate of dispersion of an injected sample may be employed as a measure of ventilation effectiveness.

An effective ventilation system must supply sufficient fresh air to replace exhausted air from the house, must properly treat the air

(filter, humidify) and must distribute it to all rooms. Few ventilation systems work well all year around.

Reasonable levels of ventilation can mop up pollutants from small and unavoidable sources but local exhaust must be employed for physically small but strong sources (stoves, dryers, bathrooms, hobbies) to prevent pollutant buildup. The solution to an air quality problem is often one of source control rather than general ventilation (removal, sealing, filtration or local ventilation).

Air motion, temperature, CO2 and humidity are often employed to evaluate the quality of ventilation.

AIR MOTION is a comfort parameter. If the motion is inadequate then the air may appear to be stuffy. If it is too fast then the occupant will complain of drafts. Speeds over 0.15 m/s in winter or 0.25 m/s in summer may be excessive.

Measurement methods include smoke tubes, and thermal anemometers. The smoke tube is one of the most useful devices for qualitative assessment of airflow and direction. It can be used to identify leaks, and help track contaminant movement. Smoke tubes are low cost. Using a smoke tube in mid room will help identify air circulation within the space and dispersal within a few seconds suggests good circulation. Smoke released near diffusers or grills gives a general indication of air movement.

Thermal anemometers provide a direct readout of air velocity. The hot wire is cooled in proportion to the air velocity. The meter must be selected for the measurement range desired and only a few measure as low as 0.15 m/s.

The Katathermometer measures airflow by the cooling effect on a moist wick and has a direct readout. This simple device is cheaper than the anemometer.

APPENDIX X5 USEFUL RELATIONSHIPS

APPENDIX X5 USEFUL RELATIONSHIPS

House as a system, house design and operation; any part of the house system and environment can be a source of pollutants (outdoor environment, house envelope, mechanical system, material contents and furnishings, occupants and their activities). An understanding of the processes that affect air flow (natural ventilation, stack effect and wind effect, the air distribution system, and the flue and vents), moisture flow and heat flow will increase the investigators chances of identifying the problem.

Indoor Air Pollutants; Specific concerns are addressed in appendix X4. Pollutants are continuously generated and removed with time and an equilibrium level is reached which often varies significantly with time. This is one factor which makes the interpretation of measurements difficult.

Excess Moisture/Humidity are common problems; Leakage, spills, unvented sources (showers or dryers), and infiltration can be significant sources of moisture. Moisture is removed and distributed by ventilation, local exhaust, dehumidifiers, air circulation, and adsorption. Excessive moisture and/or cold spots may result in visible or concealed condensation particularly on poorly insulated surfaces. The result may be physical deterioration, mould growth and health or discomfort effects.

Mould and Excess Moisture; are interrelated problems

Comfort is affected by humidity extremes, temperature extremes, excessive air movement, unevenly heated surfaces or rooms, and polluted air.

Mechanical Equipment; The HVAC system can release combustion pollutants, increase humidity and affect the air quality in general; The house mechanical equipment includes the furnace, fireplace, stove, water heater, water/air cleaners or purifiers, and filters, ventilation, exhaust systems, HRV, air conditioner, and humidifiers/ dehumidifiers. They must be present where needed, function properly, be properly designed and serviced to avoid problems. Mechanical equipment malfunction and bad ventilation are common problems.

Spillage/backdrafting; The relationship of fumes, odour and moisture complaints to house depressurization, to the performance of the flue and exhaust systems, to the wind and stack effect, and to weather should be understood.

Hypersensitivity; The special sensitivities of some individuals to even low levels of pollutants in air, water, and food must be recognized during the investigation.

APPENDIX X6 ANALYSIS OF INDICATORS, EFFECTS AND REMEDIES

APPENDIX X6 ANALYSIS OF INDICATORS, EFFECTS AND REMEDIES

FACTOR	INDICATOR/AFFECT	REMEDY
High Humidity	Lack of General Ventilation, Condensation on Windows, Condensation in Wall/Attic, Odour, Damp (Sensory Perception), Damp Basement, Warped Doors, >60% Humidity,	Increase Ventilation, Passive Vent, Forced fresh Air Supply, Dehumidify,
	Lack of Circulation	Supply Fresh Air to Bedroom and Living Area, Instal Fans, Undercut doors, Increase Number and Distribution Return Air Grills properly Sized and Not Leaky,
	Moisture Sources; Subfloor, Bathrooms, Cooking, Unvented Dryer	Local Exhaust; Kitchen Bathroom, Dryer, Hot Tub, Seal Basement Cracks,
	Determination: Hygrometer	
Low Humidity	<25%, Dry, Static,	Ventilate, Humidify
	Determination: Hygrometer	
Human Bioeffluents	CO2>3500 ppm,	Check and Adjust Ventilation, Increase Outdoor Air, Improve Air Circulation,
	Body odour,	
	Determination; CO2 Level	
High/Low Temperature	Complaints, Temperature Outside 23-27 C Summer, 20-24 C Winter	Improve Air Circulation, Adjust Thermostats/HVAC, Increase Ventilation
	Determination: Thermometer	

Uneven Temperature	Variations in Ceiling, Floor, Surrounding Furniture Temperatures Gradient >3 C Ceiling to Floor or Back to Front Determination; Thermometer	Improve Circulation with Fan, Change Lights, Window Blinds
Poor Ventilation	Stuffy, Fresh Air <5L Per Second per Room, CO2 > 3500 ppm, Odour, Determination; Tracer Gas, Airflow and CO2 measurement, smoke tube,	Improve Circulation, Install HRV, Fresh Air Intake, Adjust Ventilation
Drafty	Airflow Too High; Summer >0.25 m/s Winter >0.15 m/s Determination: Smoke Tube, Katathermometer	Adjust Airflow, Increase Clothing, Relocate Diffusers, Employ Deflectors,
Mould Spore*	Visible Mould, Odour, Water Damage, Poor Air Circulation, Many Plants, Condensation Allergic Reactions; Asthma, Watery eyes,	Wash With Bleach, Reduce Humidity, Deal with Water Leaks, Increase Ventilation, Maintain Humidity between 25 and 65%, Clean and Disinfect Reservoirs in Humidifiers and Dehumidifiers, Eliminate standing Water, Seal Cracks and Holes in Basement, Cover Sump and Drain, Remove and Vent Moisture Sources,

	Sneezing, Coughing, Fever, Shortness of Breath, Lethargy, Respiratory Problems, Determination; Lab analysis of Swabs and Samples Collected on Nutrient Agar, Viable Count is sometimes used	
Odour	Classify; Musty, Pungent, New Furniture, Combustion, Decay, Hobbies, New Carpet, Spills Determination; Experience in Classification, Leave House Frequently to Maintain Acute Sense	Verify Humidity, Remove Source, Ventilate, Clean, Coat Surface,
Offgassing From Materials, Furnishings	New Material Odour, Formaldehyde, Carpet Solvents and Glues, Drapes, Furniture Determination; See Tables for Formaldehyde and VOCs, Sampling Tubes and Badges	Ventilate, Bake Out, Remove Temporarily, Change Materials
Formaldehyde	Pungent Odour Detectable at 0.1 ppm. Eye, Nose and Throat Irritation (0.05 to 0.5 ppm), High Levels: Dizziness, Headaches, Vomiting, Sources: Building materials, Carpets, Smoking, Fabrics, UFFI Insulation, Determination; Passive Samplers	Ventilate, Remove material, Coat,

Hobby Areas	Odour from VOCs Determination; Smell, Sampling Tubes, portable analyzers,	Local Exhaust, Increase Ventilation
VOCs	Odour; Paints, Solvents, Pesticides, Cosmetics, Cleaners, Glues, Hair Sprays, Dry Cleaned Products, New Clothing and Bedding, Depression, Respiratory and Eye Irritations, Some are Narcotics, and Carcinogens, Determination; Sampling Tubes and Badges, Direct Reading Instruments, Odour and Perceptions Tend to be Non Specific Indicators,	Avoid Use, Use according to Instructions, Ventilate, Store Outdoors
Ozone	Electric Odour, Respiratory Irritant, Determination; Smell, Direct Reading Instrument	Repair Electrostatic Cleaners, Increase Ventilation
Radon	Pressure Driven Infiltration into Basement (Stack and Wind) Odourless Gas, Nominal Level is 800 Bq/m3 Determination: Passive, Active Grab Sample or Continuous Monitors	Seal Cracks in Basement, Sub Slab Ventilate, General Ventilation
Combustion Gases from Cars, Furnaces	Odour, Soot, Symptoms of Dizziness, Nausea CO, CO2, NO2, SO2, O2 is Measured. See Tables for Methods and Assessment.	Check Furnace and Outdoor Sources, Traffic, Infiltration from Attached garage, Seal entry Points

	CO is Colourless, Odourless CO2 is Colourless, Odourless, non Flammable. NO2 is Reddish Brown Gas with Pungent Odour, Highly Toxic and Irritating to Respiratory System. SO2 is Colourless Gas with Detectable Odour at low Levels, is Irritating to Skin, Eyes and Mucous Membranes	
CO2	Fatigue, Headaches, Body Odours, Stuffy 3500 ppm ALTER Determination; Direct Reading Instruments, Indicator Tubes	Ventilate, HRV Fresh Air Intake, Improve Circulation
Particulates*	Visible Dust on Floors, Shelves, Smoking, Combustion backdraft from Fireplaces, Wood Stoves, Renovations, Automobile Exhaust, Dander from Pets, Fibers from Man Made Wools, Mites, Pollen and Outdoor Dusts, Carpeting, Eye, Nose and Throat Irritation, Allergies, Headaches, Bronchitis, Determination; Gravimetric, Visual, Light Scattering,	Stop Smoking, Clean, Check Filters, Install Air Cleaner, Ventilate, Remove unvented Combustion Appliances, Use Sealed Combustion Appliances, Reduce Humidity and Clean to Keep Mite Level Down Remove Carpet

APPENDIX X7 FLOWCHARTS

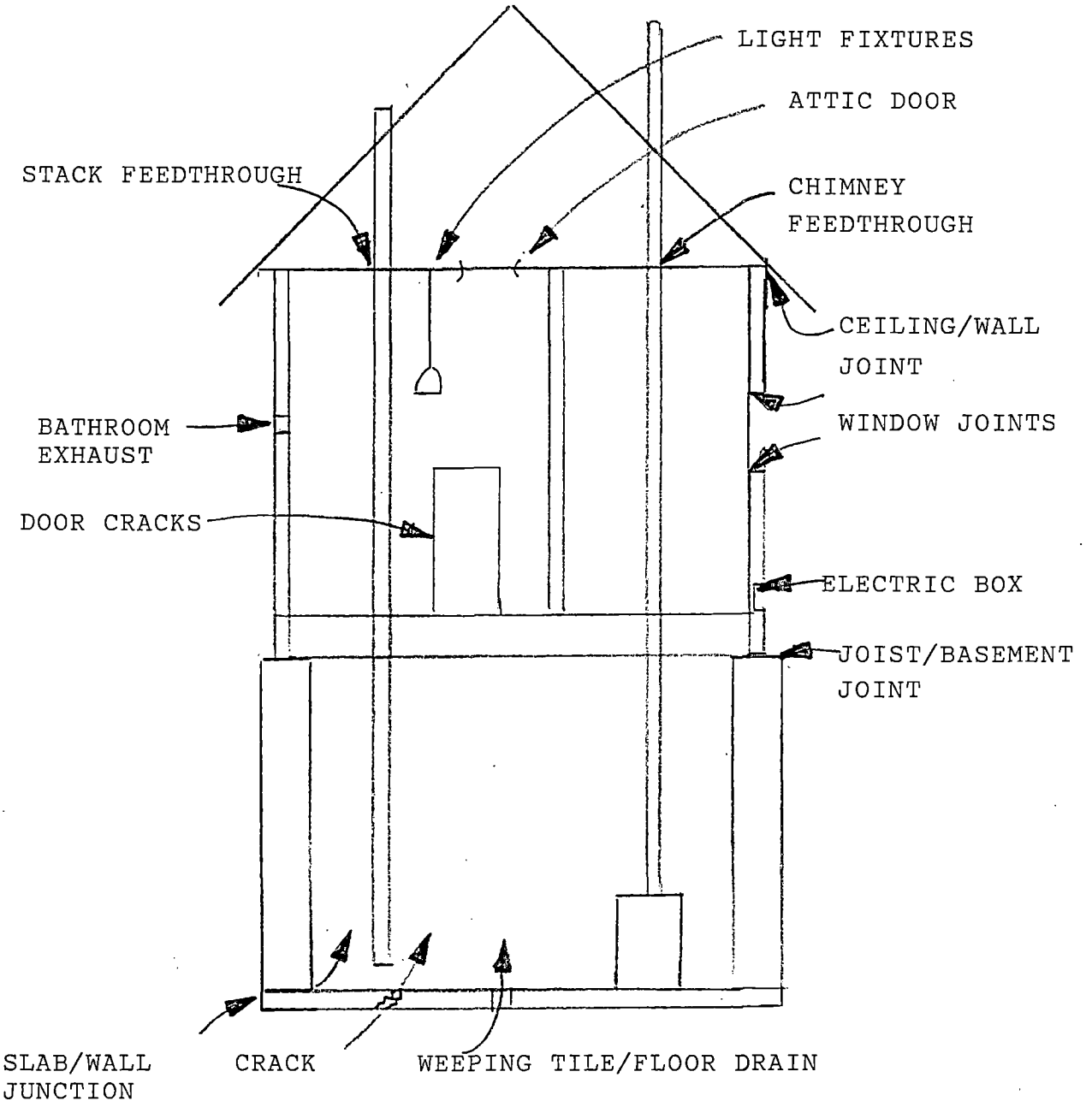
APPENDIX X7 FLOWCHARTS

This appendix contains visual aids and flowcharts, intended to supplement the guidance provided in analysis steps, 3.7.2.2 and 3.7.4.

Guidance is organized according to the following titles;

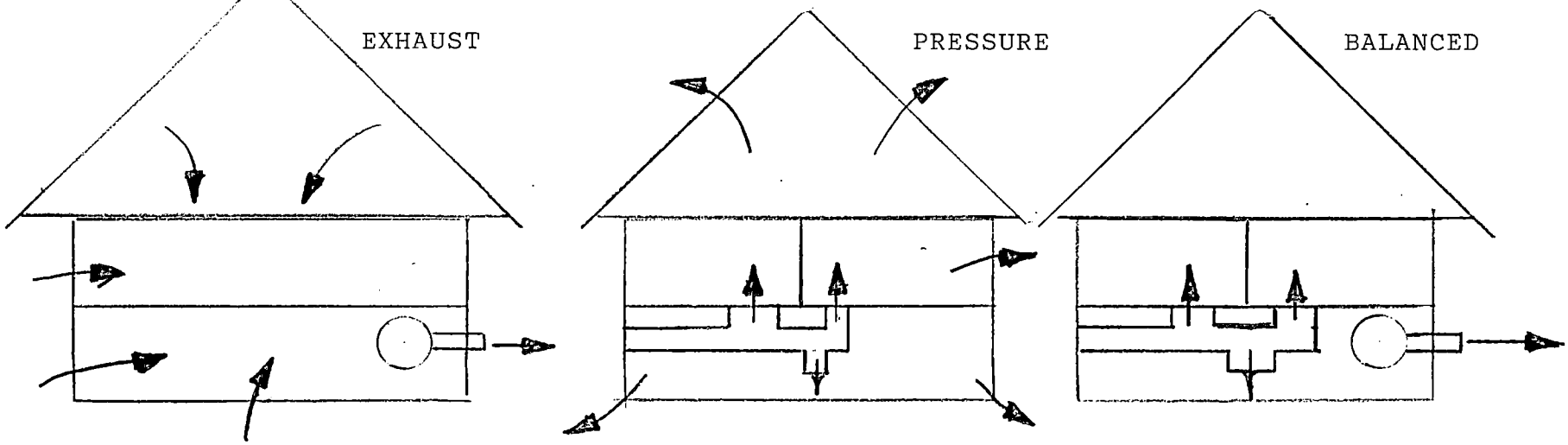
- Indoor Climate/Temperature/Humidity/Airspeed
    - Air Leakage Paths to the Interior
    - Ventilation Systems/Description
    - Flowchart HVAC, Ventilation, Circulation
    - Flowchart Temperature
    - Flowchart Humidity
- Odours, Dust and Gases from Combustion Systems
    - Flowchart Combustion Products
    - Flowchart Dust
- Odours from Chemicals: Solvents, Paints, Cleaners, Formaldehyde
    - Flowchart Formaldehyde
    - Flowchart VOCs/Pesticides
    - Flowchart Radon
- Odours Microorganisms/Mould/Rot
    - Flowchart Microorganisms

AIR LEAKAGE PATHS TO INTERIOR
MOISTURE MOVEMENT, RADON, VENTILATION



NOTE: SEASONAL, CLIMATIC, DIURNAL INFLUENCES

VENTILATION SYSTEMS: DESCRIPTION



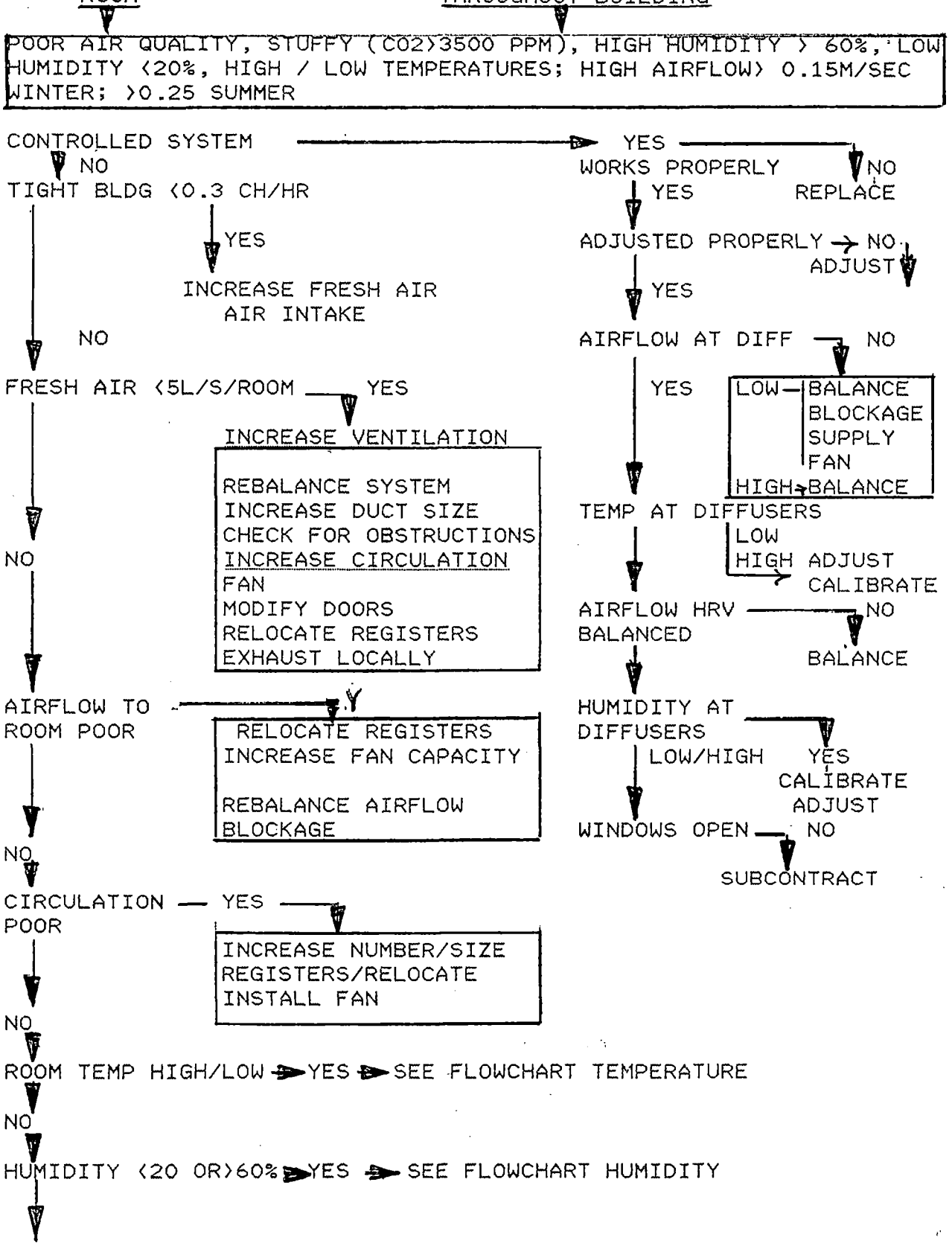
NEGATIVE PRESSURE	POSITIVE PRESSURE	BALANCED
INCREASED MOISTURE & RADON INFILTRATION	MOISTURE BUILDUP IN WALLS	MINIMAL DRAFTS
MAKE UP AIR REQUIRED	HIGHER ENERGY LOSS	MOISTURE MIGRATION
BACKDRAFTING DANGER	MINIMAL DRAFTS	BEST CONTROL
DRAFTS		HIGHER CAP & OPERATING COSTS
		DISTRIBUTION THROUGHOUT HOUSE

TYPICAL AIRFLOWS

KITCHEN HOODS	50-210 L/S
BATHROOM	20-50
CENTRAL VAC	45-65
CLOTHES DRYER	40-55
FIREPLACE	110

FLOWCHART HVAC, VENTILATION ,CIRCULATION

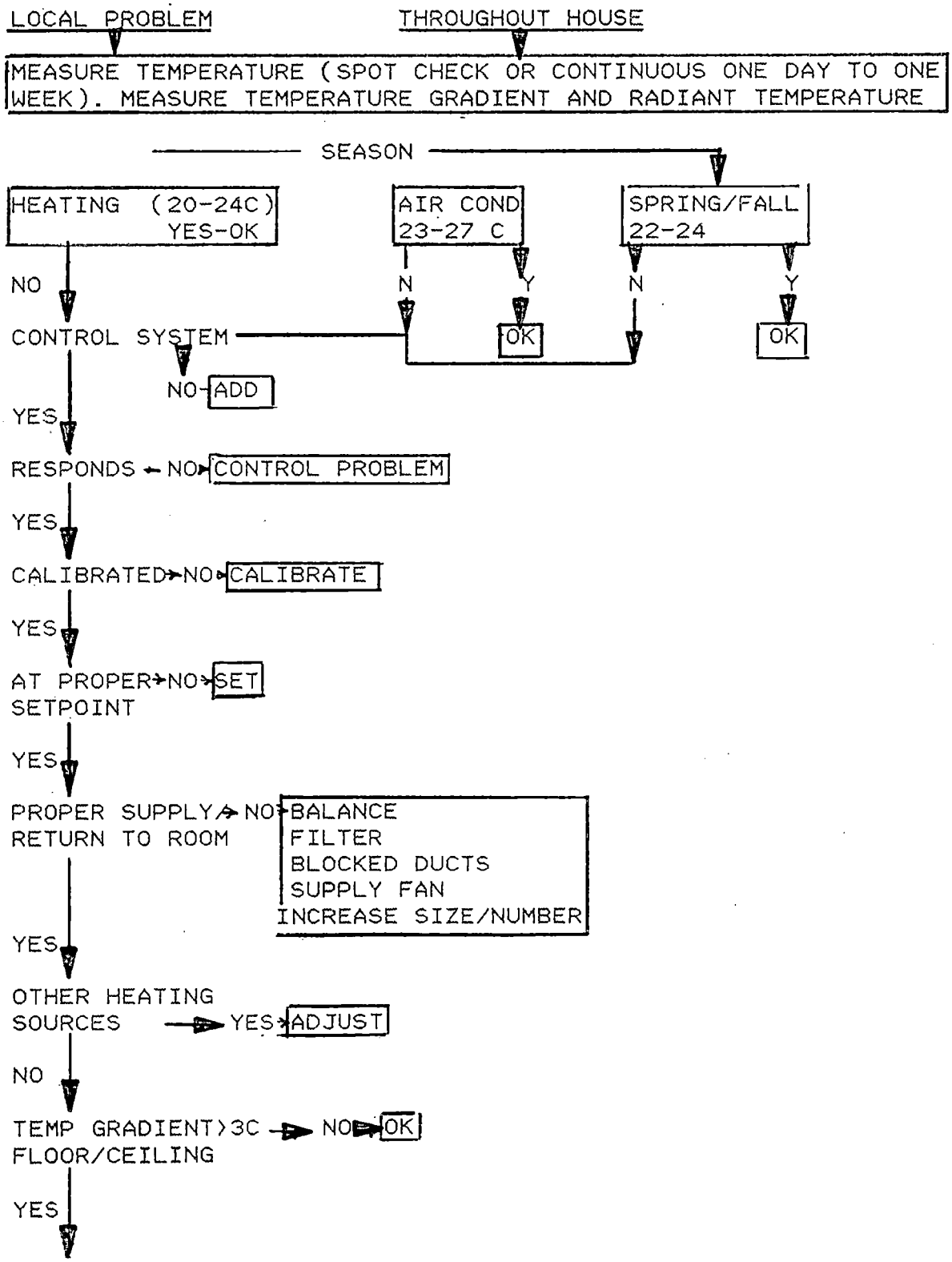
AFFECTS AIR QUALITY, COMFORT, DILUTES SOURCES, INFLUENCES BUILDING HEALTH

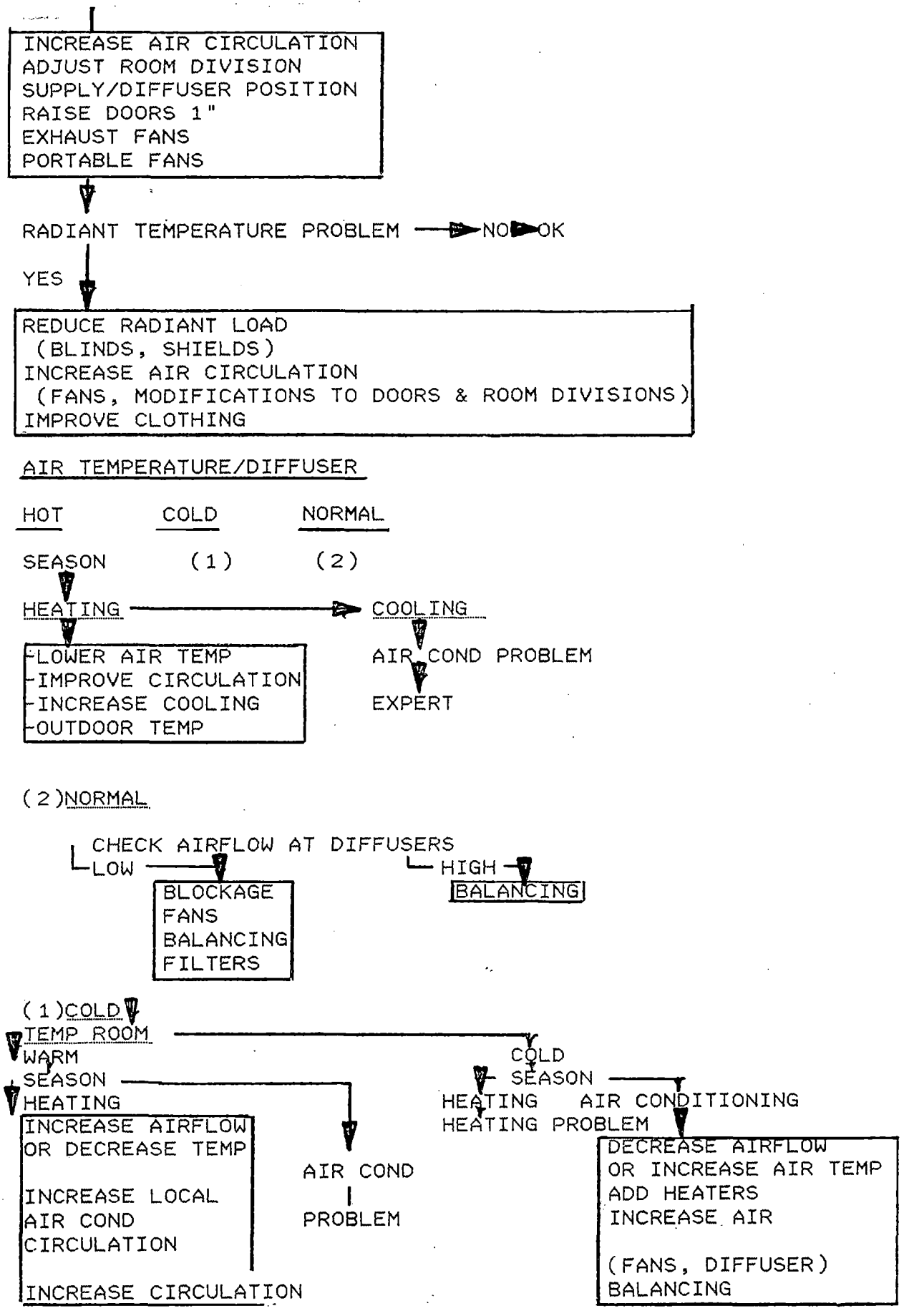


FLOWCHART TEMPERATURE

TEMPERATURE IS INFLUENCED BY OUTDOOR CLIMATE, SEASON, DAILY VARIATIONS, VENTILATION, CIRCULATION, HEATING. TEMPERATURE MAY BE LOCALIZED OR DISTRIBUTED EVENLY THROUGHOUT THE HOUSE.

HIGH TEMPERATURE RELEASES POLLUTANTS




INCREASE AIR CIRCULATION
ADJUST ROOM DIVISION
SUPPLY/DIFFUSER POSITION
RAISE DOORS 1"
EXHAUST FANS
PORTABLE FANS
RADIANT TEMPERATURE PROBLEM
NO
OK
YES
REDUCE RADIANT LOAD
(BLINDS, SHIELDS)
INCREASE AIR CIRCULATION
(FANS, MODIFICATIONS TO DOORS & ROOM DIVISIONS)
IMPROVE CLOTHING
AIR TEMPERATURE/DIFFUSER
HOT
COLD
NORMAL
SEASON
(1)
(2)
HEATING
COOLING
LOWER AIR TEMP
IMPROVE CIRCULATION
INCREASE COOLING
OUTDOOR TEMP
AIR COND PROBLEM
EXPERT
(2)NORMAL
CHECK AIRFLOW AT DIFFUSERS
LOW
HIGH
BLOCKAGE
FANS
BALANCING
FILTERS
BALANCING
(1)COLD
TEMP ROOM
WARM
SEASON
HEATING
COLD
SEASON
HEATING
AIR CONDITIONING
HEATING PROBLEM
INCREASE AIRFLOW
OR DECREASE TEMP
INCREASE LOCAL
AIR COND
CIRCULATION
INCREASE CIRCULATION
AIR COND
PROBLEM
DECREASE AIRFLOW
OR INCREASE AIR TEMP
ADD HEATERS
INCREASE AIR
(FANS, DIFFUSER)
BALANCING

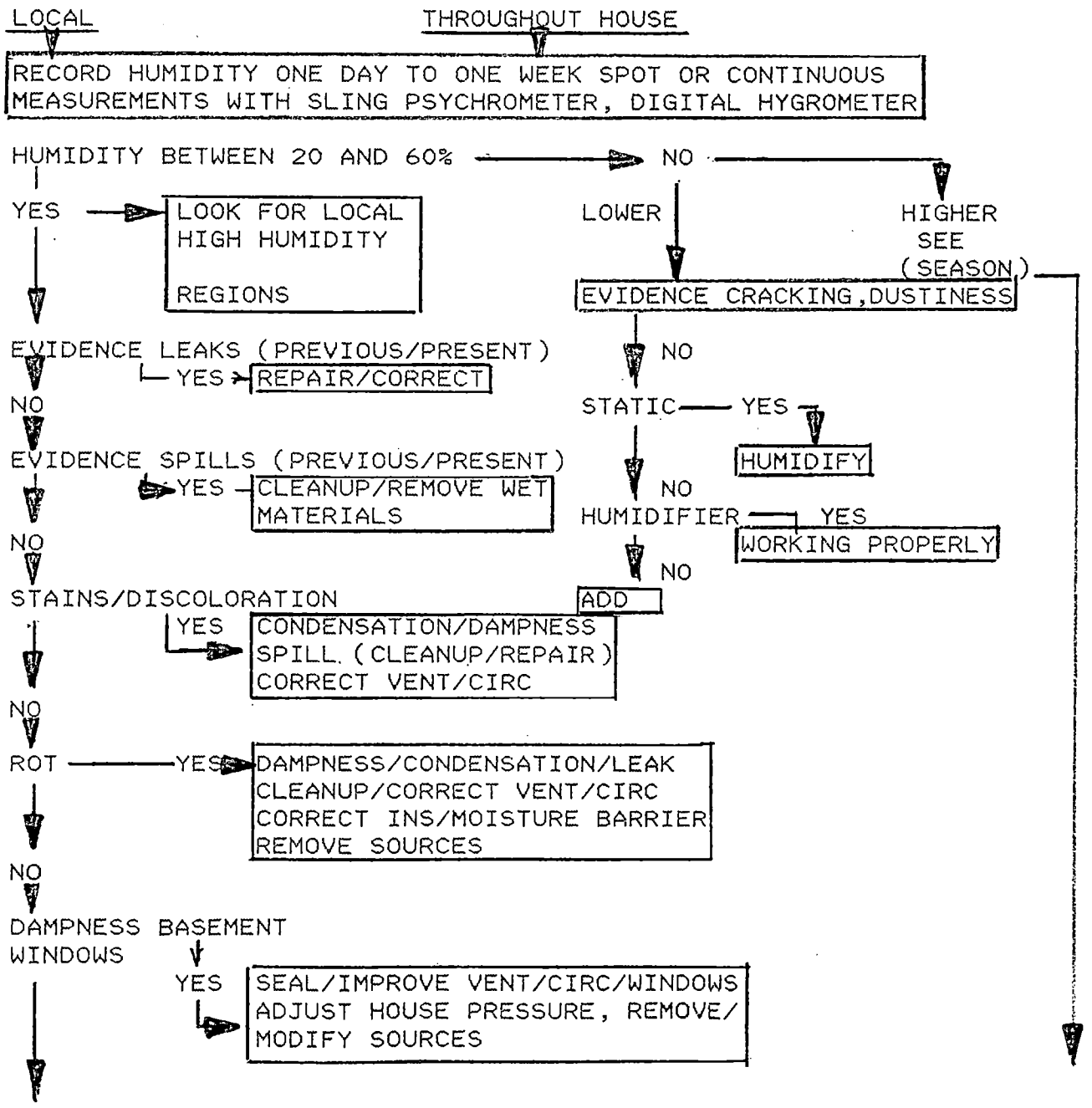
FLOWCHART HUMIDITY

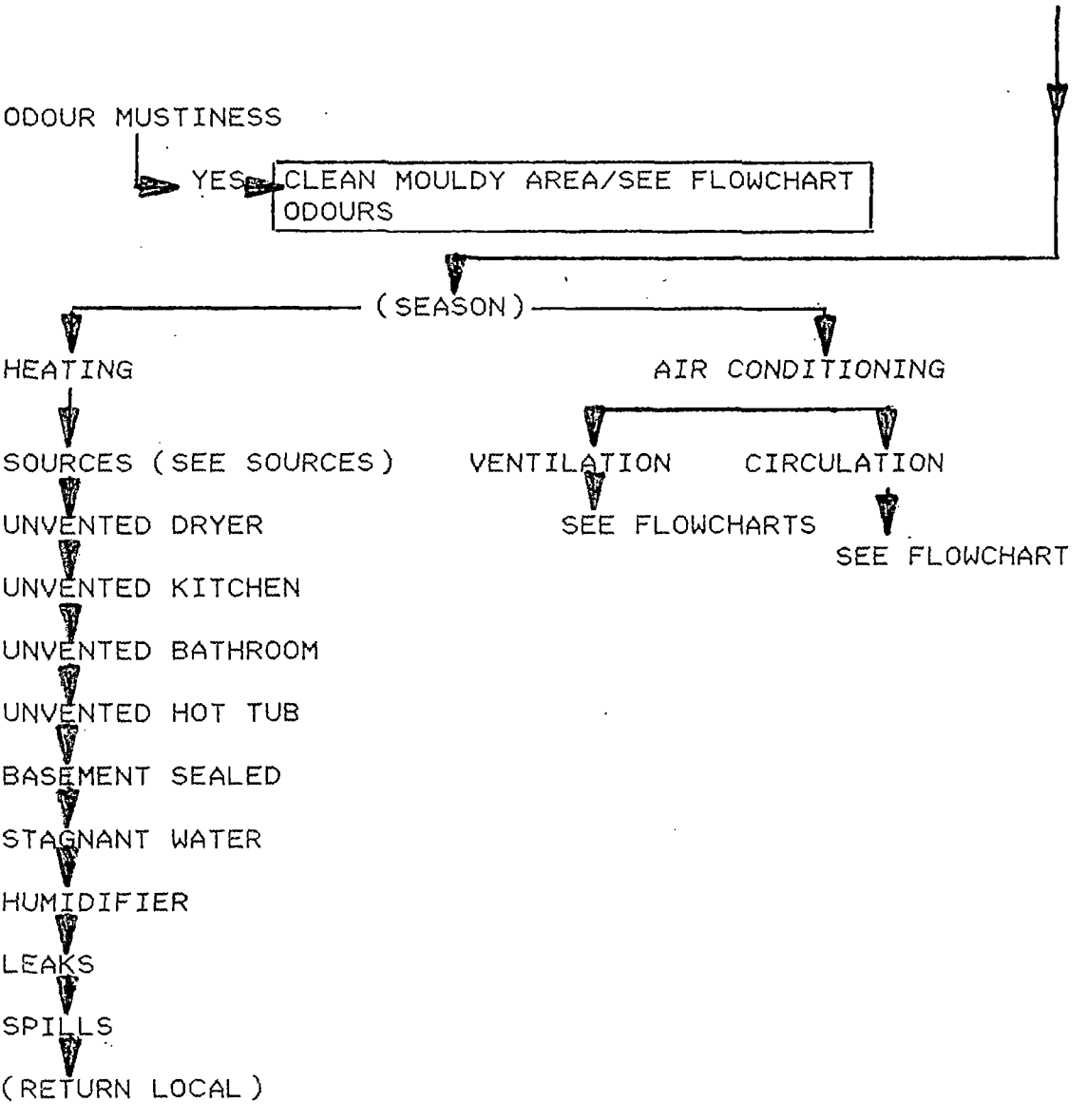
HIGH HUMIDITY ENCOURAGES BIOLOGICAL GROWTH; RELEASES POLLUTANTS, PROMOTES BUILDING DETERIORATION, CAN REDUCE INSULATION VALUE

LOW HUMIDITY PROMOTES STATIC BUILDUP, PRODUCES SENSATION OF DISCOMFORT/DRYNESS, CAUSES CRACKING DETERIORATION, WARPING

HUMIDITY VARIATIONS PROMOTE WARPING AND CRACKING OF BUILDING ELEMENTS AND FURNITURE.

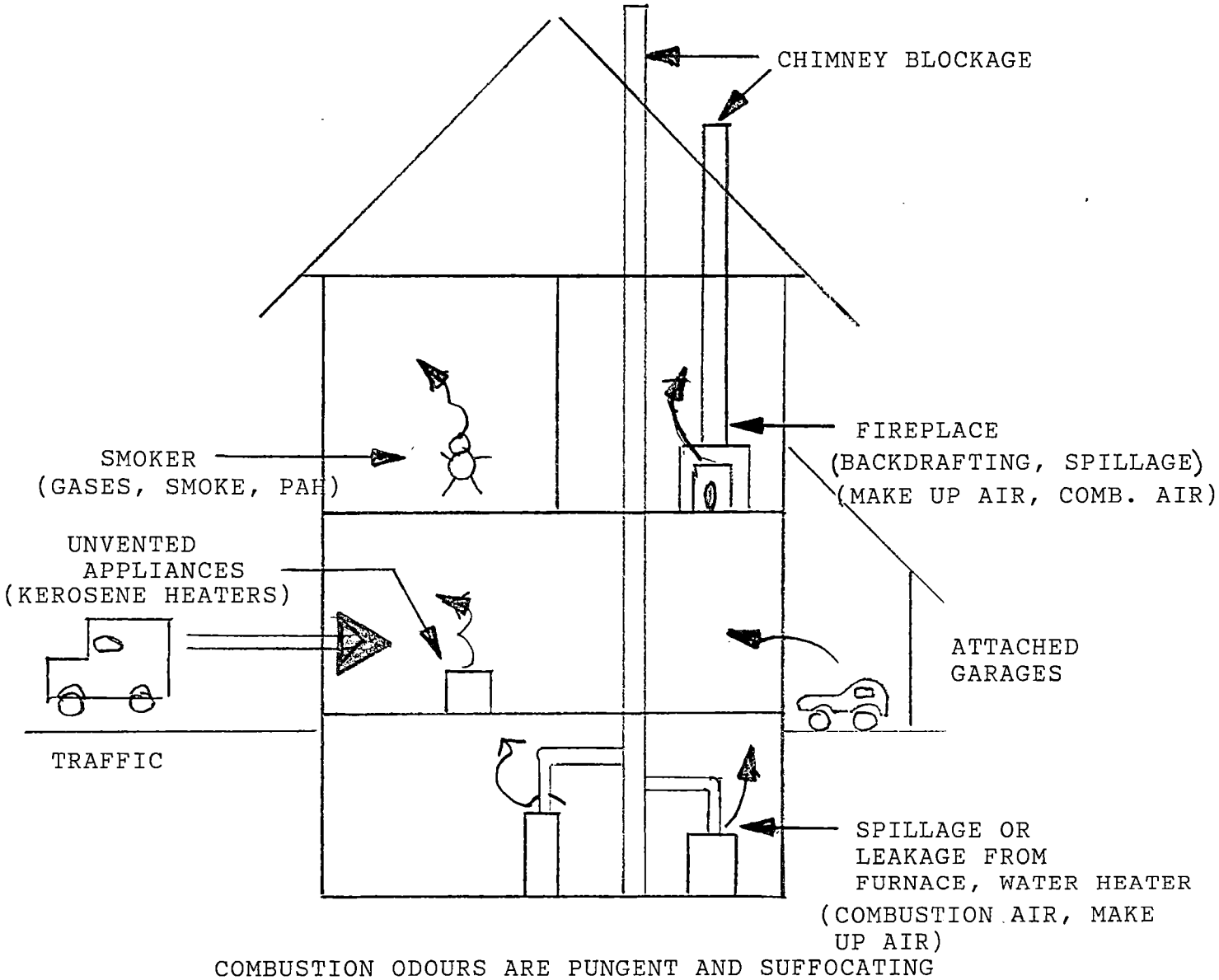
LEVELS AFFECTED BY OUTDOOR CLIMATE, HEATING, VENTILATION, AIR CIRCULATION, SOURCES. HIGH HUMIDITY/DRYNESS MAY BE LOCALIZED OR WIDESPREAD, SEASONAL AND RELATED TO OCCUPANT ACTIVITIES




ODOUR MUSTINESS
YES
CLEAN MOULDY AREA/SEE FLOWCHART ODOURS
(SEASON)
HEATING
AIR CONDITIONING
SOURCES (SEE SOURCES)
UNVENTED DRYER
UNVENTED KITCHEN
UNVENTED BATHROOM
UNVENTED HOT TUB
BASEMENT SEALED
STAGNANT WATER
HUMIDIFIER
LEAKS
SPILLS
(RETURN LOCAL)
VENTILATION
CIRCULATION
SEE FLOWCHARTS
SEE FLOWCHART

ODOURS AND DUST FROM COMBUSTION SOURCES
(NO, CO, CO2, SO2, PAH)

ODOURS AND DUST MOVE FROM SOURCES TO OTHER LOCATIONS VIA PATHWAYS(DOORS, VENTILATION)



COMBUSTION ODOURS ARE PUNGENT AND SUFFOCATING

PROVIDE COMBUSTION AND MAKE UP AIR, REMOVE UNVENTED APPLIANCE, ELIMINATE SMOKING, INCREASE VENTILATION , INSTALL CORRECT FAN

SEAL OPENINGS TO ATTACHED GARAGE, BALANCE VENTILATION

FLOWCHART COMBUSTION PRODUCTS

LOCAL — THROUGHOUT BUILDING

LEVELS AFFECTED BY VENTILATION, CIRCULATION, SOURCE LOCATION, TEMPERATURE HUMIDITY, CLIMATE.

PUNGENT CHOKING SUFFOCATING ODOUR, EYE, NOSE AND THROAT IRRITATION

CO>11PPM, CO2>3500, NO2 (0.05 ALTER; 0.25 ASTER) , SO2 (ALTER0.019;ASTER 0.38), PARTICULATES (<40UG/M3 ALTER;<100UG/M3 ASTER)

SAMPLING ONE DAY TO ONE WEEK (ALSO SPOT SAMPLING GASES)

COMBUSTION EQUIPMENT

VENTILATION AND CIRCULATION

(SEE FLOWCHARTS) MODIFIED BY WIND AND STACK EFFECT)

DEFECTIVE — Y → MAINTAIN INSPECT

N

CHIMNEY — Y → BLOCKAGE DEFECTIVE (CODE)

N

BACKDRAFT — Y → TEST POWER VENT MAKE UP/ COMBUSTION AIR EXHAUST FAN CAPACITY

N

SPILLAGE/LEAKAGE — Y → COMB AIR SUPPLY RETURN GRILL TOO CLOSE ANOTHER EXHAUST EQUIPMENT TOO CLOSE

N

UNVENTED COMB APPLIANCES — Y → REMOVE LOCAL EXHAUST

N

ATTACHED GARAGE — Y → MODIFY PATHWAY MOVE INTAKE

N

SMOKING — Y → STOP

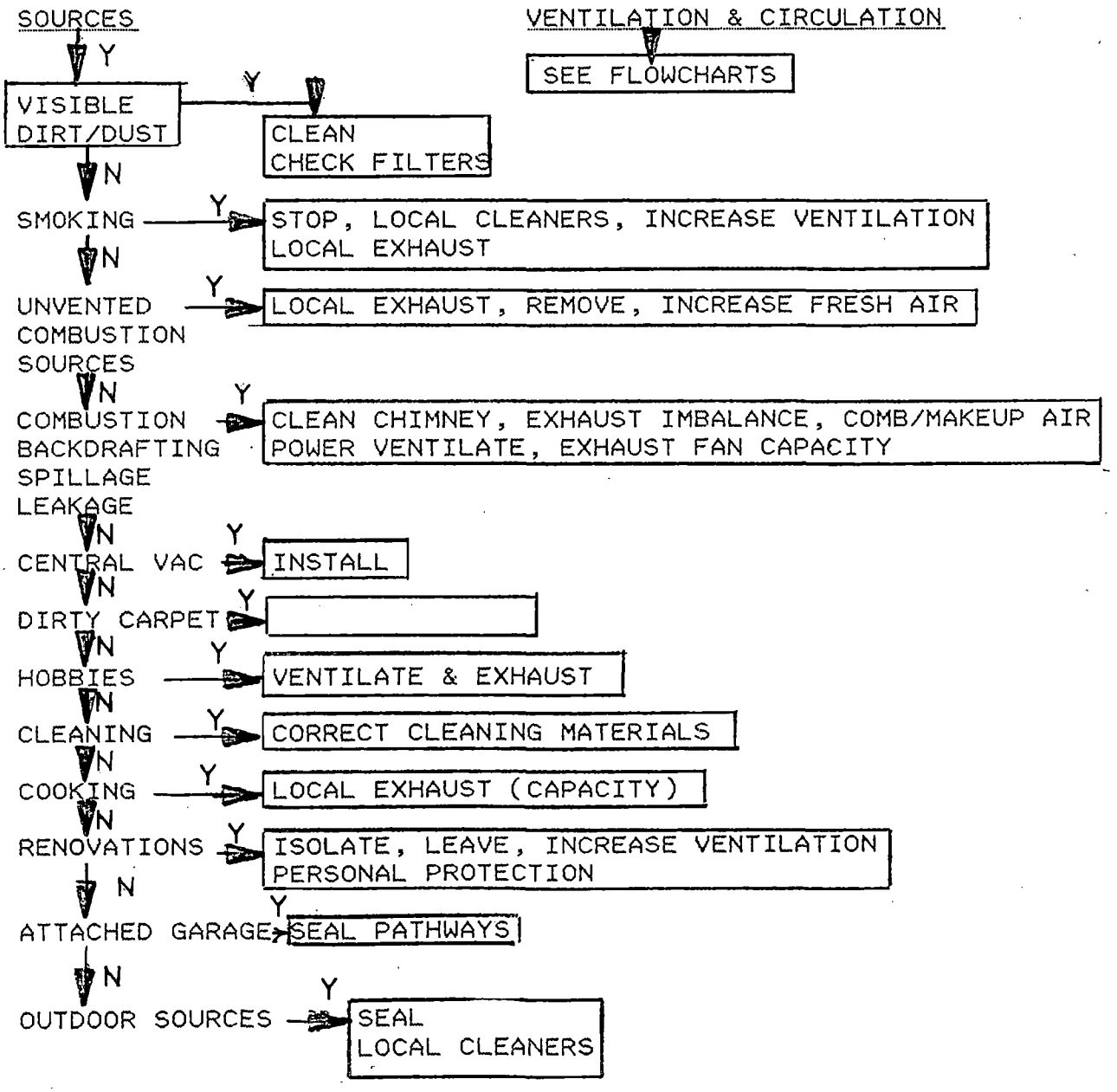
FLOWCHART DUST

LOCAL — DISTRIBUTED THROUGHOUT BUILDING

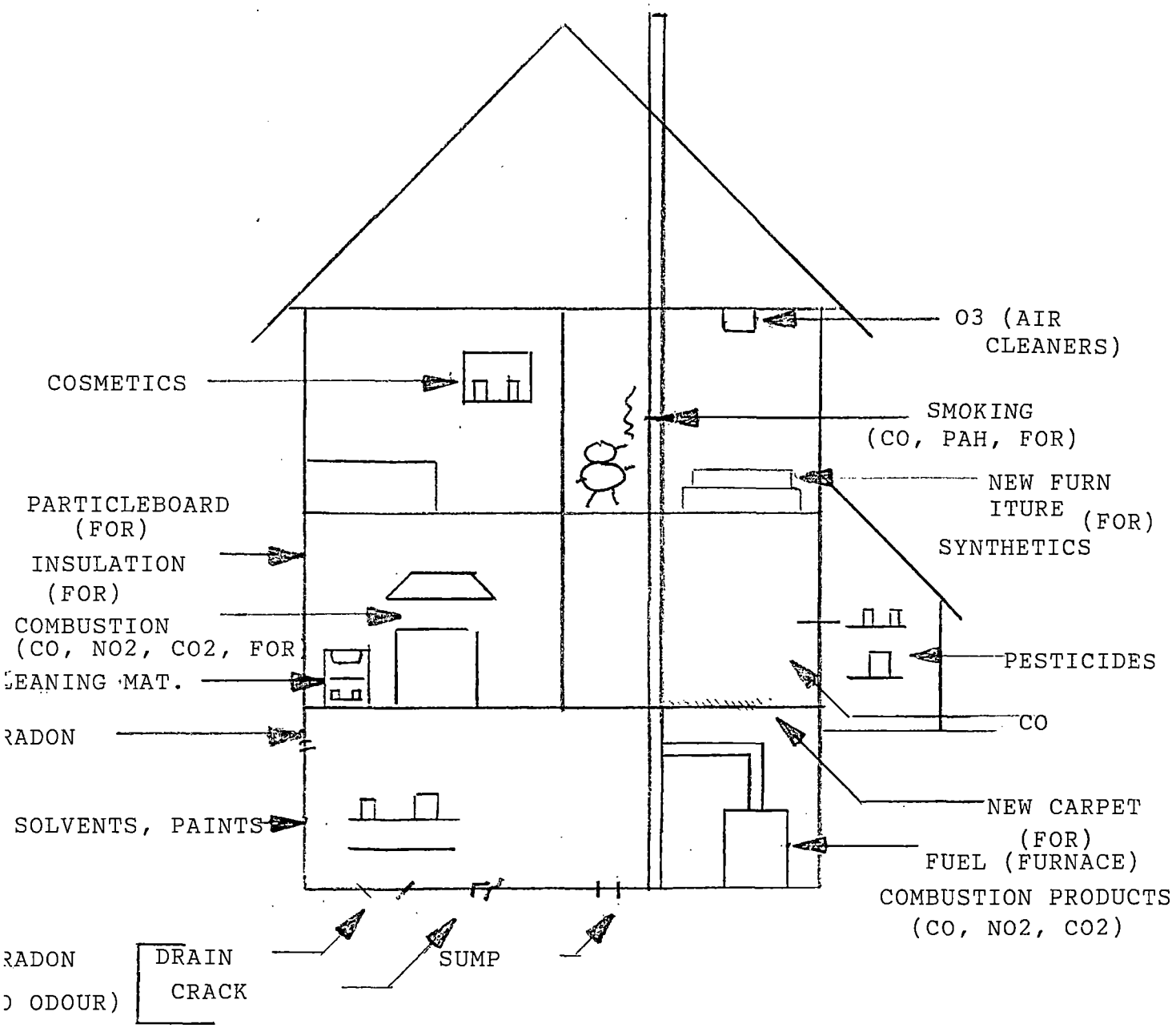
EYE, NOSE AND THROAT IRRITATION, HEADACHES, BRONCHITIS, ODOUR FROM MICROBIALS, COMBUSTION PRODUCTS

CHARACTERIZE SMOKE
CHARACTERIZE BIOLOGICAL CONTAMINANTS (BACTERIA, MOULD, MILDEW, VIRUSES, ANIMAL DANDER, MITES, POLLENS)
CHARACTERIZE INORGANICS (FIBROUS MATERIALS ASBESTOS, HEAVY METALS)
CHARACTERIZE AIRBORNE DUST, RESPIRABLE DUST, FUNGAL SPORES, HOUSE DUST

RESPIRABLE DUST (24 HOUR SAMPLING PERIOD; GRAVIMETRIC ANALYSIS)



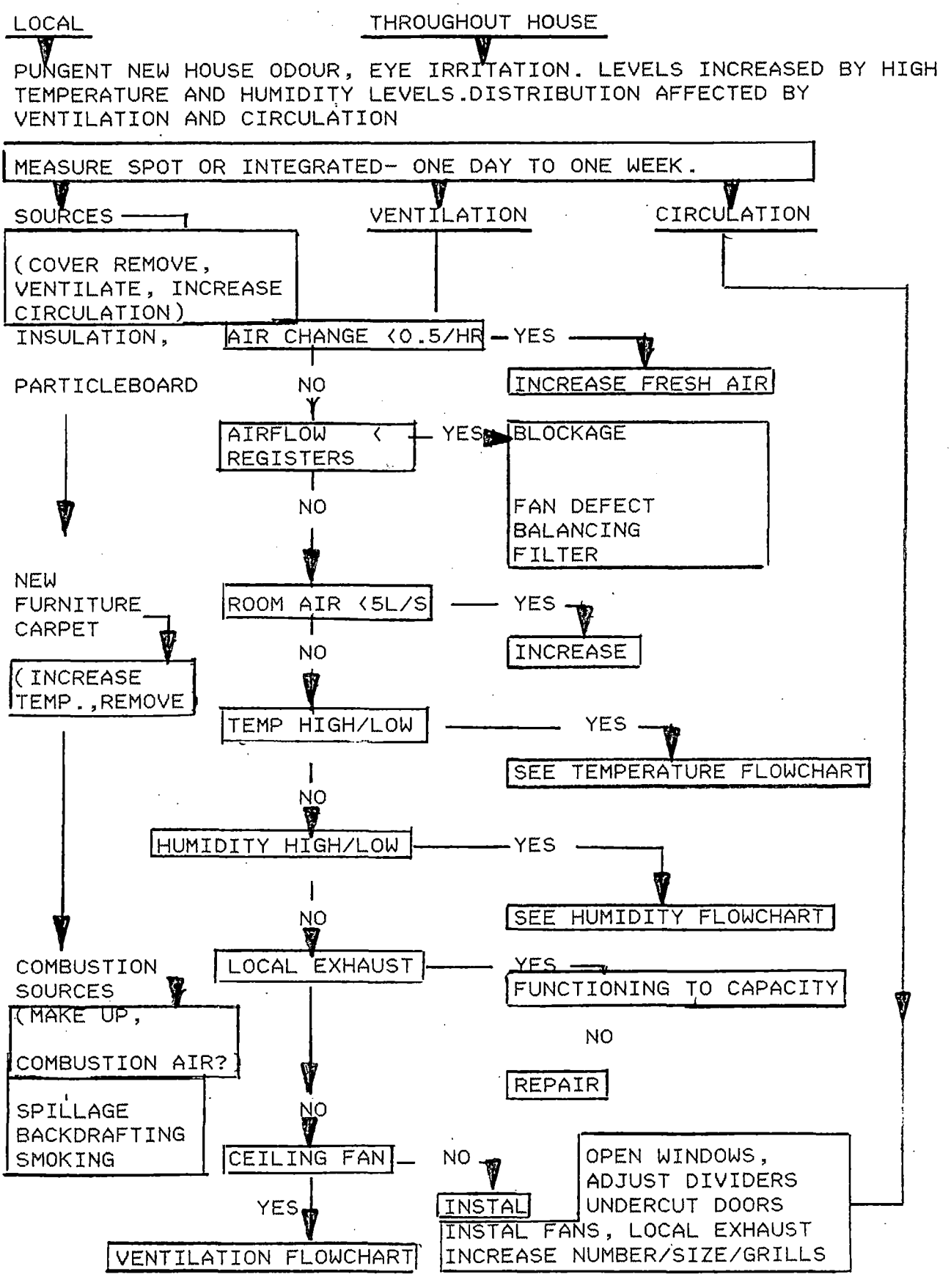
ODOURS FROM CHEMICALS: SOLVENTS, PAINTS, CLEANERS
GLUES, COSMETICS, CLEANING MATERIALS, NEW FURNITURE,
COMBUSTION, PESTICIDES, FUELS (VOCS)



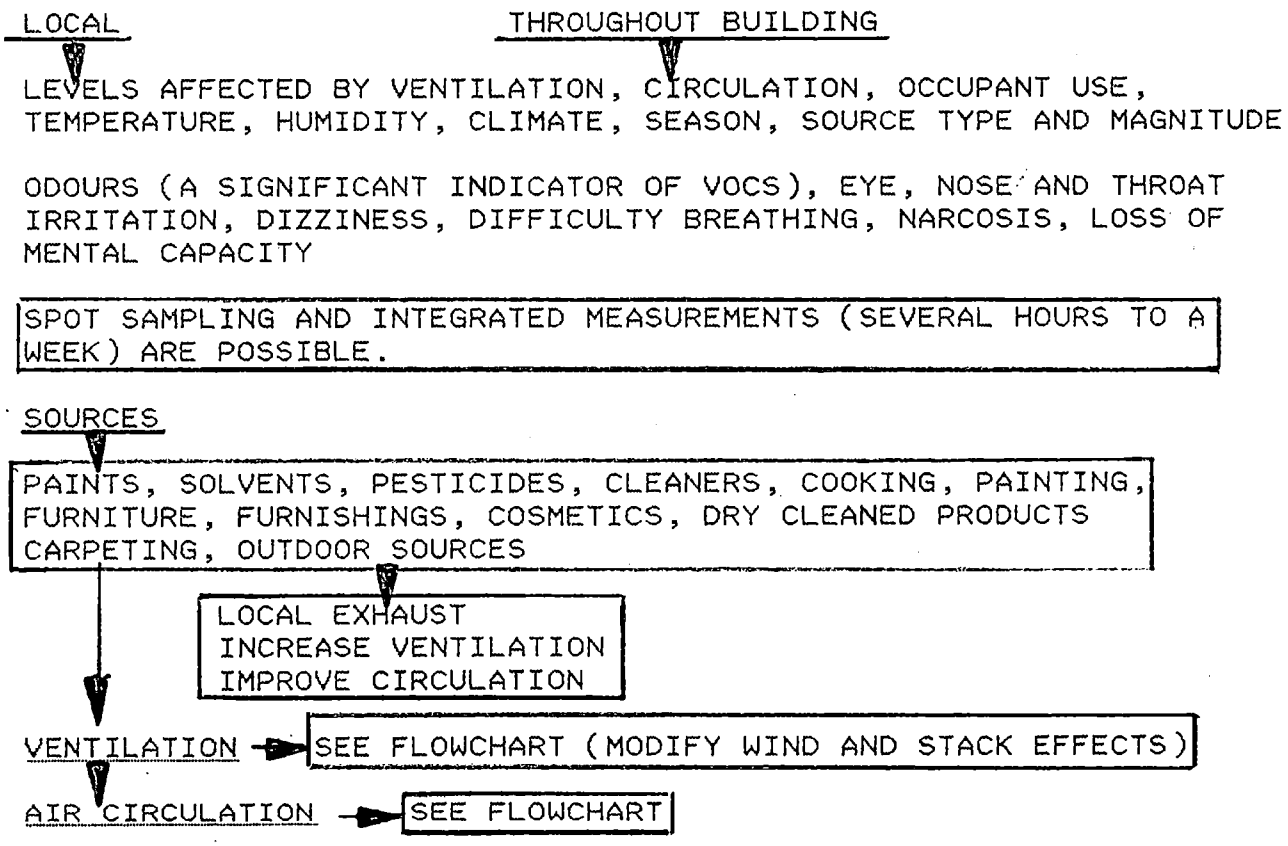
ODOURS MOVE FROM SOURCE BY MEANS OF PATHWAYS (DOORS, VENTILATION)

PROVIDE COMBUSTION AND MAKE UP AIR, REMOVE UNVENTED COMBUSTION SOURCES, ELIMINATE SMOKING, VENTILATE SOLVENT AND PESTICIDE LOCATIONS, SEAL CRACKS, BALANCE VENTILATION, IMPROVE AIR CIRCULATION, REDUCE HUMIDITY, COVER PARTICLEBOARD, CLEAN AREAS

FLOWCHART FORMALDEHYDE



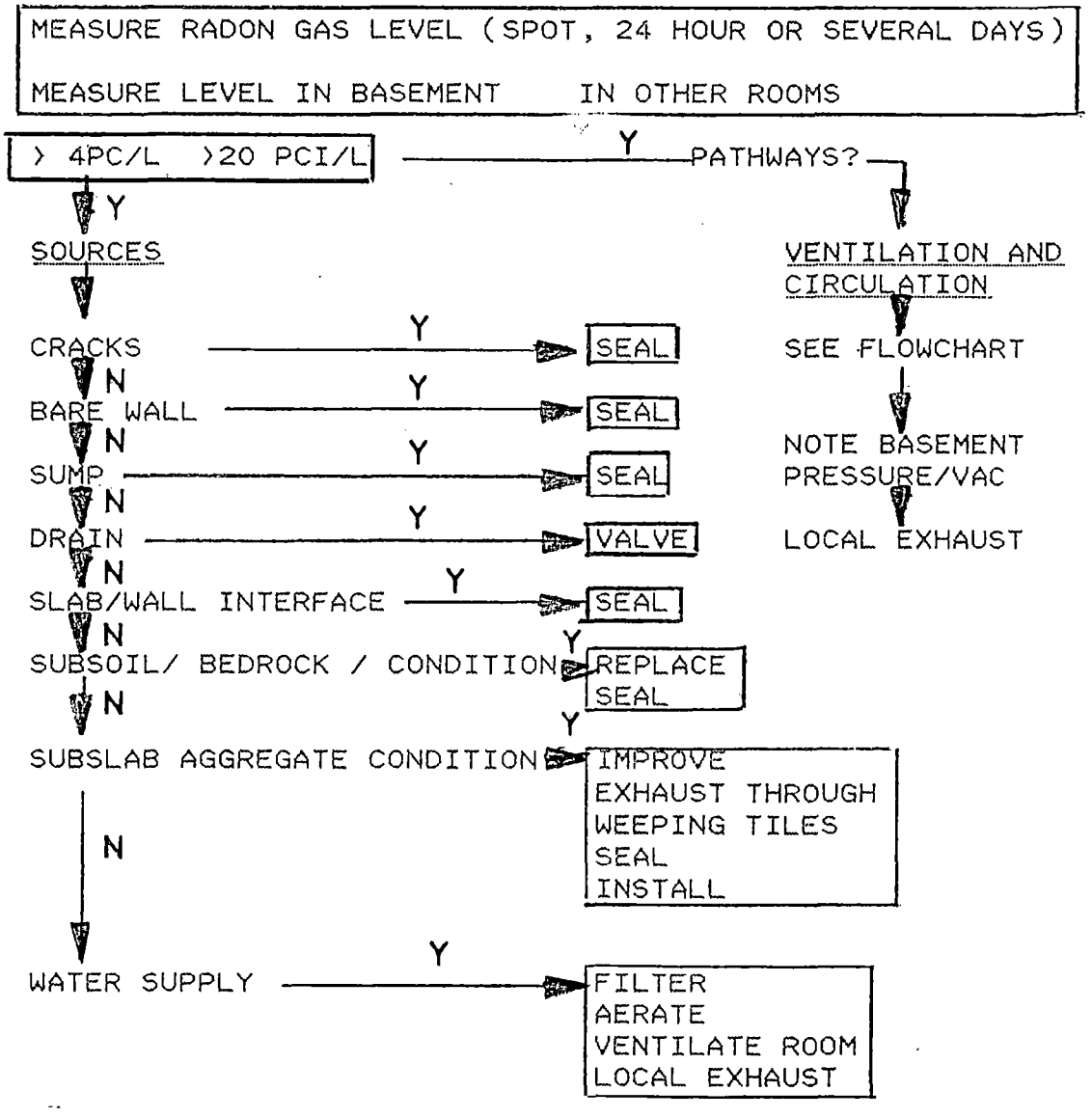
FLOWCHART VOCS/PESTICIDES



FLOWCHART RADON

BASEMENT THROUGHOUT HOUSE

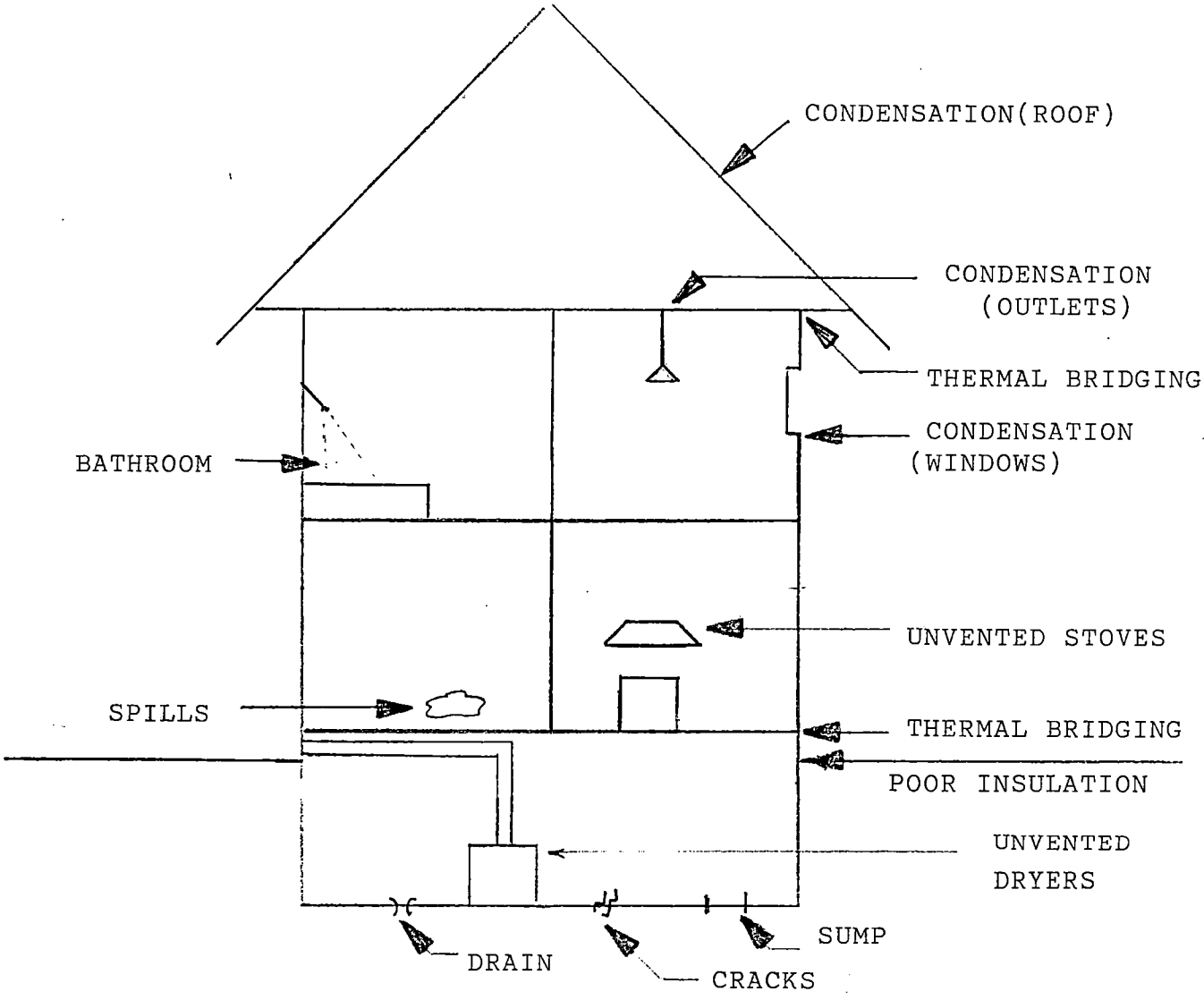
LEVELS AFFECTED STACK AND WIND, NEGATIVE PRESSURE IN HOUSE, SOIL TYPE AND PERMEABILITY, CONDITION OF BASEMENT, VENTILATION AND CIRCULATION, SEASONAL AND DIURNAL INFLUENCES



ODOURS; MICROORGANISMS/MOULD/ROT (ALLERGIES)

NOTE AIR INFILTRATION POINTS , CONDENSATION STAINS AND REGIONS OF HIGH HUMIDITY

-WATER RESERVOIRS
-SEEPAGE
-DAMP BASEMENT
-SPILLS AND WET CARPETING
-FLOOR DRAINS, SUMP
-CRACKS, SLAB/WALL INTERFACE
-WET SUBSOIL



NOTE: REACTIONS INCLUDE ALLERGIES, EYE, NOSE AND IRRITATION

CLEAN AND DISINFECT AREAS, REDUCE HUMIDITY, VENT SOURCES, INCREASE VENTILATION AND AIR CIRCULATION, INCREASE INSULATION AND REPAIR OR INSTALL MOISTURE BARRIER, DRY SPILLS

FLOWCHART MICROORGANISMS

LOCAL → PRESENCE RELATED TO HIGH HUMIDITY, SPILLS, LEAKS, THERMAL BRIDGING. SYMPTOMS MAY OCCUR AFTER EVENT. AFFECTED BY VENTILATION, CLIMATE, SEASON, CIRCULATION, SOURCES METHODOLOGY INCLUDES SYMPTOMS, VISIBLE MOULD, SOURCES OF HIGH MOISTURE, SPOT SAMPLING

THROUGHOUT HOUSE → FLOWCHART AS FOR HUMIDITY → ANALYSIS OF SPOT MEASUREMENT (AGRICULTURE CANADA)

RCS BIOTEST:	
0 CFU/M3	NO FURTHER ACTION
50 CFU/M3	ONE SPECIES ONLY; SPECIES AND SOURCE MUST BE IDENTIFIED
150 -200CFU/M3	SEVERAL SPECIES/ NO FURTHER ACTION UNLESS INDICATED BY INSPECTION
>200 CFU/M3	SEVERAL TO MANY SPECIES PRESENT; PRUDENCE REQUIRES FURTHER INVESTIGATION
=<400-500 CFU/M3	MAINLY CLADOSPORIUM ALTERNARIA; NO FURTHER ACTION
>500CFU/M3	MAINLY CLADOSPORIUM ALTERNARIA; DETERMINE REASON

ANALYSIS SWABS (LABORATORY)

PRESENCE OF MICROORGANISMS OF CONCERN

APPENDIX X8 TYPICAL REMEDIATION RECOMMENDATIONS

APPENDIX X8 TYPICAL REMEDIATION RECOMMENDATIONS

- Improved ventilation
- Improved air vapour barrier
- Minimal thermal bridging
- Improved humidity control
- Adequate furnace sizing, improved operation and safety
- Adequate or improved combustion venting
- Reduced basement dampness
- Improved conditions for the preservation of wood members
- Reduced indoor contaminants
- Adequate or improved attic venting
- Maintain or improved structural adequacy

Methods of Pollutant Control

- Air cleaning
- Source Control
- Local Exhaust
- Ventilation

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GUIDE FOR RESIDENTIAL INDOOR AIR INVESTIGATIONS

PART II TEST RESULTS

FINAL REPORT
EXTERNAL RESEARCH PROGRAM

JUNE 30/ 1994

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CR# 6585-V017-2

DISCLAIMER

This project was carried out with the assistance of a grant from Canada Mortgage and Housing Corporation under the terms of the External Research Program. The views expressed are those of the authors and do not represent the official views of the corporation.

STATEMENT OF PART V FUNDS

Canada Mortgage and Housing Corporation, the Federal Government's housing agency, is responsible for administering the National Housing Act.

This legislation is designed to aid in the improvement of housing and living conditions in Canada. As a result, the corporation has interests in all aspects of housing and urban growth and development.

Under part V of this Act, the Government of Canada provides funds to CMHC to conduct research into the social, economic and technical aspects of housing and related fields, and to undertake the publishing and distribution of the results of this research. CMHC therefore has statutory responsibility to make widely available, information which may be useful in the improvement of housing and living conditions.

This publication is one of the many items of information published by CMHC with the assistance of federal funds.

ACKNOWLEDGEMENT

The authors wish to thank Jim White, Virginia Salares, Don Fugler, Ray Merrill, and the homeowners who participated in the project, for their contributions.

FORWARD/CAUTION

This Guide presents one researchers opinion as to how an investigation should be carried out. Until it is used by others and improved over time it should be used with caution-and only by those with some understanding of building science and the possible health consequences of indoor air problems. We are all at an early stage in our understanding of what poor indoor air quality can cause in the way of illness or discomfort in the individuals exposed to that indoor air. Certain people will be much more sensitive than others to certain pollutants or combinations of pollutants.

Should you have comments on this Guide please pass themm on to Jim White, CMHC, National Office, 700 Montreal Road, OTTAWA, Ont., K1A OP7 (FAx 613-748-2402) and reference file number CR #6585-V017-2. Your input will be carefully considered during development of a consensus Guide that will be produced under the auspices of ASTM.

Note; The complete research report consists of Part I, Short Guide and Reference Guide, and Part II, Test Results.

SUMMARY

The Guide was evaluated by investigating four problem houses and the detailed reports for these investigations are included in a separate report. The test houses were not selected specifically for this study but rather originated as complaints to CMHC and were taken when found. The complaints received however, were typical of those often reported to CMHC.

The problems in three of the four houses were easily identified without any in-depth testing. The exceptional house is being investigated by a contractor and our research was discontinued. The Guide was found to be repetitive and in all cases there was some difficulty in following the stepwise strategy at the test site. The occupants and the layout of the house often affected the sequence of the investigation, but this did not seem to alter the fact that much of the Guide was eventually covered and found useful. The repetition found in the document tended to reinforce earlier observations and helped ensure completeness.

The reported problems were moisture and mould (1), dust (2), moisture and spillage (3), and allergies (4). The evaluation pointed out many problems which required attention and/or pointed out areas which needed improvement.

It was not possible to carry out an in-depth investigation over the phone in any of the cases, and a walk-through the site was necessary before any suggestions could be made. The phone conversation was, however, a useful preparation for the site visit. The investigator was able to evaluate the emergency status of the situation, characterize or review the problem and focus or limit the task. The equipment requirement was easily defined, the occupant was informed of the probable strategy that would be employed, as well as the time involved, and the investigation proceeded quickly or efficiently. The investigator/occupant were both better prepared as a consequence to explain/understand details as the investigation proceeded. The occupant not only had a better understanding of the process, but was able to provide some useful input, and was better able to act on the recommendations. There may be some value in asking the occupant to complete or review the Short Guide in preparation for the walkthrough to help reduce investigation costs.

With practice and use of the Guide, the investigation became more systematic and refined. The Guide is therefore a significant educational tool and would be of value to most inspectors and homeowners.

SUMMARIZED HOUSE RESULTS

The Guide/Short Guides were pilot tested in four houses and the detailed results are presented in a separate report. A summary of the results of these pilot tests is presented here.

House 1; Moisture and Mould

This house had visible water, high humidity and mould in the basement.

Inspection of the house on the outside revealed that the terrain sloped inwards to the house, that the house had no eavestroughs, that the chimney had been rebuilt, that the mortar was deteriorating, and that the roof was complicated and had multiple angles.

Inside the house, there were visible stains on the ceiling near the fireplace, a high ambient humidity and many plants, a bathroom with no exhaust and water damage to walls, a basement with exposed water, efflorescence on carpets and walls, an area with a raised floor and underfloor moisture, several large holes in the floor, many moldy books, and a furnace with a poorly adjusted damper (spillage). The humidifier was still connected to the furnace and the fan was on continuously.

Recommendations for improving drainage included excavating and installing weeping tiles, sealing the foundation, proper backfill, proper slope, and installation of eavestroughs.

Other recommendations included sealing the holes in the floor, removing damaged carpet, venting the subfloor, disconnecting the humidifier, properly adjusting the furnace damper, installing an exhaust fan and refinishing the bathroom.

The roof and fireplace had been previously repaired; the roof was recovered one year earlier.

House Number 2; A Dust Problem

A material was depositing and forming a black stain around kitchen cabinets, on the ventilation diffusers, on the bedspread and at the corners of the rooms. The occupant was concerned about the effects of an unidentified pollutant on her health and kept the windows and doors open.

The house was a new semi-detached house located in a suburban area near a busy road. The neighbours had identical houses but did not have a similar complaint.

The air intake for the gas furnace and the HRV were located close to one another at the rear of the house, about 2 feet above the ground. The rear of the house was located about 30 feet from a noise shield adjacent to a busy highway. There is the possibility that the contaminant may have entered the house via the HRV and may be still doing so.

The HRV was off on arrival, and the door was open to ventilate the house. The HRV filters had been recently cleaned and were of the coarse filter type (so incapable of removing fine particulate). The HRV had a deposit of coarse dirt along the bottom of the fresh air house supply duct from the HRV. The fresh air house supply duct was connected to the gas furnace return air plenum located about 25 feet away.

The house employed a gas heater, gas fireplace and gas hot water heater. The contractor inspected the operation of these devices and found no problems. There was no evidence of soot buildup in the wall cavity adjacent to the fireplace where all the chimneys were located.

The kitchen exhaust was not connected and the bathroom exhaust fan exhausted air at a slow rate. The contractor covered the diffusers with a white cloth in an attempt to verify the origin of the materials entering the living space but there was no evidence of dust.

No obvious dust sources were located. Nor was it clear whether the dust problem was a single or ongoing event. The HRV filters are inadequate to stop the type of particulate (soot) that is causing the problem from entering the building and there is evidence that, at some time, a lot of dust did enter via this route.

The occupant has indicated that the soot could not have originated from the unvented kitchen stove as she does not cook much. There are no open flames in the house (candles), nor were there any in the past. There are no occupant activities which could have produced a sooty dust.

The fireplace was not tested and the flame was not examined as the contractor verified that these parameters were OK.

The source of the problem was not immediately located and tests are underway to isolate and characterize the source. This is a situation where a particulate analysis would be useful ie. Is this an ongoing event? What is the particulate size? The particulate size will help characterize the source (diesel fumes, traffic fumes, outside fires, poorly burning gas flames, leaky combustion chambers, a prior deposit in the ducting).

Research was discontinued at this time since the landlord had already contracted out the task to a specialist.

House Number 3; Moisture and Spillage

In this house an older furnace had been replaced by a high efficiency unit. The occupant had complained about spillage particularly when the strong kitchen fan was on. The house was not tight but the fan was capable of over 200 cfm exhaust airflow.

The chimney was not well designed and did not draw well. The occupant was in the process of improving ventilation to the attic since he observed icing around the access door.

When the efficient gas furnace was installed, the humidity levels in the basement increased and the occupant suspected that this was due to spillage. The new furnace did not incorporate a low speed fan to continuously circulate air around the house and through the basement as did the older furnace.

The occupant had installed a passive fresh air intake directly into the basement, with little improvement in basement humidity levels or on suspected spillage. The occupant was still convinced that spillage was the problem, even though the furnace had a powered vent.

No evidence for spillage was found and the lower humidity levels observed with the older furnace were attributed to improved air circulation (large furnace fan) and more air circulation into the basement. The old furnace continuously vented damp air from the basement, preventing a buildup there and movement of that damp air into upstairs areas.

The occupant was advised to dehumidify his house or to install a low speed fan to encourage more air circulation. The passive vent that he introduced did not improve matters because the house was already quite leaky. During summer periods the humid outdoor air tended to increase basement humidity levels.

House Number 4; Allergies

A boy of 10 years suffered from allergies and hyperactivity.

The house was located on a busy road, was surrounded by vegetation and had a swimming pool in the back yard. The pool was only marginally-treated, and often contained microbiological activity.

The floors were covered with carpeting and a large dog was present. An efficient stove was employed in the basement to heat the entire house. The chimney was stainless and insulated and there was no evidence of spillage. The air circulation in the house was poor and the upstairs areas were often cool with condensation in the windows during winter periods.

A doctor advised a change in diet, plus the removal of carpeting,

plastic drapes and vinyl wallpaper from the boys bedroom as a first step. There was an immediate improvement in the boys health, and no further modifications of the boys living environment were attempted.

The Guide readily identified the probable cuases of the boys allergies and suggested useful remediation measures. It was also noted that a stepwise remediation strategy would be a usefull addition to the stepwise investigation strategy presented in the Reference Guide, since it would also help reduce costs.

DETAILED RESULTS

Case 1

Short Guide for Field Reference

Refer to the main guide for additional information

	File	01
Initial Contact by phone	Date	April 1993
	Location	Ottawa
		Rockliffe

Describe problem and any action/results

health related

neighbourhood related

house related

Complaint is moisture/mould related/ visible moisture in basement in spring/ Moisture leakage near region of chimney.

Identify Caller/address/no. occupants

Two occupants of retirement age/technical background

Assess Urgency and Document Occupant Health/Symptoms Information

Describe complaint/magnitude/timing

No health related complaints

Occupant opinion about urgency

Not urgent

Combustion, gas, biological, chemical odours

None

Symptoms severity, duration and suddenness of onset

None

Association of odours/locations/symptoms

Some odours from basement

Hypersensitivity

n/a

Review of family medical history (short)

No problems

Review of work environment and exposure to sources

Stressful work environment

Remediation attempted by occupant

Furnace fan on continuously, chimney 10 years, new chimney saddle installed without success,

Anyone contacted by occupant for assistance

Several contractors called with respect to roof leak (in

progress).

Assessment of urgency and need for immediate walkthrough
Situation is not urgent

Dangerous Situation

n/a

Instruct client to leave and/or reduce hazard
Contact health services
Contact gas/furnace company
Contact family members/responsible person/neighbour
Evaluate need for other professional assistance
Implement

Immediate Visual Inspection to Relieve Danger

n/a

Emergency equipment needs
Assess hazard
Inspect combustion systems
Spillage
Gas leaks
Venting, chimney and makeup air supply deficiencies
Check for moisture sources, spills and accumulation
Chemical and biological hazards
Outdoor air sources

Walkthrough by Phone **By Investigator**

Equipment needs
Supporting materials
Occupant cooperation/participation

Outdoor Environment/House Exterior
Describe neighbourhood/terrain
older suburb/hilly/wooded
Record climate
5 degrees, calm, clear, spring conditions
Review neighbourhood for sources (checklist)
non identified other than vegetation
Previous use of lot
n/a
Describe lot/drainage around foundation
Lot sloping to house at back, sandy soil, heavily treed
Describe house/age/condition
House is bungalow, about 50 years old, multiple slopes in roof (odd angles), chimney in front of house,
Review building exterior
chimney

Chimney work 10 years ago, problems with leakage around saddle, brick debris still adjacent to building

roof

Replaced last year, odd angular roof

siding

Brick, mortar deteriorated, staining under windows

foundation

Block construction

backfill

Garden adjacent to wall, land sloping into house, brick debris adjacent to house to reduce erosion

eavestroughs

No eavestroughs

other

Vegetation

Large trees in backyard, vines on walls in rear, garden adjacent to wall in rear, bushes along side and in front of house. This is a mature neighbourhood.

Driveway

Asphalt driveway adjacent to house is old and deteriorated

other

comment

Outdoor Source checklist

High road traffic	___	Exhaust from neighbour	
Airport	___	combustion	___
Pollen (plants)	_*_	dryer	___
Dust	___	pesticide spraying	___
Smog	___	Near golf course	___
Near stagnant water	___	Near business	
Near polluted		gas station	___
groundwater	___	dry cleaner	___
Near effluent	___	other	___
On problem soil	___	Near industry	___
		smelting	___
Over dumps	___	paper mill	___
Near landfill site	___	other	___
Soil gas	___	Near agriculture	___
Radon hot spots	___	fertilizer	___
Noticeable happenings		pesticide	___
to residents of the area	___	Other	___

Indoor Environment

Describe house interior

Previous use of house/occupancy

Recent events-renovations, spills

New roof last year, Flooding every spring, not sure if roof

still leaks around chimney (stains on living room sealing)

General impression

House interior in good shape, house seems damp, no obvious odours, lots of plants (60)

Occupant Activities and Air Quality

any venting
No in bathroom, good kitchen vent
cooking
hobbies
cleaning
renovations-painting, construction
other

Describe crawlspace/basement
Partially finished cement block basement, lots of books and shelves, lots of wool, laundry room in basement, sectioned into four large rooms, raised floor in one of the rooms.

Describe building envelope

tightness
Not tight
leakage around windows/doors
Double windows, no condensation evident (owner), no drafts
leakage through cracks/sump/drain
Open sump, open hole with water, efflorescence on walls carpets, and floor, visible, water on floor, water under finished floor.
insulation and cold spots
Older house
VOC sources;carpets, building materials, flooring, drapes
No new materials
Moisture/radon sources; Drains, crawlspace, sump, basement
Plants, exterior moisture through basement, unvented bathroom

Combustion systems

Describe;type, age, condition, status
old oil furnace, condition uncertain, fan continuously running
gas and combustion leaks
Possible spillage from damper which is at odd angle, Drainage stains on chimney
evidence spillage
Barometric damper probably spills
venting, chimney and makeup air supply deficiencies

n/a
filter inspection
n/a
combustion systems safety check
n/a
humidifier
connected
other
comment
Hole adjacent to furnace through floor is source

Ventilation/HRV/Air Conditioning/Humidification/Dehumidification

Describe
Humidifier on furnace
general air quality impression; stuffy, humid, odours
Humid
uncontrolled/controlled
uncontrolled ventilation, some attempt is made by opening and closing doors and using the kitchen fan
drafts/leaks
Building is not tight, air movement not checked
air movement and circulation with smoke pencil
Not done
stagnant water
no
filters
Standard low efficiency filter
depressurization and airflow balance
particulate sources/removal
other
comment

Moisture Sources

unvented dryers
unvented bathrooms
yes
humidifiers
furnace
unvented cooking
dirt floor crawlspace/ damp basement
yes
stored firewood
vegetation
Many plants
other
comment
Many books in basement could act as sink

Chemical Sources

odours
    Mould
chemical type
storage areas
use
hobby areas
spills
local exhaust
new materials, furniture, furnishings

Biological Sources

mould
    Little evidence
animals
    Previous dog
unclean areas
garbage
other

House Dust Sources

nature and level
    previous dog left hair in ducting
location (shelves, heating system)
furnace filter
rugs, drapes, hard to clean shelves
    Not many rugs
other

Air Cleaners

type
    Furnace only
size,
condition,
ozone generation
other

Stored building materials

firewood
construction materials
type/quantity
other

Bathrooms

general impression
    walls and ceiling need work
vented/ventilation
    no local exhaust

odours
insulation
humidity
    evidence of high humidity
condensation/leaks
deterioration
    yes
mould/moisture accumulation (toilet, sink, bathtub)
spills
other

Kitchen

general impression
    good shape
odours
venting/ventilation
    high capacity kitchen exhaust fan
insulation
condensation/leaks
humidity
moisture/mould (sinks, refrigerator)
deterioration
spills
other

Ceilings/attic

general impression
condensation
moisture, leaks
    Evidence of previous leak
mould
loose insulation
stained ceilings
    Yes
asphalt shingles
obvious air movement through ceiling fixtures, cracks (smoke pencil)

Garage/storage building

attached
    none
chemicals present
pathways

General Review/Verbal Summary on Site

The following are problems/potential problems;
    -drainage
    -eavestroughs

-humidifier on furnace
-large number of plants
-flue pipe
-bathroom venting
-paper storage

Describe/Recommend

-eavestroughs
-sloping land away from house/grass/to excavation and installation of proper footing drains, damproofing and backfill
-dehumidifier
-disconnect furnace humidifier
-vent finished basement floor
-finish bathroom with local exhaust

Case 2

Short Guide for Field Reference

Refer to the main guide for additional information

	File	02
Initial Contact by phone	Date	May 11/93
	Location	Amberwood
Describe problem and any action /results		Ottawa

health related
Perceived problem; concern about air quality

house problem
Black/oily dust/markings on cabinets/supply diffusers bedspread. A contractor is investigating.

environment related

Dust may originate from outside

other

Identify Caller/age/occupancy

Retired disabled woman/sole occupant

Assess Urgency and Document Occupant Health Information

Describe complaint/magnitude/timing
Origin recent/timing unclear/doors are now left open and HRV/furnace is off.

Occupant opinion about urgency
Occupant concerned

Combustion, gas, biological, chemical odours
None
Symptoms severity, duration and suddenness of onset

No obvious symptoms
Association of odours/locations/symptoms
No odours
Hypersensitivity
No
Review of family medical history (short)
Occupant handicapped
Review of work environment and exposure to sources
none
Remediation attempted by occupant

Anyone contacted by occupant for assistance
Company hired/checked furnace/checked dust flow/checked
HRV filters/reviewed house and outdoors for sources
Assessment of urgency and need for immediate walkthrough
Not urgent

Dangerous Situation

a n/a *

Instruct client to leave and/or reduce hazard

Contact health services

Contact gas/furnace company

Contact family members/responsible person/neighbour

Evaluate need for other professional assistance

Implement

Immediate Visual Inspection to Relieve Danger

a n/a *

Emergency equipment needs

Assess hazard

Inspect combustion systems

Spillage

Gas leaks

Venting, chimney and makeup air supply deficiencies

Check for moisture sources, spills and accumulation

Chemical and biological hazards

Outdoor air sources

other

Walkthrough by Phone **By Investigator**

Equipment needs

Supporting materials

Occupant cooperation/participation

Outdoor Environment

Note weather
Calm, warm, clear skies

Describe neighbourhood/Terrain
New subdivision located on rolling terrain. Semidetached housing

Review neighbourhood for sources (checklist)

Previous use of lot
Farmland
Describe lot/drainage around foundation
Standardized

Describe house/age/condition
New house

Review building exterior

chimney

roof
asphalt shingles
siding
brick
foundation
poured concrete/basement
backfill
OK
eavestroughs
yes
Vegetation
none

Driveway
asphalt
Other

Outdoor Source checklist

High road traffic	_*_	Exhaust from neighbour	
Airport	___	combustion	___
Pollen (plants)	___	dryer	___
Dust	___	pesticide spraying	___
Smog	___	Near golf course	___
Near stagnant water	___	Near business	
Near polluted		gas station	___
groundwater	___	dry cleaner	___
Near effluent	___	other	___
On problem soil	___	Near industry	___
		smelting	___
Over dumps	___	paper mill	___
Near landfill site	___	other	___
Soil gas	___	Near agriculture	___
Radon hot spots	___	fertilizer	___
Noticeable happenings		pesticide	___
to residents of the area non		Other	___

Indoor Environment

Describe house Interior
House has main floor and basement/hardwood floors/gas fireplace on main floor/large living room.

Previous use of house/occupancy
no previous occupants
Recent events-renovations, spills
none
General impression
House clean, no odours but being ventilated by open door
Other

Comment
No sources identified at this stage

Occupant Activities and Air Quality

any venting

cooking
exhaust not connected/does not often cook
hobbies
no
cleaning
no

renovations-painting, construction
new house
other
occupant does not burn candles or engage in fume generating hobbies.

Describe crawlspace/basement

clean/dry basement/no leaks/no stored materials

Describe building envelope

tight
yes
leakage around windows/doors
no
leakage through cracks/sump/drain

insulation and cold spots

VOC sources;carpets, building materials, flooring, drapes
no obvious sources
Moisture/radon sources; Drains, crawlspace, sump, basement
n/a
Other

Comment

Combustion systems

Describe; Age, condition, type
Gas furnace/long fresh air intake/central location
Gas fireplace/
Systems checked by contractor
Gas water heater
gas and combustion leaks
no obvious/furnace was off during visit/checked by contractor
evidence spillage
none/no test done
venting, chimney and makeup air supply deficiencies
none

filter inspection
filters to coarse
combustion systems safety check
not done

humidifier connected
yes/off
other

comments
The occupant claims that the contractor and furnace

technician checked the combustion systems/possibility something left inside?

Ventilation/HRV/Air Conditioning/Humidification/Dehumidification

describe system
HRV installed/filters clean on intake and exhaust/filters too coarse to trap type of deposit noted

general air quality impression; stuffy, humid, odours
house was open prior to visit
uncontrolled/controlled
controlled HRV
drafts/leaks
no
air movement and circulation with smoke pencil
not tested
stagnant water

filters
cleaned
depressurization and airflow balance
not known
particulate sources/removal
evidence of dust intake through HRV/large deposit in bottom
other

comment

Moisture Sources

unvented dryers

unvented bathrooms
bathroom exhaust poor
humidifiers

unvented cooking

dirt floor crawlspace/ damp basement

stored firewood

vegetation

other

comment

Chemical Sources

odours

chemical type

storage areas

use

hobby areas

spills

local exhaust

new materials, furniture, furnishings

other

comments

House Dust Sources

nature and level
    fine oily black deposit
location (shelves, heating system)
    cabinets/diffusers/bedspread
furnace filter
    ok
rugs, drapes, hard to clean shelves
    clean
other

comment

Air Cleaners

type
    HRV/standard filters
size,

condition,
    cleaned by contractor
ozone generation

other

Stored building materials

firewood

construction materials

type/quantity

other

Bathrooms

general impression

vented/ventilation
    poor
odours
    no
insulation

humidity

condensation/leaks

deterioration

mould/moisture accumulation (toilet, sink, bathtub)

spills

other

comments

Kitchen

general impression
    clean

odours
    no
venting/ventilation
    poor
insulation

condensation/leaks

humidity

moisture/mould (sinks, refrigerator)

deterioration

spills

other

comments
occupant dose not cook often

Ceilings/attic

general impression
not checked

condensation

moisture, leaks

mould

loose insulation

stained ceilings

asphalt shingles

obvious air movement through ceiling fixtures, cracks (smoke pencil)

other

comments

Garage/Storage Building

attached
yes
chemicals present
no
pathways

other

comment

General Review/Summary on Site

-black deposit noted as claimed
-origin undetermined. Contractor has covered diffusers to isolate furnace influence.
-Occupant claims sooty deposit could not have originated from cooking although fan does not work.
-the occupant does not engage in candle burning etc.
-As far as the occupant knows no outdoor sources/events were noted

Describe/Recommend

-the contractor is attempting to isolate the source by cleaning the HRV filters and putting filters on the diffusers. The HRV filters are poor quality and probably will not remove the fine type of dust coming in from the outside.
-Air samples are recommended to identify material and/or determine whether the source is still active. Outdoor samples are also recommended.
-Medium efficiency furnace filters could be employed; with the ventilation continuously on.

Case 3

Short Guide for Field Reference

Refer to the main guide for additional information

	File	03
Initial Contact by phone	Date	May 6/1993
	Location	SW Ottawa

Describe problem and any action/results

health related
Occupant claims spillage may be still occurring after old furnace was replaced.

house problem
Occupant complains of spillage and moisture problems. Has installed new high efficiency furnace but humidity levels in basement remain high. Strong kitchen fan used to backdraft furnace.

environment related

other

Identify Caller/age/occupancy
Retired couple/2 occupants age about 55.
Assess Urgency and Document Occupant Health Information

Describe complaint/magnitude/timing
Concern about spillage during furnace operation.
Occupant opinion about urgency
Concern/not urgent
Combustion, gas, biological, chemical odours
No combustion odours/air movement from dilution port
Symptoms severity, duration and suddenness of onset
No symptoms

Association of odours/locations/symptoms

Hypersensitivity

Review of family medical history (short)

Review of work environment and exposure to sources

Remediation attempted by occupant
Occupant has replaced furnace with high efficiency gas/powered vent/has introduced fresh air duct in basement/is ventilating attic/complains that may need to install furnace fan to circulate air in house to reduce humidity levels. Kitchen used to backdraft older furnace.

Anyone contacted by occupant for assistance
Furnace company recommended new furnace/fresh air vent

Assessment of urgency and need for immediate walkthrough
Not urgent

Dangerous Situation

a n/a *

Instruct client to leave and/or reduce hazard

Contact health services

Contact gas/furnace company

Contact family members/responsible person/neighbour

Evaluate need for other professional assistance

Implement

Immediate Visual Inspection to Relieve Danger

a n/a *

Emergency equipment needs

Assess hazard

Inspect combustion systems
Spillage
Gas leaks
Venting, chimney and makeup air supply deficiencies

Check for moisture sources, spills and accumulation

Chemical and biological hazards

Outdoor air sources

other

Walkthrough by Phone **By Investigator**

Equipment needs
Inclined manometer/spillage detector/humidity/temperature gauge, smoke pencil
Supporting materials

Occupant cooperation/participation
Very interested
Outdoor Environment

Note weather
calm, clear, 15 C
Describe neighbourhood/Terrain
Older suburb in Ottawa near Queensway/terrain flat/corner lot

Review neighbourhood for sources (checklist)

Previous use of lot
Not known
Describe lot/drainage around foundation
Grassed lot/some trees and bushes adjacent to house/drainage appears to be adequate

Describe house/age/condition
Bungalow/40 years old/work on attic ventilation in progress

Review building exterior

chimney
Ok outside/occupant indicated that airflow between furnace and chimney inside chimney is convoluted/restricting movement.
roof
Asphalt single/ok
siding

foundation
Poured concrete basement
backfill
not known
eavestroughs
yes
Vegetation
bushes around house/small flower gardens adjacent

Driveway
    Older asphalt
Other

Outdoor Source checklist

High road traffic	___	Exhaust from neighbour	
Airport	___	combustion	___
Pollen (plants)	___	dryer	___
Dust	___	pesticide spraying	___
Smog	___	Near golf course	___
Near stagnant water	___	Near business	
Near polluted		gas station	___
groundwater	___	dry cleaner	___
Near effluent	___	other	___
On problem soil	___	Near industry	___
		smelting	___
Over dumps	___	paper mill	___
Near landfill site	___	other	___
Soil gas	___	Near agriculture	___
Radon hot spots	___	fertilizer	___
Noticeable happenings		pesticide	___
to residents of the area	___	Other	___

Indoor Environment

Describe house Interior
    Extensive carpeting/finished crowded basement with office space

Previous use of house/occupancy
    unknown
Recent events-renovations, spills
    New gas furnace/fresh air intake
General impression
    House clean and well kept
Other

Comment

Occupant Activities and Air Quality

    any venting
        Powered furnace vent/fresh air vent
    cooking
        High volume kitchen fan
    hobbies

    cleaning

renovations-painting, construction

other

Describe crawlspace/basement

Poured foundation/full basement

Describe building envelope

tightness

Older building/probably not very tight

leakage around windows/doors

Sliding windows/Occupant has attempted to seal with tape etc.

leakage through cracks/sump/drain

Typical for older housing

insulation and cold spots

Investigation in spring

VOC sources;carpets, building materials, flooring, drapes

Moisture/radon sources; Drains, crawlspace, sump, basement

No obvious sources/sump and drain open

Other

Comment

Combustion systems

Describe; Age, condition, type

New high efficiency gas furnace and water heater

gas and combustion leaks

No evidence found/occupant claims spillage is increasing humidity levels in basement.

evidence spillage

Not found

venting, chimney and makeup air supply deficiencies

Occupant claims that horizontal venting is causing spillage.

filter inspection

combustion systems safety check

Not done/furnace company claims OK

humidifier connected

No

other

comments

Furnace fan operates only during cycle and occupant want air to circulate continuously throughout house.

Ventilation/HRV/Air Conditioning/Humidification/Dehumidification

describe system

Air conditioner on upper floor

general air quality impression; stuffy, humid, odours

Humid in basement

uncontrolled/controlled

uncontrolled

drafts/leaks

air movement and circulation with smoke pencil

Not tested

stagnant water

filters

depressurization and airflow balance

particulate sources/removal

other

comment

The occupant has attempted to ventilate basement by means of fresh air intake without success.

Moisture Sources

unvented dryers

unvented bathrooms

humidifiers

unvented cooking

dirt floor crawlspace/ damp basement

High humidity in basement

stored firewood

vegetation

other

comment

Chemical Sources

odours

chemical type

storage areas

use

hobby areas

spills

local exhaust

new materials, furniture, furnishings

other

comments

House Dust Sources

nature and level

location (shelves, heating system)

furnace filter

rugs, drapes, hard to clean shelves

other

comment

Air Cleaners

type

size,

condition,

ozone generation

other

Stored building materials

firewood

construction materials

type/quantity

other

Bathrooms

general impression

vented/ventilation
Local exhaust
odours

insulation

humidity

condensation/leaks

deterioration

mould/moisture accumulation (toilet, sink, bathtub)

spills

other

comments

Kitchen

general impression

odours

venting/ventilation
High volume fan
insulation

condensation/leaks

humidity

moisture/mould (sinks, refrigerator)

deterioration

spills

other

comments

Ceilings/attic

general Impression
Attic is poorly vented as is sealing of attic door and at fixtures.

condensation

moisture, leaks

mould

loose insulation

stained ceilings

asphalt shingles

obvious air movement through ceiling fixtures, cracks (smoke pencil)
Poor sealing to attic

Garage/Storage Building

attached
No garage

chemicals present

pathways

other

comment

General Review/Summary on Site

-Spillage with older furnace particularly when kitchen fan on
-Replaced with high efficiency gas furnace and DHW and now reports high humidities in basement.
-Introduced fresh air intake in basement with no improvement
-Air circulation to basement is poor and air conditioner is operating on ground floor.

Describe/Recommend

-High humidities probably due to introduction of high efficiency furnace. Older furnace probably improved basement ventilation through depressurization.
-A continuous fan must be installed to circulate air through the house and/or additional basement heaters introduced.
-There is no evidence nor reason for spillage with the new

furnace.

Case 4

Short Guide for Field Reference

Refer to the main guide for additional information

	File	04
Initial Contact by phone	Date	June 9/1993
	Location	Aylmer P.Q.

Describe problem and any action taken

health related
Occupant suffering from allergies which may be house related.

house problem
The occupants house may include sources to which the occupant is sensitive.

environment related
Possible influence

other

Identify Caller/age/occupancy
The occupant is 15 years/a family of five individuals no of which appear to suffer from health problems

Assess Urgency and Document Occupant Health Information

Describe complaint/magnitude/timing
Occupant becomes hyperactive, suffers from nasal congestion sneezing

Occupant opinion about urgency
Illness affects individuals performance at school
Combustion, gas, biological, chemical odours
House contains high efficiency wood stove
Symptoms severity, duration and suddenness of onset
Symptoms become pronounced at night
Association of odours/locations/symptoms
No obvious odours associated with bedroom
Hypersensitivity
uncertain
Review of family medical history (short)
No previous problems
Review of work environment and exposure to sources
Not known
Remediation attempted by occupant

None
Anyone contacted by occupant for assistance
Local doctor advises change in diet and removal of potential problem materials from bedroom
Assessment of urgency and need for immediate walkthrough
Occupant reactions are not life threatening and the situation is not considered to be urgent

Dangerous Situation

a n/a *

Instruct client to leave and/or reduce hazard

Contact health services

Contact gas/furnace company

Contact family members/responsible person/neighbour

Evaluate need for other professional assistance

Implement

Immediate Visual Inspection to Relieve Danger

a n/a *

Emergency equipment needs

Assess hazard

Inspect combustion systems
Spillage
Gas leaks
Venting, chimney and makeup air supply deficiencies

Check for moisture sources, spills and accumulation

Chemical and biological hazards

Outdoor air sources

other

Walkthrough by Phone **By Investigator**

Equipment needs

Supporting materials

Occupant cooperation/participation

Outdoor Environment

Note weather
Calm, temperature c
Describe neighbourhood/Terrain

Older neighbourhood/House located on busy street.

Review neighbourhood for sources (checklist)
High traffic level/near golf course
Previous use of lot
Not known
Describe lot/drainage around foundation
Large lot in rear of house below grade/drainage should be acceptable/land in rear sloping away from house.

Describe house/age/condition
Bungalow with attached garage below main floor/ 35 years old/good condition/poured concrete basement adjacent to garage.

Review building exterior

chimney
Insulated chimney exterior to house
roof
Asphalt shingles/complicated angular roof
siding
Asbestos siding
foundation
Poured concrete
backfill
not checked
eavestroughs
yes
Vegetation
Bushes adjacent to house
Driveway
Asphalt sloping to house
Other

Outdoor Source checklist

High road traffic	_*_	Exhaust from neighbour	
Airport	___	combustion	___
Pollen (plants)	___	dryer	___
Dust	___	pesticide spraying	___
Smog	___	Near golf course	_*_
Near stagnant water	___	Near business	
Near polluted		gas station	___
groundwater	___	dry cleaner	___
Near effluent	___	other	___

On problem soil	___	Near industry	___
		smelting	___
Over dumps	___	paper mill	___
Near landfill site	___	other	___
Soil gas	___	Near agriculture	___
Radon hot spots	___	fertilizer	___
Noticeable happenings		pesticide	___
to residents of the area	___	Other	___

Indoor Environment

Describe house interior

Extensive carpeting/drywall construction/three bedroom/one bathroom main floor/finished basement/tight wood stove in basement/baseboard heating elsewhere.

Previous use of house/occupancy

Previous owner

Recent events-renovations, spills

Ongoing repairs/renovations to interior

General impression

Clean house

Other

Comment

Large dog stays indoors most of time

Occupant Activities and Air Quality

any venting

cooking

hobbies

cleaning

renovations-painting, construction

Ongoing

other

Describe crawlspace/basement

Finished basement

Describe building envelope

tightness

Moderate

leakage around windows/doors

Moderate/untested

leakage through cracks/sump/drain

Moderate/untested

insulation and cold spots
Moderate/inspection in spring
VOC sources;carpets, building materials, flooring, drapes
carpets/building materials/paints
Moisture/radon sources; Drains, crawlspace, sump, basement

Other

Comment

Combustion systems

describe; Age, condition, type
Tight stove used for heating house/insulated chimney

gas and combustion leaks

evidence spillage
No visual evidence/did not test
venting, chimney and makeup air supply deficiencies
OK

filter inspection

combustion systems safety check

humidifier connected

other

comments

Ventilation/HRV/Air Conditioning/Humidification/Dehumidification

describe system

general air quality impression; stuffy, humid, odours
Air quality appears to be ok/uneven distribution of heat in house because it is primarily heated by woodstove.
uncontrolled/controlled
uncontrolled
drafts/leaks

air movement and circulation with smoke pencil

stagnant water

filters

depressurization and airflow balance

particulate sources/removal

other

comment

Moisture Sources

unvented dryers

unvented bathrooms

humidifiers

unvented cooking

dirt floor crawlspace/ damp basement

stored firewood

vegetation

condensation
winter
other

comment

Chemical Sources

odours

chemical type

storage areas

use

hobby areas

spills

local exhaust

materials, furniture, furnishings
Carpeting in occupants bedroom

other

Pet hair in carpeting.
comments

House Dust Sources

nature and level

location (shelves, heating system)

furnace filter

rugs, drapes, hard to clean shelves

other

comment

Air Cleaners

type

size,

condition,

ozone generation

other

Stored building materials

firewood
stored in garage
construction materials

type/quantity

other

Bathrooms

general impression

vented/ventilation

odours

insulation

humidity

condensation/leaks
winter
deterioration

mould/moisture accumulation (toilet, sink, bathtub)
none found
spills

other

comments

Kitchen

general impression

odours

venting/ventilation

insulation

condensation/leaks
winter
humidity

moisture/mould (sinks, refrigerator)
None found
deterioration

spills

other

comments

Ceilings/attic

general Impression

condensation

moisture, leaks

mould

loose insulation

stained ceilings