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INDOOR AIR QUALITY
TEST KIT
USER MANUAL

May 1989

Canada

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Building Performance Division
Technology
Architectural & Engineering Services
Public Works Canada

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1.0 INTRODUCTION

The Test Kit consists of several pieces of equipment for making indoor air quality (IAQ) measurements, this user manual and a maintenance manual.

The kit has been put together by the Building Performance Division of Technology, Architectural and Engineering Services. For several years Building Performance has been responding to complaints about indoor air quality, with problems ranging from poor ventilation to ceiling mould. Through experience, the Division has usually been able to identify the problem and solve it.

Improvements in technology have recently made simple instruments available for monitoring indoor air quality parameters. The aim of this manual is to enable people without specific training in air quality or instrument use to perform tests and assess the results.

The test kit, which is loaned out at no cost to PWC regions, provides:
- the instruments required to identify the problem and the degree of its severity
- instructions for use of the instruments and for conducting a building investigation (this manual)
- instructions for upkeep of the equipment (maintenance manual).

The equipment is fairly simple. The strategy for investigation contained in this manual is one being applied by Building Performance to several types of environmental problems. It involves three stages of activity:
- preliminary assessment
- measurements with simple instruments
- measurements with complex instruments.

The preliminary assessment stage does not use instruments, but relies simply on information, i.e., observations made in the building, knowledge of the operation of the HVAC system, details of complaints, etc. Sometimes it is possible to identify causes with a high degree of certainty at this stage. However, to do this one must recognize the significance of the information collected.

The simple instruments used in the second stage are mostly the same as those included in this kit. They are normally portable, battery-powered and give instant results. Often the information they supply is enough to prove or disprove the cause of a problem.

Complex instruments are used only if the simple instruments are unavailable, or are inadequate because
- they lack accuracy
- they lack sensitivity (the instrument does not detect very small quantities)
- the data yielded by the equipment is not directly comparable to accepted building standards
- they cannot record measurements continuously throughout the day.

These instruments are often not fully portable, and may require an AC electrical supply and an experienced operator.

The information in this manual covers the first two stages of investigation only: the preliminary assessment and measurements with simple instruments. These should prove adequate for diagnosing problems in most cases. If not, or if the IAQ Test Kit does not contain equipment for measuring an important parameter, the Building Performance Division maintains a number of other simple and complex instruments at Headquarters and can advise on the best course of action.

Following is an outline of the sections of this manual.

Section 2.0 identifies possible causes of air quality problems in office buildings. The causes fall into two groups - airborne pollutants and factors relating to the operation of the building. This is a useful basic introduction for people unfamiliar with the subject of air quality.

Section 3.0 contains a Building Checklist of information to be collected during a preliminary assessment. It also describes how to evaluate that information, and indicates some good locations for taking measurements. This Checklist can save wasting time on unnecessary measurements.

Section 4.0 moves into a discussion of measurement with simple instruments. It covers choosing locations and times at which to make measurements. This section should be used together with the Building Checklist.

Section 5.0 contains basic instructions for using the equipment in the test kit. Topics covered are normal and abnormal operation of equipment, calibration and battery-charging.

Section 6.0 provides data sheets for recording measurements.

Section 7.0 tells how to assess the measurements, and provides a table of good and bad numbers for each type of measurement.

Section 8.0 lists solutions to problems identified by the Checklist and measurements.

Section 9.0 covers follow-up to using the kit. This includes advice on what to do with the results, contacts for further information, and an evaluation of the kit.

Note:
Most of the Building Checklist (Section 3.0), the data sheets (Section 6.0) and parts of Section 9.0 are not reusable. New copies must be made for each building investigated. Copies on yellow paper of all of the non-reusable material are included in the Appendix.

2.0 AIR QUALITY IN OFFICE BUILDINGS

2.1 GENERAL REMARKS

Although we are focusing on office buildings, this section also applies to other medium-sized or large buildings that rely on mechanical ventilation systems, for example schools, hospitals and some public facilities.

Complaints about air quality in office buildings have increased dramatically in the last ten years, as energy conservation measures have been implemented that sealed buildings more tightly and cut down the amount of fresh air being circulated. Because of the similarity in the symptoms of illness reported, the problem is often referred to as "sick building syndrome." These symptoms are also typical of colds, allergies and flu, and usually are not specific enough to pinpoint any of the likely causes of the problems. They are thus of limited use in an investigation.

An approach based on investigating the buildings rather than the symptoms has been more successful. As a result, there is now reasonable agreement on the major causes of air quality problems and complaints. Certain causes reappear regularly, and are responsible for the majority of the problems diagnosed.

Tables 1 and 2 list possible causes of air quality problems in office buildings, and indicate the frequency with which each is likely to occur. Table 1 deals with air pollutants. An air pollutant can be defined as any substance in the air present in high enough concentration to cause discomfort, irritation or illness. The definition covers airborne chemical, biological and particulate material. Important sources of these pollutants in office buildings are also given in Table 1. Table 2 lists the other causes, the most important of which is inadequate ventilation.

Table 1 Causes of air quality complaints/occupant discomfort related to air pollutants in office buildings

Air Pollutant	Frequency of Occurrence	Sources
asbestos	rarely	insulation or fire retardant lining a ventilation duct or ceiling plenum
biological material	occasionally	stagnant water associated with HVAC system (fan coil units, cooling towers, humidifier pans, damp ducts or plenums), plants, water-damaged furnishings, pollen (from outdoors)
carbon dioxide	frequently (as an indicator of poor ventilation)	people
carbon monoxide	occasionally	auto exhaust (from internal parking garages, contaminated air intakes, loading docks)
formaldehyde	occasionally	unsealed plywood or particleboard, UFFI, fabrics, adhesives, glues, carpets, furnishings, carbonless copy paper
nitrogen dioxide	rarely	diesel exhaust, combustion of natural gas or kerosene used for heating or cooking
ozone	rarely	photocopiers, electrostatic dust filters (electronic air cleaners)
particulates	occasionally	contaminated air intakes, tobacco smoke, hard water residue, paper, insulation lining a duct or plenum, people
radon	rarely	soil, groundwater
sulphur dioxide	only if outdoor air is polluted	no indoor sources
volatile organic compounds	occasionally	copying and printing machines, carpets, furnishings, cleaning materials, pesticides, tobacco smoke, glues, adhesives, caulking

Table 2 **Other causes of air quality complaints/occupant discomfort in office buildings**

Other Causes	Frequency of Occurrence	Details
inadequate ventilation	frequently	causes include: overzealous energy-saving, design or maintenance problems with ventilation system, occupant intervention
temperature and humidity extremes	occasionally	causes include: faults in placing or operation of thermostats (temperature), inability of system to compensate for climate extremes and leaky buildings (humidity) results include: increased pollutant emission, changed occupant perception of the environment
other physical stressors	occasionally	symptoms induced by acoustic or visual stress can be the same as those of the "sick building syndrome"

2.2 BACKGROUND INFORMATION ON CAUSES OF INDOOR AIR QUALITY PROBLEMS

Air pollutants and ventilation both play a part in determining indoor air quality. The pollutants come from a variety of sources as indicated in Table 1, and emission from these sources may be weak or strong. The situation can be regarded as a contest between the pollutants and the ventilation system: If a source is weak and the ventilation system is performing as designed, air quality will be good; However, if a strong source is present, then the ventilation system may be overwhelmed and air quality will be bad.

__asbestos__ This is an important pollutant because it is carcinogenic. In 1981 Treasury Board banned the use of sprayed asbestos in construction of federal buildings because of the danger of release of fibres into the air. Since then PWC has inspected all of its older buildings and made inventories of the asbestos they contain. There is also an on-going PWC program involving reinspection and control of asbestos that has become hazardous (see Section 8). Usually asbestos is hazardous only when in contact with ventilation air (inside ducts or plenums), or when released during renovation.

__biological material__ Problems are caused mainly by fungi (mould, mildew, slime, etc.). Fungi and their spores are always present in outdoor air, but can become a problem indoors when there is a suitable place inside for them to breed, and when the population can move easily from the breeding area into the ventilation system. Suitable habitats are cooling towers and stagnant water in pans under fan coil units and humidifiers. Lined ventilation ducts breed fungi only if dirty, and if the humidity is greater than 70%. The only bacteria that cause significant problems are legionella, and these are usually associated with air-conditioning systems.

__carbon dioxide__ People are by far the most important source of carbon dioxide. Being a metabolic product, carbon dioxide is an irritating rather than a dangerous substance. High levels are usually due to the presence of too many people (e.g. when an office designed for two is converted into a waiting room seating twenty), or to inadequate ventilation (see below). The presence of high levels of carbon dioxide can be taken as an indication that the amount of fresh air or the air circulation rate needs to be increased.

__carbon monoxide__ In contrast to carbon dioxide, carbon monoxide is highly toxic. A by-product of fuel-burning, its sources include auto exhaust, kerosene space heaters, natural gas heating units and stoves, and tobacco smoke. In an office building auto exhaust is usually the only major source. It may enter from an internal parking garage or loading dock, or with outdoor air if the fresh air intake is located just above a busy street, or close to the garage exhaust or the loading dock. The most frequent cause of problems is an internal parking garage. Tobacco smoke contributes only small quantities of carbon monoxide to the air, though a smoker's blood level of carbon monoxide may be high.

<u>formaldehyde</u> An important component in the manufacture of many synthetic materials, formaldehyde can later be released from them into the surrounding air. Major problems are usually associated with houses (urea formaldehyde foam insulation (UFFI)), and mobile homes (plywood and particleboard). Offices are more likely to contain a variety of weak sources that are difficult to identify (see Table 1).

<u>nitrogen dioxide</u> This is produced during fuel-burning, for example by heaters or stoves using kerosene or natural gas. Diesel exhaust is a stronger source than gasoline exhaust, and internal parking garages are not usually a problem. Although nitrogen dioxide may enter from outdoors, there are usually no indoor sources in office buildings.

<u>ozone</u> An important outdoor pollutant, ozone is usually present in much lower concentrations indoors because it is a reactive chemical and is easily destroyed by contact with surfaces and other chemicals in the air. The only important indoor sources are electrostatic dust filters (electronic air cleaners) and photocopiers. However, electrostatic filters in the main air handling units are unlikely to cause high levels of ozone in occupied areas because most of the chemical will disappear in the ducts, and problems involving photocopiers are rare.

<u>particulates</u> This category includes fibres, dust, smoke and mist. From the health or comfort point of view, the most important particulates are the ones that do not settle on surfaces but remain in the air and are inhaled. Tobacco smoke, paper, people and insulated linings in ventilation ducts are important indoor sources. The residue of evaporation of hard water can contribute if spray humidifiers are used. If the air handling systems do not include filters, outdoor particulates (from nearby construction or birds' nests in the air intake, for example) can also enter ventilation air.

<u>radon</u> Radon is a short-lived gas produced during natural decay of uranium, and is a health hazard because of the radiation produced during its own decay. All soil contains some radon, as does most groundwater, because radon is soluble in water. It enters buildings either as a gas released directly from the soil, or in water that has recently been in contact with soil (water from reservoirs is usually safe, but well water may contain much more radon). Entry points include cracks in foundations, crawlspaces with exposed soil, and poorly ventilated shower areas. Such spaces are rare in office buildings.

<u>sulphur dioxide</u> This is an important outdoor pollutant and a constituent of acid rain. The main sources are industrial processes, petroleum refining and coal-fired or gas-fired electricity plants. However, there are normally no sources inside office buildings.

<u>volatile organic compounds (VOC)</u> This category covers hundreds of chemicals that can enter the air by evaporation from solids or liquids. Examples are:

- solvents that evaporate during drying of paint, curing of adhesives and caulking compounds, or operation of photocopiers

- chemicals given off by cleaning compounds such as rug shampoo
- chemicals used in the manufacture of synthetic furnishing materials, fabrics and plastics. These are retained in the finished product and emitted over the next few months
- pesticides
- chemicals used in special processes such as printing, photographic developing, conservation and restoration.

There are some strong sources of VOC in office buildings. In addition, there are always many small, weak sources present, and therefore a large number of airborne chemicals. Identifying these and their sources is usuallly expensive and time-consuming.

<u>inadequate ventilation</u> In the context of air quality, this can be defined as insufficient air to remove pollutants that are degrading the quality of the air. Causes include:

- early shutdown and late startup of the ventilation system
- insufficient fresh (outdoor) air entering the ventilation system
- poor air distribution by the ventilation system
- poor air mixing in occupied areas.

The first two causes are often a direct result of overzealous energy-saving procedures. The remaining causes can be due to:

- poor design
- incorrect installation of components
- operating the system differently from the design
- incorrect balancing
- component malfunction
- occupant intervention

<u>temperature extremes and humidity extremes</u> These factors can affect the emission rates of some pollutants, such as formaldehyde. Howevere, the way the extremes affect occupant perception is probably more important. High humidity and high temperature cause people to feel lethargic and to want more air movement. Low humidity induces coughing, dry throats and dry eyes. These are all symptoms of the "sick building syndrome" mentioned above, and are thus usually blamed on poor air quality. An additional problem with low humidity is that it improves the sense of smell.

<u>other physical stressors</u> Noise from the mechanical systems or glare from lights can cause headaches and fatigue. Again, these are symptoms of the "sick building syndrome" and may be blamed on the air. A European researcher, Molhave, has suggested that the symptoms of "sick building syndrome" can be caused by any combination of physical, chemical, environmental and psychological stressors.

3.0 PRELIMINARY ASSESSMENT: BUILDING CHECKLIST

This section covers the preliminary assessment stage of the investigation of a building. Two activities are involved:
- collection of information about the building
- interpretation of this information to provide evidence for or against the various causes of problems

The Checklist consists of a questionnaire plus an assessment summary, which indicates how the answers relate to the various problem causes.

This preliminary stage is essential to any investigation because on its completion:
- the cause(s) of the air quality problems may be apparent with near certainty, and other causes eliminated;
- even if causes are not clearly identified, it should be apparent which measurements are the most important;
- the best places for collecting data will have been identified.

The first task is to answer the questions on the Checklist. Some answers will already be known. Getting the rest involves talking to people and inspecting different places in the building. The questions are straightforward - most requiring a simple "Yes" or "No" answer. For some, space is provided for filling out the relevant locations. These are places to collect data later.

The six parts of the Checklist deal with the following problems:
- carbon monoxide/combustion byproducts
- radon
- other pollutant sources
- mechanical systems and HVAC operation
- building usage, maintenance and design
- occupant complaints and complaint area observations

Each paragraph of questions in Parts 1 to 5 deals with a possible source or cause of indoor air pollution. Answer the numbered questions by circling "YES" or "NO". If the answer is "NO", go to the next numbered question. If the answer is "YES", answer the rest of the questions in the paragraph before going to the next numbered question.

3.1 CARBON MONOXIDE / COMBUSTION BYPRODUCTS

1) **Does the building contain an <u>enclosed parking garage</u>?** **YES / NO**
   Is the garage's ventilation system controlled by carbon monoxide sensors? Yes / No
   Is it more than six months since the carbon monoxide sensors were recalibrated? Yes / No
   Are there any obstructions in the exhaust or fresh air? Yes / No
   Are there cars coming and going most of the day? Yes / No
   Are there elevator shafts or stairwells that open into the parking garage? Yes / No
   Does the checkout booth lack its own ventilation? Yes / No

2) **Does the building contain an <u>internal loading dock</u>?** **YES / NO**
   Is there an outer door that is closed after a truck's arrival? Yes / No
   Do the drivers keep their motors running in the dock when the outer door is closed? Yes / No
   Are there elevator shafts or stairwells that open into the parking garage? Yes / No
   Are there usually more than ten deliveries each day? Yes / No
   Are doors to other parts of the building kept open? Yes / No
   Is the reception office open to the loading dock? Yes / No
   Does the reception office lack its own ventilation? Yes / No

3) **Does the building contain <u>a kitchen with gas stove(s)</u>?** **YES / NO**
   Are the exhaust hoods above the stoves missing or faulty? Yes / No
   Are the stoves often operated without the exhausts switched on? Yes / No

4) **Does the building contain a <u>gas-fired heating system</u>?** **YES / NO**
   Are there any signs of leaks in the furnace or chimney? Yes / No
   Is there a smell of gas or burning in the furnace room? Yes / No
   Is the furnace room hot, humid or stuffy? Yes / No

5) **Does the building contain any <u>small free-standing gas heaters</u>?** **YES / NO**
   Is there a smell of gas or burning around the heaters? Yes / No
   Is the exhaust from any of the free-standing heaters not vented? Yes / No
   Is the exhaust vented into the building ventilation system rather than direct to outdoors? Yes / No

3.2 RADON

The parts of the building below ground level should be inspected for possible entry points for this pollutant.

6) **Are there basement or sub-basement areas or crawlspaces with dirt floors?** **YES / NO**
Are there people who work more than ten hours a week nearby (i.e., in the next room)? Yes / No
If YES, describe locations:

____

Do these spaces lack ventilation? Yes / No
Are there musty odours in these areas or nearby? Yes / No

7) **Are there rooms with sizeable holes in the walls or floor, such as sump pits or gas and water entrances, in which there is exposed soil?** **YES / NO**
Are there people who work more than ten hours a week nearby (i.e., in the next room)? Yes / No
if YES, describe location(s):

____

Do these spaces lack ventilation? Yes / No
Are there musty odours in these areas or nearby? Yes / No

8) **Are there cracks in the walls of the basement that could allow soil gases to seep into the building (for example, dissolved in groundwater that leaks in)?** **YES / NO**
Are there people who work more than ten hours a week nearby (i.e., in the next room)? Yes / No
if YES, describe location(s):

____

Do these spaces lack ventilation? Yes / No
Are there musty odours in these areas or nearby? Yes / No

3.3 OTHER POLLUTANT SOURCES

Possible sources of volatile organic compounds, formaldehyde, biological material and particulates are covered here.

9) **Are there showers in the building?** **YES / NO**
   Are the showers used more than ten hours a week? Yes / No
   Is there any mould visible on the floor or walls of the shower stalls, the shower heads or shower curtains? Yes / No
   Are there mouldy odours in the stalls or nearby? Yes / No

10) **Does the building contain wet-process photocopiers?** **YES / NO**
   (Note: such as the photocopiers made by Savin)
   If Yes, describe location(s):

   ____

   Are any of these machines in small rooms with no air supply or exhaust? Yes / No

11) **Does the building contain a printshop?** **YES / NO**
   Are solvents used regularly (at least once a week) to clean the printing equipment? Yes / No
   Are the waste rags or paper used during cleaning disposed of in an open garbage can? Yes / No
   Are any of the bottles or cans of chemicals usually left open or with the lids loose? Yes / No
   Do any of the machines lack an exhaust hood? Yes / No
   Are there any exhaust hoods that vent into the building's ventilation system? Yes / No

12) **Does the building contain a laboratory that uses chemicals (for cleaning, processing, conservation etc.)?** **YES / NO**
   Does the laboratory use the same ventilation system as the rest of that area of the building? Yes / No
   Is there a persistent chemical odour in the laboratory area? Yes / No
   Are chemicals that evaporate quickly used often? Yes / No
   Are these volatile chemicals used without the protection of a fume hood? Yes / No

13) **Does the building contain stored chemicals (pesticides, waste solvents etc.)?** **YES / NO**
   Is the storage area or storage cabinet unventilated? Yes / No
   Is there a persistent chemical odour in the storage area? Yes / No
   Do any of these chemicals evaporate quickly? Yes / No
   Are any of the bottles or cans storing these chemicals left open or with the lids loose? Yes / No

14) Does the building contain a storeroom or storage area with <u>shelves made of fairly new plywood or particleboard</u> (under four years old)? **YES / NO**

Is the plywood or particleboard used as bought, without a coat of paint or varnish? Yes / No

Is the storage area unventilated? Yes / No

Is there a persistent chemical odour in the storage area? Yes / No

15) Is smoking allowed in this building? **YES / NO**

Is smoking restricted to special smoking rooms? Yes / No

Do any of these have neither a window fan nor an electronic air cleaner? Yes / No

If <u>Yes</u>, describe location(s):

____

Do any of these have a fan or window fan that blows the smoky air into the rest of the building? Yes / No

If <u>Yes</u>, describe location(s):

____

16) Are large amounts of <u>paper</u> stored or handled in this building? **YES / NO**

If <u>Yes</u>, describe location(s):

____

Is paper often moved into and out of the storage area? Yes / No

Is there dust on surfaces in this area? Yes / No

17) Are large amounts of textiles stored in this building? **YES / NO**

If <u>Yes</u>, describe location(s):

____

Are many of these textiles permanant press? Yes / No

3.4 MECHANICAL SYSTEMS AND HVAC OPERATION

If the building contains two or more towers or wings, each controlled by a different HVAC system, a copy of this sheet should be filled out for each.

18) Is the <u>amount of fresh air</u> used by the ventilation system the same all year round? YES / NO
What is the percentage of fresh air used?
__________ %

19) Does the HVAC system use an <u>economiser cycle</u>? YES / NO
What is the maximum percentage of fresh air used?
__________ %

What is the minimum percentage of fresh air used?
__________ %

What is the fresh air percentage just now?
__________ %

20) Is <u>air supplied to the floors</u> by:
constant volume boxes / variable air volume (VAV) boxes / heat pumps / other or unknown ?

21) At what temperature is the tank supplying <u>hot water</u> to the building maintained?
__________ ^{o}C

22) Are there distinct <u>fresh air intakes</u> for the building HVAC system ? YES / NO
Are there intakes below third floor level <u>and</u> above a busy street ? Yes / No
Are there intakes within 10 metres (30 feet) of the entrance to a loading dock? Yes / No
Are there intakes within 10 metres (30 feet) of the entrance or exit to a parking garage? Yes / No
Are there intakes within 10 metres (30 feet) of the exhausts of this or an adjacent building? Yes / No
Are there any other pollution sources near any of the intakes? Yes / No
If <u>Yes</u>, briefly describe the pollution source:

____

Are there obstructions (such as birds' nests) lodged in any of the air intakes? Yes / No

23) **Does this building have a <u>particulate (dust) filter</u> system installed in the fresh air intake?** **YES / NO**
Are the filters missing? Yes / No
Are the filters changed less frequently than recommended by the manufacturer? Yes / No
Do the filters fit so poorly that air bypasses them at the edges? Yes / No
Are the filters matted or dirty? Yes / No
Are the filters wet? Yes / No
Does the dust filter system lack a pressure drop indicator? Yes / No

24) **Is the <u>ventilation in the work areas</u> decreased or shut off overnight or on weekends?** **YES / NO**

If <u>decreased</u>, to what percentage of the daytime rate does the system drop? ____________ %

At what time is the ventilation system turned off or down? __________ p.m.

At what time is the ventilation system turned back on or up? __________ a.m.

When does the normal workday start? __________ a.m.

When does the normal workday end? __________ p.m.

25) **Are <u>spray humidifiers</u> used in this building?** **YES / NO**
Are the spray humidifiers supposed to operate at this time of year? Yes / No
Are the spray humidifiers operating just now? Yes / No
If <u>Yes</u>, answer the questions below:
Are the spray humidifier pans plugged so that they are not draining properly? Yes / No
Is there slime in the humidifier pans? Yes / No
Are there mouldy odours? Yes / No
Is there mould in the ducts near the humidifiers? Yes / No
Is there evidence of foaming in the humidifiers? Yes / No
Is the water hard in this region? Yes / No
If so, are there hard water deposits on the vanes? Yes / No
Are the hard water deposits removed by scraping the vanes and blowing the dust into the ducts? Yes / No

26) Are **steam humidifiers** used in this building? **YES / NO**
Are the steam humidifiers supposed to operate at this time of year? Yes / No
Are the steam humidifiers operating just now? Yes / No
If Yes, answer the questions below:
Are chemicals used in the boiler or the pipes to protect against corrosion? Yes / No
If Yes, state names of chemicals:

____

27) Does this building have an **air-chilling system**? **YES / NO**
Is the chilling system supposed to operate at this time of year? Yes / No
Is the chilling system operating just now? Yes / No
If Yes, answer the questions below:
Are the condensate trays cleaned less often than once a week? Yes / No
Is there slime in the condensate trays? Yes / No
Is there dirt on the cooling coils? Yes / No
Are there mouldy odours in the system? Yes / No

28) Are the ventilation ducts or plenums **insulated**? **YES / NO**
Is the insulation on the inside and directly exposed to the moving air? Yes / No
Is it more than five years since the ducts or plenums were last cleaned? Yes / No

3.5 BUILDING USAGE, MAINTENANCE AND DESIGN

29) What year was the building constructed? ______________

Are the as-built design diagrams for this building missing? Yes / No
Are the current design diagrams for this building missing? Yes / No
Are the operating and maintenance manuals for the building's HVAC system missing? Yes / No
Is there no routine maintenance program for the HVAC system? Yes / No

30) Can the windows in the work areas be opened? **YES / NO**
Do the occupants frequently open the windows? Yes / No

31) Have there been any changes in the floor layout since the building was opened (i.e. open office spaces converted to closed offices, partitions put up, walls added or removed)? **YES / NO**
If YES, describe location:

____

Was the original ventilation retained in this areas? Yes / No
Do most of the closed offices lack working thermostats? Yes / No

32) Is the occupant density higher than originally planned anywhere in the building (i.e. due to conversion of office space to boardrooms or waiting rooms)? **YES / NO**
If Yes, describe location:

____

Was the original ventilation retained in this space? Yes / No
Does this space lack a working thermostat? Yes / No
Is this space used for more than two hours each day, or ten hours each week? Yes / No

What is the maximum number of people normally occupying this space? __________

What is the area (in square metres) of this space? __________

33) **Have any work areas been <u>recarpeted</u> recently?** **YES / NO**
Did odours persist for more than a week after the carpet was laid? Yes / No
If <u>Yes</u>, describe location(s):

____

34) **Have any work areas been <u>repainted</u> recently?** **YES / NO**
Did odours persist for more than a week after the paint was applied? Yes / No
If <u>Yes</u>, describe location(s):

____

35) **Is there <u>foam insulation</u> in the walls of the building?** **YES / NO**
The type of insulation is polyurethane / polystyrene / urea formaldehyde / unknown

3.6 OCCUPANT COMPLAINTS AND COMPLAINT AREA OBSERVATIONS

Often problems can develop locally so that only one person or a small group of people is affected. These people may be able to supply useful information about the problem, and the investigator can supplement this by inspecting the complaint area. Therefore, this part of the Checklist consists of two short questionnaires, one to be filled out by the person making the complaint, and one to be filled out by the investigator. Both should be completed for each space investigated. If several people in an area are complaining, it may be appropriate for each to fill out a complaint sheet. If necessary, identification numbers can be entered at the top right to distinguish the sheets.

3.7 OCCUPANT COMPLAINT SHEET no. ________

Where in the building are your complaints worst? Please give the Floor, room or workstation number, or briefly describe (e.g. main lobby, everywhere):

____

Your answers to the questions below apply to this location. Where a choice is given, please circle the most appropriate answer. Enter your own answer where requested. Space for comment is provided.

1) **Describe the usual temperature here:**
   okay / too hot / too cold / sometimes too hot, sometimes too cold

2) **How would you usually describe the air here?**
   okay / drafty / stagnant / stuffy / stale

3) **Are you bothered by odour here?** **YES / NO**
   If YES, how often do you smell this odour?
   rarely / occasionally / frequently / all the time
   Which of the following best describes the odour?
   auto exhaust / diesel fumes / furnace smell / heating system
   body odour / mouldy or musty / chemical / like solvent
   (wet) cement or plaster / dusty or chalky smell
   What do you think causes the odour?
   ____

4) **Do you have a history of allergies?** **YES / NO**
   If YES, the type of allergy is: respiratory / skin / food / other
   Are your allergies worse while you are in this building? Yes / No

5) **Which of the following do you suffer from that you think are due to the building?**
   headache / tiredness / faintness / dizziness
   nausea / stomach problems / skin irritation
   dry eyes / itching eyes / watery eyes / blurred vision
   stuffy nose / runny nose / sneezing
   sore throat / dry throat / bad chest / coughing / asthma

6) **What time of day are your complaints worst?**
   morning / afternoon / the same all day
   What day of the week are your complaints worst?
   Monday / mid-week / Friday / the same all week
   What season of the year are your complaints worst?
   spring / summer / fall / winter / the same all year

7) **Do the symptoms coincide with or follow cleaning or maintenance activities in this area?** **YES / NO**
   If YES, describe this activity:
   ____

Comments:

3.8 COMPLAINT AREA OBSERVATION SHEET

no.______

Where in the building do these observations apply? Please give the Floor, room or workstation number, or briefly describe (e.g. main lobby, everywhere):

____

Please answer all questions by circling or filling in the answers as required.

1) <u>General observations</u>
Is there damp or mould on the walls or ceiling? Yes / No
Are there many potted plants in this area? Yes / No
Is there mould on the plants or their pots or soil? Yes / No
Are there odours here? Yes / No
Which of the following best describes the odour?
auto exhaust / diesel fumes / furnace room / heating system
body odour / mouldy or musty / chemical / like solvent
(wet) cement or plaster / dusty / chalky
Are people using fans to create more air movement? Yes / No
Is there much dust visible on flat surfaces? Yes / No
Is there evidence of condensation on windows or walls? Yes / No

2) **Is this an <u>enclosed office</u> (with walls and door)?** **YES / NO**
If <u>YES</u>, does it lack a working thermostat? Yes / No

3) **Is this an <u>open office</u> area?** **YES / NO**
If <u>NO</u>, go to question 4
Are screens used to divide the area? Yes / No
If <u>NO</u>, go to question 4.
Are the screens five or more feet high? Yes / No
Do the screens extend all the way to the floor? Yes / No
What is the average area in square metres
enclosed by the screens? __________

4) **Check the <u>air supply diffusers</u>:**
Does this area lack supply air? Yes / No
Can you see any of the following around the diffusers?
mould / chalky dust / dirt marks
Are any of the air supply diffusers blocked by
furniture, paper or other obstruction? Yes / No

5) **Are there any <u>air exhaust louvers</u>?** **YES / NO**
If <u>NO</u>, go to question 6.
Are there dirt marks around the air exhaust louvers? Yes / No
Are any of the air exhaust louvers blocked by
furniture, papers or other obstruction? Yes / No

6) **Are any of the following <u>pollutant sources</u> within 10 metres (30 feet) of this room/workstation:**

Wet-process photocopier?	**Yes / No**
A printshop?	**Yes / No**
A room where chemicals are used?	**Yes / No**
A room where chemicals are stored?	**Yes / No**
An area with plywood or particleboard shelves?	**Yes / No**
A room for smoking?	**Yes / No**
An area with a large amount of stored paper?	**Yes / No**
An area with a large amount of stored textiles?	**Yes / No**

<u>Comments</u>:

3.9 ASSESSMENT SUMMARY

Three factors must be assessed before it is decided whether an air quality problem warrants further investigation with simple instruments. One can remember them as PIP - People, Inadequate ventilation and Pollutants. The presence of people is important, for problems can sometimes be tolerated in unoccupied areas such as basement mechanical rooms. Ventilation that is adequate in one situation, such as a large office, may be inadequate in another, such as a printshop. It all depends on the balance between the capacity of the ventilation system and the strength of the pollutant sources.

An assessment procedure is described below for each of the parts of the Checklist questionnaire. Most of the questions have been worded so that a "Yes" answer means a possible problem. The simplest assessment procedure consists of counting the number of "Yes" answers. Sometimes it is necessary to refer to the answers of other questions to obtain an effective assessment.

Section 3.1 Carbon monoxide/combustion byproducts

Each numbered question refers to a possible source of carbon monoxide/combustion products in the building. For each of these that the building contains (i.e. each "YES" answer), problems are likely only if there are one or more "Yes" answers to other questions in the same paragraph. The more "Yes" answers, the more chance of a problem.

Section 3.2 Radon

Each numbered question refers to a possible source of radon in the building. These sources tend to be in unoccupied areas. Therefore, for each of these that the building contains (i.e. each "YES" answer), both the nearby presence of people and evidence of poor ventilation (odours or absence of air supply and exhaust) are required before the situation needs further investigation.

Section 3.3 Other pollutants

Each numbered question refers to a possible pollutant source in the building. For each of these that the building contains (i.e. each "YES" answer), problems are likely in practice only if "Yes" answers are obtained for other questions in the same paragraph. The more "Yes" answers, the more chance that this pollutant source will be causing problems. The pollutant sources that the numbered questions refer to are:

9) fungi if mould is visible anywhere, or mouldy odours are present
   radon if the area is used more than ten hours each week
10) volatile organic compounds (VOC)
11) VOC
12) VOC

13) VOC
14) formaldehyde
15) particulates
16) particulates
17) formaldehyde

Section 3.4 Mechanical systems and HVAC operation

For questions 22, 23, 25, 26, 27 and 28, a "**YES**" answer indicates that problems are likely if "Yes" answers are obtained for other questions in the same paragraph. The more "Yes" answers, the more chance of a real problem.

The types of problems indicated by the answers are described below:

18) and 19) Less than 15% fresh air is likely to result in non-compliance with ASHRAE standards.
20) VAV boxes respond to temperature, and may not deal effectively with strong local pollution sources.
21) If the temperature is higher than 60°C, legionella bacteria are unlikely to survive and breed.
22) Carbon monoxide may be a problem if the intakes are either just above a busy street or close to a loading dock or parking garage that has been identified as a potential problem source (check answers to questions (1) and (2)).
    Particulates may be a problem if there are obstructions in the intake and if particulate filters either are not used in the HVAC system, or are poorly maintained (check question (23)).
    Contaminated air from the exhausts can re-enter the building if intakes and exhausts are too close together. This will increase concentrations of all pollutants.
23) See reference to particulates in question (22)
24) The ventilation system should be turned on (or up) at least two hours before the start of the workday, and turned off (or down) at least two hours after the end of the workday. It is particularly important to allow enough lead and lag time if the system is turned off completely at night.
25) Biological contamination can be caused by spray humidifiers if the pans are not kept clean.
    Particulate problems can be caused by spray humidifiers if the water contains dissolved material that will form dust when the water evaporates. This will occur if local water is hard, or if large quantities of solid biocide are added (this may cause foaming). Problems are most likely to occur when local water is hard and the humidifier cleaning procedure blows solids scraped off the vanes into the ventilation ducts.
26) Chemicals used to protect the boiler or steam pipes may enter the ventilation system and be distributed around the building. Amines (a type of VOC) are noted for this problem.
27) Biological contamination can result if the air-conditioning system is not cleaned regularly. Most outbreaks of legionellosis are caused in this way, and fungal contamination is also possible.
28) Particulates originating in ducts and plenums can be accumulated dirt, or insulation fibres (if the insulation is on the inside of the duct or plenum). If the insulation appears to be a problem,

check to see whether it is asbestos. Building Performance can supply information on PWC's asbestos program.

Section 3.5 Building usage, maintenance and design

A "**YES**" answer to a numbered questions indicates that a problem is possible. The likelihood is increased if one or more "Yes" answers are obtained to other questions in the same paragraph.

The types of problems indicated are described below:

29) the absence of design diagrams suggests alterations or refit might have been performed without taking into account the effects on the HVAC system.
The absence of operating/maintenance information suggests HVAC operation could be incorrect, and maintenance is likely to be inadequate.

30, 31 and 32: either inadequate temperature control or inadequate ventilation (fresh air or air circulation). Inadequate ventilation is likely to cause elevated carbon dioxide levels in these locations.

33) VOC

34) VOC

35) urea formaldehyde points to a possible formaldehyde problem. Polyurethane and polystyrene can release other types of VOC. If the answer here is "do not know," check the building plans, which should contain this information. If this is unsuccessful, extract a small piece of the insulation from the wall cavity, and send it to Building Performance for testing.

Section 3.6 Occupant complaints and complaint area observations

Assessment sheets are provided for both the occupant complaint questionnaire and the complaint area observation questionnaire. Table 3, which provides common descriptions of odours, can be used as an aid for both assessments.

Section 3.7 Occupant Complaint Sheet

To do the assessment, relate the points below to the corresponding question and answer on the OCCUPANT COMPLAINT SHEET.

1) Any answer except "okay" indicates poor temperature control. This could be due to faults in the HVAC, blocked intake or exhaust, or lack of a thermostat. Check the OBSERVATION sheet, also Section 3.5, questions (30), (31) and (32).
2) Any answer except "okay" indicates poorly controlled air movement. "stagnant," "stuffy" or "stale" suggest inadequate ventilation and a carbon dioxide problem.
3) If there are odours here, check Table 3 to see if they match any description. An odour that is present all the time is probably associated with the building structure or furnishings. An occasional odour can be due to intermittent occupant activities, intermittent HVAC control, or weather conditions. It may be necessary to get more information here to decide which is the most likely cause.
4) Someone with a history of severe allergies may be affected by pollutant concentrations that do not bother other people, and that are much less than required by building performance standards. If this situation is suspected, ask a health professional for advice.
5) Most symptoms can be linked to several possible sources:
   carbon dioxide: headache, tiredness
   carbon monoxide: headache, tiredness, dizziness, nausea
   formaldehyde: eye irritation, nausea, headaches
   particulates: sneezing, coughing, dry nose and throat, allergies
   VOC: headache, eye, nose, throat or skin irritation
   biological material: allergies (runny nose, stuffy nose, sneezing, asthma)
   low humidity: sneezing, coughing, dry eyes, nose and throat
   high temperature and humidity: tiredness, headache
6) The timing of the appearance of the symptoms can help in identifying the source of the problem. Symptoms caused by pollutants from daily occupant activities (for example, carbon dioxide, and VOC from photocopiers or printshops) will be worst in the afternoons, possibly on Fridays, and in winter and summer if the building is on an economiser cycle. Pollutants from the structure or furnishings (for example, formaldehyde or VOC from furnishings, biologicals) will be worse mornings and Mondays if the ventilation is off during silent hours.
7) A VOC problem is likely if products containing solvents or other volatile chemicals are used.

Section 3.8 Complaint Area Observation Sheet

To do the assessment, relate the points below to the corresponding question and answer on the COMPLAINT AREA OBSERVATION SHEET.

1) general observations
   Yes = biological material
   Yes = biological material (mould)
   Yes increases the probability of a biological problem
   Yes = almost any pollutant. To try to determine which one, check descriptions against Table 3 and enter the most likely source:

   ____

   Yes = ventilation (likely to cause high carbon dioxide)
   Yes = particulates
   Yes = too much humidity

2) enclosed office = YES
   Yes (no thermostat) = temperature / ventilation (carbon dioxide)

3) open office = YES

   Yes = poor local air circulation (and high carbon dioxide)

   Yes increases probability of local air circulation problem
   Yes increases probability of local air circulation problem
   average area less than 10 m^2 (100 sq. ft.) increases the probability of problems

4) air supply diffusers
   Yes = fresh air / ventilation (carbon dioxide)
   mould = biological material; chalky dust = particulates from structural alterations or spray humidifier; dirt marks = particulates in the ventilation system
   Yes = fresh air / ventilation (carbon dioxide)

5) air exhaust louvers
   Yes = particulates in the room or nearby
   Yes = ventilation (carbon dioxide)

6) **pollutant sources** within 10 metres (30 feet)

Yes - check question 10 for likely source strength (VOC)
Yes - check question 11 for likely source strength (VOC)
Yes - check question 12 for likely source strength (VOC)
Yes - check question 13 for likely source strength (VOC)
Yes - check question 14 for likely source strength (formaldehyde)
Yes - check question 15 for likely source strength (particulates)
Yes - check question 16 for likely source strength (particulates)
Yes - check question 17 for likely source strength (formaldehyde)

Table 3 Odours that can occur in office buildings

Possible descriptions of the odour	Problem indicated	Other indicators of of this problem
auto exhaust, diesel fumes, furnace room smell, heating system,	carbon monoxide	symptoms: headaches, nausea, dizziness, tiredness
body odour	carbon dioxide (low ventilation rates)	symptoms: headaches and tiredness complaints: lack of air, stagnant air, stuffiness
mouldy, musty	biological material	mould may be visible, symptoms of allergy
chemical smell, like formalin	formaldehyde	presence of unpainted pressed wood products symptoms: eye irritation, nose and throat irritation
solvent smell, chemical smell	VOC	presence of chemicals, or products containing them, symptoms of allergy
(wet) cement, (wet) plaster, dusty smell, chalky smell	particulates (from humidifier)	hard water in this area, spray humidifiers used, white dust on diffusers

4.0 WHERE AND WHEN TO MEASURE

Let us assume that the Building Checklist has brought problems to light that are serious enough to warrant further investigation. One would then proceed to the second stage of activity - measurement with simple insturments. When measuring pollutant concentrations it is not enough to simply go to the places that the Checklist indicates may be the source of a problem, and to take measurements when it is convenient. Such data may be quite meaningless because:

- the severity of the problem may vary depending on the time of day and the day of the week;
- outdoor air varies from place to place, and this is going to affect the air indoors;
- the type and quantity of pollutants in indoor air will also depend on the building age and height, the type of ventilation system, the structural materials and furnishings, the local climate and the time of year;
- the equipment might not be working correctly.

For an effective assessment, it is therefore important to establish a baseline for the pollutant data by taking measurements at control locations and comparing them to measurements made at the test locations indicated by the Building Checklist. This approach takes into account variations in outdoor air quality and differences between buildings, and compensates for some equipment malfunctions.

Suitable control locations are:

- the air intakes
- another outdoor location (if there is a chance that the intake air is being contaminated)
- places indoors assumed to be free of the pollutant being measured

Test locations should include:

- places the Checklist indicates may contain a source of the pollutant being measured
- complaint locations (pollutants can move around a building in surprising ways)
- the air exhausts

It is best to monitor pollutants arising from the building structure, furnishings or ventilation (formaldehyde, some volatile chemicals, biological contamination, etc.) in the mornings if the ventilation system is turned off overnight (most are). However, pollutants generated by the occupants (such as carbon dioxide) or their activities (photocopier chemicals) are best checked towards the end of the working day.

Account also has to be taken of the time of year. If the building is on an economiser cycle, fresh air rates will be less during very cold or very hot weather, so pollutant concentrations will generally be higher in mid-winter and mid-summer. Some sources are also seasonal: humidifiers in winter, air-conditioning systems in summer, pollen in summer, etc.

The above gives some general criteria to use when choosing where and when to make measurements. Details are listed for control locations in Table 4 and for test locations in Table 5. Table 5 refers to pollutant sources and complaint locations identified in the Building Checklist.

Control locations are not used for temperature, relative humidity and air movement measurements, since these parameters are controlled by the building mechanical systems. Thus indoor values are expected to be different from outdoor values.

Usually it is best to do the control and test measurements together, choosing a time appropriate for the test locations.

Table 4 Suitable control locations for measuring pollutants

Pollutant	Suitable control location
carbon dioxide	air intakes (if not contaminated) outdoors, street level or roof indoors, unoccupied area
carbon monoxide	air intakes (if not contaminated) outdoors, roof or upper floor indoors, above second floor
formaldehyde	air intakes (if not contaminated) outdoors, sheltered area (no wind or rain) indoors, lobby or reception area
particulates	air intakes (if not contaminated) outdoors, roof or upper floor on the building side of particulate filters indoors, unoccupied area
radon	outdoors, sheltered area (no wind or rain) indoors, above second floor
VOC	air intakes (if not contaminated) outdoors, street level or roof indoors, away from identified pollutant sources
biological contamination	air intakes (if not contaminated) outdoors, roof indoors, area with no mould, no water, no plants

Table 5 Test locations and ideal times for measuring pollutants and other parameters

Pollutant or Parameter	Test locations	Time to measure
carbon dioxide	pollutant sources (questions 31, 32) complaint areas mixed supply air ducts exhausts	late morning late afternoon when fresh air rate low
carbon monoxide combustion	pollutant sources (questions 1-5, 22) complaint areas stairwells linked to sources elevators linked to sources exhausts	early morning late afternoon when fresh air rate low
formaldehyde	pollutant sources (building) (questions 14, 17, 35) complaint areas	early morning when fresh air rate low
particulates	pollutant sources (questions 15,16,22,23,28) complaint areas exhausts	afternoon
radon	pollutant sources (questions 6-8, 9)	when fresh air rate low
VOC	pollutant sources (building) (questions 14, 26) complaint areas exhausts	early morning Mondays when fresh air rate low
VOC	pollutant sources (activity) (questions 10-13, 33, 34) complaint areas exhausts	late morning late afternoon when fresh air rate low

Table 5 Test locations and ideal times for measuring pollutants and other parameters .... continued

Pollutant or Parameter	Test locations	Time to measure
biological contamination	pollutant sources (building) (questions 25, 27) complaint areas	early morning Mondays when fresh air rate low summer
temperature	areas without a thermostat complaint areas	early mornings late afternoons
humidity	supply air complaint areas	mornings Mondays midwinter midsummer
air movement	near diffusers near room exhausts complaint areas	while the ventilation system is operating normally

5.0 THE EQUIPMENT AND HOW TO USE IT

5.1 GENERAL REMARKS

While each piece has a manual supplied by the manufacturer, the manuals contain more information than is needed for routine use of the equipment. This section provides a short set of instructions for each piece of equipment, which is sufficient to cover day-to-day operation and regular maintenance (such as battery-charging). Occasional maintenance procedures and trouble-shooting are covered in the accompanying Test Kit Maintenance Manual, which includes copies of the manufacturers' manuals.

Not all of the pollutants and other causes of air quality problems discussed in Section 2.0 can be monitored using the equipment in this kit. Only simple pieces of equipment whose operation has been evaluated by PWC are included here. A list of these is given in Table 6. Section 8.0 contains details of Building Performance's other measurement capabilities. Some of the simple instruments listed there may be added to the Test Kit at a later date.

Table 6 Equipment included in the Test Kit

Pollutant/Cause	Equipment	Units of Measurement
carbon dioxide	either Fuji ZFP5 or Horiba APBA-210	ppm ppm
carbon monoxide	either ISD CO260 or Dynamation 104	ppm ppm
formaldehyde	STC chemical kit	ppm
radon	passive detectors	pCi/L or WL
VOC	Gastec pump and tubes	ppm
relative humidity (RH) and temperature (T)	Vaisala HMI 31	% ^oC
air movement	Gastec smoke tube kit	
biological material (fungi)	RCS Biotest air sampler with agar strips	CFU/m^3

5.2 EXPLANATION OF UNITS OF MEASUREMENT

ppm - parts per million - is a volume-per-volume unit used for measurements involving a single pollutant present in very small amounts. For example, a formaldehyde concentration of 4 ppm indicates that there are 4 units of volume of formaldehyde out of every million such units of air.

mg/m3 - milligrams per cubic metre - is a weight-per-volume unit. This unit is used when mixtures of pollutants are measured, such as total VOC or particulates. The unit can be used for single pollutant measurements also, and its size is similar to the ppm for most VOC.

Three units for radon are widely used:

Bq/m^3 - becquerels per cubic metre - is the number of nuclear decay processes (alpha particle production processes) occurring in a cubic metre of air in one second. Alpha-particles are the most damaging radiation generated by radon.

pCi/L - pico curies per litre - is a measure of the amount of alpha-particle radiation generated in a litre of still air in one second.
1 pCi/L = 37 Bq/m^3

WL - working levels - is a unit which takes into account both the amount of alpha-particle radiation generated and the effect of ventilation on this amount.

The relationships between the WL and the other units are variable, but are usually taken to be:

1 WL = 200 pCi/L 1 WL = 8000 Bq/m^3

CFU/m^3 - colony-forming units per cubic metre - is the number of fungal growths observed per cubic metre of air sampled after the agar strips have been incubated.

5.3 THE FUJI ZFP5 CARBON DIOXIDE MONITOR

The Fuji ZFP5 is a portable, battery-operated monitor that weighs about 6 kg (13 lb). It operates by detecting the absorption of infrared light by air containing carbon dioxide. The air is pumped through the instrument by an internal pump. This allows the instrument to respond to changes in carbon dioxide concentration within ten seconds, but requires the use of heavy-duty rechargeable batteries. The concentration of carbon dioxide is displayed in ppm by a pointer on an analogue scale on the front of the instrument. The instrument has two operating ranges: 0-2000 ppm and 0-5000 ppm.

5.3.1 Directions for use

The controls are identified in Illustration 1. The labels on the illustration are not exactly the same as the labels on the instrument.

- Make sure the AC/battery select switch is set to BATTERY, and the range select switch to L (Low range, 0-2000 ppm).
- Switch the instrument on, using the power switch (top right). The red power light above the switch will come on, and the pointer will overshoot the scale on both sides before stabilizing.
- Check the instrument response by flipping the pump switch down (timed operation). The pump will run for 20 seconds, then switch off. Before it stops, the pointer should move to show a reading above 300 ppm. The pump light will stay on while the pump is running.
- Wait 15 minutes with the pump off for the instrument to warm up fully.
- Calibrate the instrument (the procedure is described in the next paragraph).
- When taking measurements, use the pump on timed operation where possible to avoid running the battery down too quickly. Place the instrument on a flat surface. Stand as far away from it as possible when reading the scale to avoid your breath affecting the reading. If you have to stand closer than 5 feet away to read the scale clearly, hold your breath while the pump is on. Alternatively, attach a piece of tygon tubing 2 feet long to the air inlet, and leave it pointing away from you during measurement.
- When finished, turn off the power switch. All lights will go out, and the pointer will go to zero.

5.3.2 Calibration Procedure

The equipment required includes zero gas (listed as carbon dioxide-free on the can), span gas, regulators, tygon tubing and a small slotted-head screwdriver for adjusting the controls. The pump should <u>not</u> be running during calibration, since this will give inaccurate results.

- Screw the small brass regulator hand-tight onto a can of zero air.
- Open the regulator tap slowly until gas comes out. You should be able to hear the gas flow, or to feel the coolness of the flow on

the back of your hand.

- Attach the regulator outlet to the air/gas inlet of the Fuji with tygon tubing.
- The scale pointer will move towards zero. When it stops moving (about 10 seconds), turn the zero adjust screw until the reading is zero.
- Check that the gas is still flowing. Then close the regulator tap and unscrew the regulator from the can.
- Check to see if the o-ring and plastic collar from the can are still attached to the regulator. If so, replace them in the can top (o-ring first) using a screwdriver or the end of a pencil.
- Repeat the preceding 6 steps, this time using span gas, which contains both carbon dioxide and carbon monoxide in air. The carbon dioxide concentration is listed on the can. After 10 seconds of gas flow, turn the span adjust screw until the pointer shows the correct concentration. Turn up the flow a little, and check that the concentration does not change.
- close the regulator tap and unscrew the regulator from the can.
- If either the zero or the span adjustments has changed the concentration by more than 100 ppm, repeat both zero and span gas calibrations.

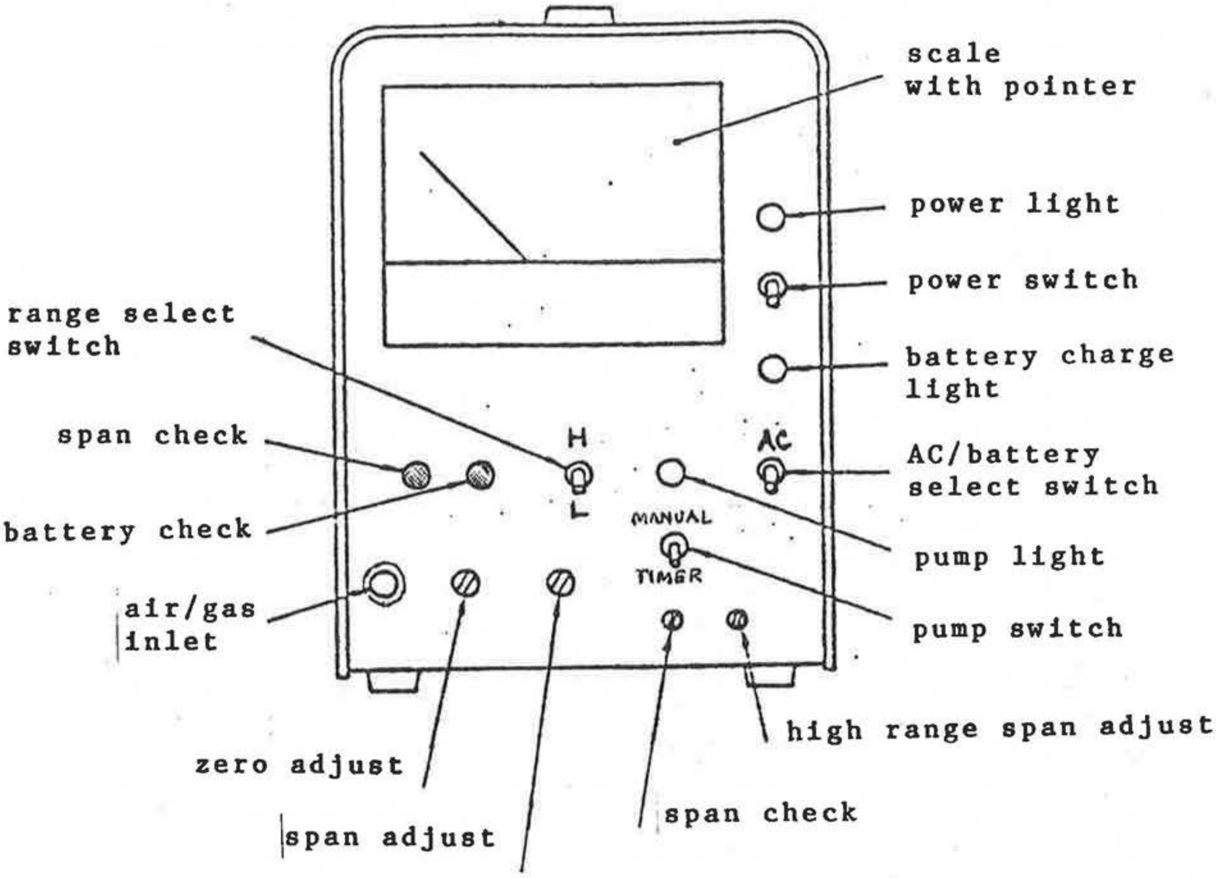
5.3.3 Maintenance

The only regular maintenance involves the rechargeable battery, which should allow 5 hours operation with the pump running continuously, and a full day if the pump is used on timed mode. There is a button for checking battery strength, but it is not reliable. The instrument should always be charged after use. Connect the charger unit to the Fuji (back of the instrument, near the base), and plug it into an AC outlet. With the power switch off, charge for 16 hours. The battery charge light will flicker when the unit is approaching full charge. Disconnect the Fuji from the charger, then the charger from the outlet. Always store the instrument fully charged.

5.3.4 Troubleshooting

If the instrument does not start up when the power switch is turned on, check the AC/battery select switch. The instrument will not work if:

- the switch is set to AC, and the unit is not connected up to the charger, or the charger is not connected to an AC outlet;
- the switch is set to battery and the battery is very low.



<u>**Illustration 1**</u>

5.4 THE HORIBA APBA-210 CARBON DIOXIDE MONITOR

The Horiba APBA-210 is a portable, battery-operated monitor weighing 6 kg (13 lb). It detects the absorption of infrared light by air containing carbon dioxide. An internal pump circulates the air through the instrument, allowing it to respond quickly to changes in carbon dioxide concentration. The concentration of carbon dioxide is displayed in ppm by a pointer on an analogue scale on the top of the instrument. The instrument has two operating ranges: 0-2000 ppm and 0-5000 ppm. It uses a heavy-duty rechargeable battery.

5.4.1 Directions for use

The controls are identified in Illustration 2. The labels on the illustration are not exactly the same as the labels on the instrument.

- Use the power/range select switch to turn the instrument on, and set it to operate in the 0-2000 ppm range. The pointer will overshoot the scale on both sides before stabilizing.
- Check the instrument response by flipping the pump switch to the right (timed operation). The pump will run for 15 seconds, then switch off. Before it stops, the pointer should move to show a reading above 300 ppm.
- Wait one hour for the instrument to warm up fully.
- Calibrate the instrument with zero gas and span gas (the procedure is described in the next paragraph).
- When taking measurements, use the pump on timed operation where possible to avoid running the battery down too quickly. Place the instrument on a flat surface. Stand as far away from it as possible when reading the scale to avoid your breath affecting the reading. If you have to stand closer than 5 feet away to read the scale clearly, hold your breath while the pump is on. Alternatively, attach a piece of tygon tubing 2 feet long to the air inlet, and leave it pointing away from you during measurement.

- When finished, turn off the power switch. The scale pointer will go to zero.

5.4.2 AC operation

The battery in the Horiba has a long warm-up time and a short operating time. It may be best to operate the instrument routinely on AC rather than battery. The instrument does not lose much accuracy when it is moved and turned on and off several times. If the choice is made to operate it on AC, then it should be calibrated on AC also. Warm-up time on AC is 15 minutes.

5.4.3 Calibration Procedure

The equipment required includes zero gas (listed as carbon dioxide-free on the can), span gas, regulators, and tygon tubing. The pump should not be running during calibration, since this will give inaccurate results.

- Screw the small brass regulator hand-tight onto a can of zero air.
- Open the regulator tap slowly until gas comes out. You should be able to hear the gas flow, or to feel the coolness of the flow on the back of your hand.
- Attach the regulator outlet to the air/gas inlet of the Horiba with tygon tubing.
- The scale pointer will move towards zero. When it stops moving (about 10 seconds), press down on the zero adjust knob and turn it until the reading is zero.
- Check that the gas is still flowing. Then close the regulator tap and unscrew the regulator from the can.
- Check to see if the o-ring and plastic collar from the can are still attached to the regulator. If so, replace them in the can top (o-ring first) using a screwdriver or the end of a pencil.
- Release the two push buttons and remove the side panel of the unit to expose the span adjust control (a yellow knob, see Illustration 2).
- Repeat the first 6 steps, this time using span gas, which contains both carbon dioxide and carbon monoxide in air. The carbon dioxide concentration is listed on the can. After 10 seconds of gas flow, turn the span adjust control until the pointer shows the correct concentration. Turn up the flow a little, and check that the concentration does not change.
- close the regulator tap and unscrew the regulator from the can.
- If either the zero or the span adjustments has changed the concentration by more than 100 ppm, repeat both zero and span gas calibrations.

5.4.4 Maintenance

The only regular maintenance involves the rechargeable battery, which usually operates for only 2-3 hours. Following use, the instrument should be charged with the power switch off. The charger is internal, and the instrument is charged simply by connecting the AC cable (Illustration 2) to an outlet. Charge for 16 hours, then disconnect the cable. The instrument should always be stored fully charged.

Note

The special gas inlet (labelled "gas checker" on the instrument) can be used only with the cans of calibration gas supplied by Horiba. Building Performance uses cans from Matheson Gas, and calibration is carried out using the air/gas inlet.

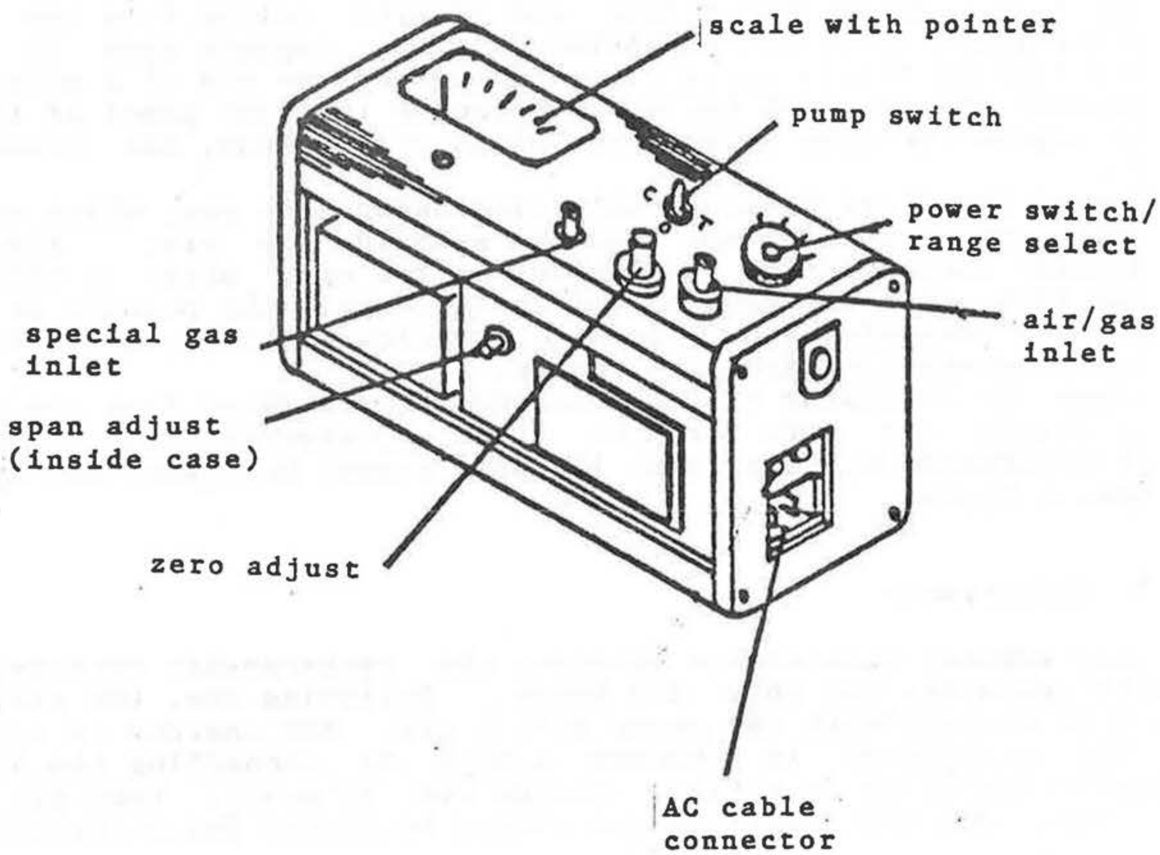


Illustration 2

5.5 THE ISD CO260 CARBON MONOXIDE MONITOR

The CO260 is a pocket-sized instrument that uses an electrochemical cell (similar to a battery) to measure carbon monoxide. The cell responds to gas diffusing into it through a screen in the case. However, the diffusion process is slow, and the instrument may take a minute to respond fully to changes in carbon monoxide levels. The concentration of carbon monoxide is displayed digitally. The concentration range that can be measured is 0-1999 ppm, and the accuracy is about $\pm$1 ppm at the low end of the range. The instrument is equipped with a light for reading the display in dark places (use the push button on the right side of the unit), and an alarm (buzzer and the word "ALARM" on the display). The alarm is set to go off at 100 ppm.

5.5.1 Directions for use

- To switch on the instrument:
- loosen the knurled knob attached to the wrist strap;
- turn the plate that says "caution" upside down, so that the metal button on the plate fits into the hole marked "S";
- tighten the knurled knob again.
  (See Illustrations 1 and 2) When the unit is on, a number will show on the digital display.
- As the CO260 retains its calibration well, it needs to be calibrated only once a week, or whenever the instrument has been exposed to more than 200 ppm of carbon monoxide. The calibration procedure is described below.
- When measuring, wait one minute at each location before reading off the concentration.
- When the measurements are completed, switch the instrument off by turning the plate that says "caution" right side up (so that the metal button fits in the unmarked hole at the left), and tightening the knurled knob. The display should go blank.

5.5.2 Calibration procedure

- Place the black calibration cup over the top of the instrument, and press down firmly. The shorter part of the cup goes at the front and the longer part over the cutaway back with the sensor screen on it (see Illustration 1);
- Loosen the knurled knob, turn the plate until it is at a right angle to the instrument body (Illustration 2, at the bottom), and tighten the knob again. This exposes the zero adjust (Z) and span adjust (S) controls. A miniature slotted head screwdriver is required to change the settings;
- Screw the small brass regulator hand-tight onto a can of zero air (listed as carbon dioxide free on the can).
- Open the regulator tap slowly until gas comes out. You should be able to hear the gas flow, or to feel the coolness of the flow on the back of your hand.

- Attach the regulator outlet to the calibration cup inlet with tygon tubing.
- Allow the zero gas to flow through the calibration cup to the sensor for two minutes before reading the concentration. If the concentration is not zero, turn the zero adjust screw until the reading is zero.
- Check that the gas is still flowing, then close the regulator tap and unscrew the regulator from the can.
- Check to see if the rubber o-ring and plastic collar from the can are still attached to the regulator. If so, replace them in the can top (o-ring first) using a screwdriver or the end of a pencil.
- Repeat the preceding 6 steps, this time using the span gas, which contains both carbon dioxide and carbon monoxide in air. The carbon monoxide concentration is listed on the can. After two minutes of gas flow, use the miniature screwdriver to turn the span adjust screw until the correct concentration is displayed.
- Close the regulator tap and unscrew the regulator from the can.
- If either the zero or the span adjustment has changed the concentration by more than 10 ppm, repeat both procedures.
- Remove the calibration cup.
- Return the plate under the knurled knob to the "power on" position (Illustration 2, middle), and tighten the knob.

5.5.3 Maintenance

- The 4 AA-size batteries in the CO260 should last for two thousand hours of operation. When they need to be replaced the word "LOBAT" will appear at the left of the digital display. The battery replacement procedure is described in the Maintenance Manual.

5.5.4 Troubleshooting

- The instrument does not work well in cold weather.
- Display of "LOBAT", a red light, and the number 1 with flashing minus sign indicate battery failure. Remove the batteries from the unit immediately, and replace with fresh ones.
- If the instrument displays 000 ppm with both zero and span gas, or if the instrument cannot be adjusted to read a concentration as high as the span gas concentration, the sensor may have failed. Building Performance keeps spare sensors in stock, and the replacement instructions are in the Maintenance Manual.

Illustration 3

Illustration 4

5.6 THE DYNAMATION MONOGARD 104 CARBON MONOXIDE MONITOR

The Dynamation Monogard 104 is a pocket-sized instrument that uses an electrochemical cell (similar to a battery) to measure carbon monoxide. The cell responds to gas diffusing into it through a screen in the case. However, the diffusion process is slow, and the instrument may take a minute to respond fully to changes in carbon monoxide concentration. The concentration of carbon monoxide in ppm is displayed digitally. The concentration range that can be measured is 0-999 ppm, and the accuracy is about ± 1 ppm at the low end of the range. The instrument is equipped with a light for reading the display in dark places (use the switch labelled "LITE" on the top of the unit), and an alarm that is set to go off at 200 ppm.

5.6.1 Directions for use

- Open the leatherette case to expose the top of the instrument.
- Push the power switch to the ON position. A number will appear on the digital display.
- Test the alarm by pushing the 3-position switch on the top of the instrument to TEST. You should see a flashing light next to the digital display, and hear an intermittent buzzer.
- Wait 30 seconds for the unit to warm up.
- Calibration need only be done once a week, and is described below.
- When measuring, wait one minute at each location before reading off the carbon monoxide concentration.
- When your measurements are completed, switch the instrument off using the power switch. The display should go blank.

5.6.2 Calibration procedure

- Place the calibration pad over the sensor screen (the larger of the two screens, the smaller one being the alarm speaker).
- Screw the small brass regulator hand-tight onto a can of zero air (listed as carbon dioxide-free on the can).
- Open the regulator tap slowly until gas comes out. You should be able to hear the gas flow, or to feel the coolness of the flow on the back of your hand.
- Attach the regulator outlet to the nipple on the calibration pad with tygon tubing.
- Allow the zero gas to flow over the sensor for two minutes before reading the concentration. If the concentration is not zero, turn the zero adjust screw (labelled _ on the instrument top) until the reading is zero.
- Check that the gas is still flowing, then close the regulator tap and unscrew the regulator from the can.
- Check to see if the o-ring and plastic collar from the can are still attached to the regulator. If so, replace them in the can top (o-ring first) using a screwdriver or the end of a pencil.
- Repeat the preceding 6 steps, this time using the span gas, which contains both carbon dioxide and carbon monoxide in air. The

carbon monoxide concentration is listed on the can. Adjust the span setting (labelled C on the instrument top) to this concentration after two minutes of gas flow.

- Close the regulator tap and unscrew the regulator from the can.
- If either the zero or the span adjustment has changed the concentration by more than 10 ppm, repeat both procedures.
- Remove the calibration pad.

5.6.3 Maintenance

- The 9 V battery in the Dynamation should last for several hundred hours of operation. When the battery needs to be replaced, the buzzer will sound with a steady tone, and the light next to the digital display will go on continuously (do not confuse this with the alarm signal, where both light and buzzer are intermittent). The battery replacement procedure isdescribed in the Maintenance Manual.

5.6.4 Troubleshooting

- If the instrument displays 000 ppm with both zero and span gas, or cannot be adjusted to read a concentration as high as the span gas concentration, the sensor may have failed.
- If the concentration on the display goes below -6, the buzzer will sound with a steady tone. This indicates either that the zero is set incorrectly or that there is a problem with the sensor or electronics.

5.7 THE AIR TECHNOLOGY LABS STC FORMALDEHYDE KIT

The Air Technology Labs STC kit uses a small bottle containing a solution of chemical in water to collect formaldehyde from the air. The formaldehyde passes into the solution through a porous disk in the cap of the bottle. Addition of another chemical one hour after the completion of sampling starts a reaction that turns the solution a greenish colour. The depth of this colour is measured by a colorimeter, and is converted into an air concentration of formaldehyde using calibrations (Tables of Results) supplied by the manufacturer.

5.7.1 General Precautions

- Read the instructions first and follow them closely. Timing is critical.
- Do not let chemicals come in contact with your eyes, mouth or clothes. If this happens accidentally, wash off immediately with water. The chemicals are not harmful to your hands or the counter top, but it is best to wash them off without too much delay.
- Keep all of the chemical containers tightly capped with their own caps when they are not being used.
- Store the kit away from sunlight, out of reach of children, and away from excessive heat or cold.

5.7.2 Kit Contents

Sampling equipment:

- 5 small glass bottles,
- 5 caps with holes for the bottles,
- pack of diffusion disks (porous disks that fit inside the holed caps),
- 5 clear plastic stands,
- 5 metal clips to secure the bottles on the stands,
- 5 solid caps for the bottles.

Ilustration 5 shows how these fit together for sample collection.

Chemicals and their measurement:

- distilled water (in a large white plastic bottle),
- reagent A (little pills in a small brown bottle),
- reagent B (yellow liquid in a small brown bottle),
- large plastic dropper with a corrugated top,
- small medicine dropper with black top,
- syringe (optional).

When measuring out distilled water, use the large dropper. For reagent B, use the medicine dropper or the syringe. Do NOT use the same dropper for both liquids.

Analysis equipment:

- colorimeter with protective orange cap for sample well,
- detachable scale for colorimeter,

- black light cap for sample well,
- glass bottle (no cap) for zeroing colorimeter,
- calibration card (Tables of Results for colorimeter).

The parts of the colorimeter are identified in Illustration 6.

Miscellaneous items:
- carrying case,
- marker pen,
- brush for cleaning sample bottles.

While the kit contains enough parts for collection of five samples, we recommend collecting a maximum of four samples at a time, and using the remaining parts to run a blank (no-exposure) sample.

5.7.3 Directions for use

5.7.3.1 Sample collection

- Fill the glass bottles to exactly the 5 ml mark with distilled water. Use the large plastic dropper if necessary. The bottom of the curved line of the water should coincide with the 5 ml mark when the bottle is held with the mark at eye level.
- Add a reagent A pill to each bottle. With occasional gentle shaking, the pill takes about 5 minutes to dissolve.
- While the pills are dissolving, place a new diffusion disk in each holed cap, holding the disk by the edges only. Screw the caps firmly onto the bottles.
- Write an identifying number on each bottle using the marker pen. Do NOT write on the cap or the disk.
- Slide clips over the bottoms of the bottles (do NOT try to push them onto the sides of the bottles, as the bottles will break). If chemicals are spilled on the clips, wash them with water immediately and dry them.
- Use the clips to secure the bottles upside down on the plastic stands (see Illustration 5). The bottles must remain upside down throughout the sampling time.
- Place the bottles at the sampling locations. Record on the data sheet the identification number of each bottle and the time it was placed at its location.
- The sampling time should be between 1 hour (locations where formaldehyde concentration is expected to be high) and 5 hours (formaldehyde concentration expected to be low, or unknown).
- At the end of the sampling time:
    - write down the stop times on the data sheet
    - take the bottles off the stands and remove the clips
    - replace the holed caps and disks with solid caps
    - dispose of the used disks in the garbage
- **STORE THE SAMPLES FOR 1 HOUR BEFORE CARRYING OUT THE ANALYSIS** (if kept overnight, store in a refrigerator).

The blank (no-exposure) sample should be made up as follows: measure 5 ml of distilled water into a bottle and dissolve a pill of reagent A in the water. Cap the bottle with a solid cap and label the bottle.

Store for the same time and in the same manner as the exposed samples.

5.7.3.2 Sample analysis

- At the end of the storage time, add 1 ml of reagent B to each bottle (exposed and blank samples) using the medicine dropper or the syringe. Replace the solid cap and shake gently to mix.
- **WAIT 15 MINUTES FOR THE COLOUR TO DEVELOP FULLY.**

The colorimeter is a small box containing a lamp and a detector. The detector measures how much of the light from the lamp passes through the sample solution, and displays the result - the percentage transmission (%T) - on a scale on the top of the box.

- Fill a sample bottle to the 5 ml mark with distilled water, wipe it dry and clean of fingerprints, place it in the sample well of the colorimeter (Illustration 6), and put black light cap over the top of it. It is important to exclude room light from the detector during measurement.
- Check that the detachable scale of the colorimeter is properly slotted into place.
- Depress the "READ" button and turn the "FULL SCALE" knob until a stable reading of 100 is obtained (100%T represents zero colour).
- Now that the colorimeter has been zeroed, measure the %T for the blank and each of the exposed samples using the following procedure:
    - wipe the bottle clean of fingerprints
    - hold it by the cap and place it in the colorimeter sample well
    - place the light cap over the bottle
    - depress the "READ" button, read the %T on the scale and record it on the data sheet.
- If any of the values of %T are less than 10, the solutions must be diluted and remeasured. Dilute by using the large plastic dropper to add distilled water to the bottle up to the 10 ml mark. Clean the bottle and remeasure the %T as above.
- Replace the bottle of distilled water in the colorimeter, and check the %T. It should be 100_2. If the %T is outside this range, reset it to 100, and remeasure %T for the blank and the samples.

5.7.4 Getting the concentration of formaldehyde

The kit contains a card with two numerical tables for estimating formaldehyde concentrations. The colorimeter number printed in the top right corner of the card should match the one stamped on the bottom of the colorimeter.

The upper table is used for normal samples, and the lower table for samples diluted to 10 ml. The tables give formaldehyde concentrations for a range of sampling times, but only for %T of 80, 70, 60, etc. Thus formaldehyde concentrations can only be estimated roughly. For more accurate values, use a calculator and process your results using the formulas under the tables.

If the blank concentration is 0.01 ppm or higher, subtract it from the concentrations of the other samples to give corrected concentrations. For example:

formaldehyde concentration of sample 123	= 0.13 ppm
formaldehyde concentration of blank	= 0.04 ppm
corrected formaldehyde concentration of sample 123	= 0.09 ppm

5.7.5 Follow-up

- Clean the bottles and caps with water and a brush immediately after use. Dirty bottles can cause false high formaldehyde concentrations.

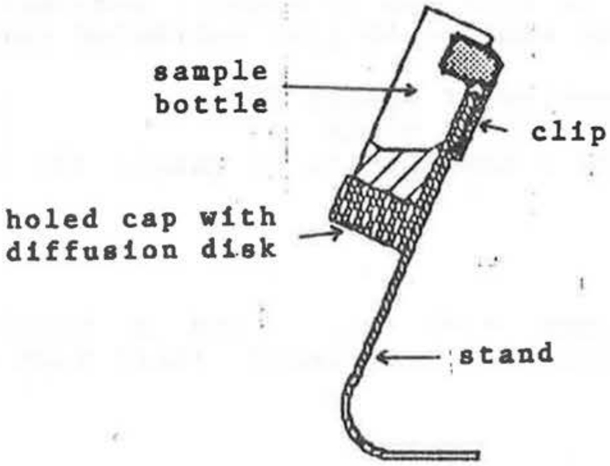


Illustration 5

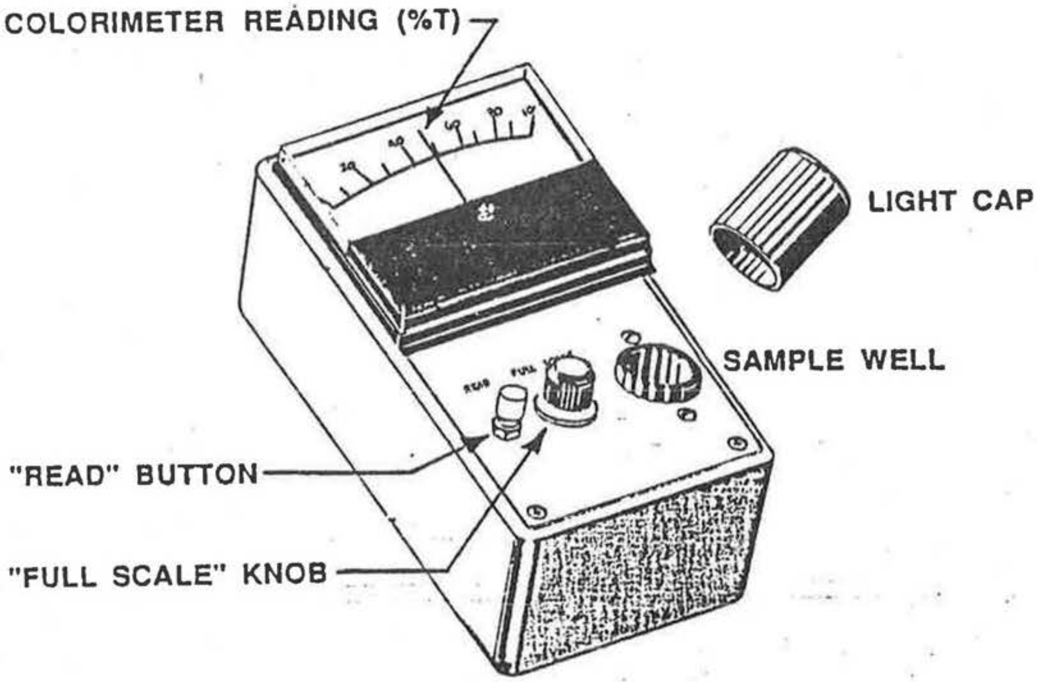


Illustration 6

5.8 RADON DETECTORS

Radon is measured using pocket-sized passive detectors that collect a sample by diffusion. No pumps are necessary. The detectors are placed close to suspected sources of radon and left there for the length of time recommended by the manufacturer. They are then sent to a laboratory for analysis and determination of the concentrations. Usually the laboratory is run by the detector manufacturer.

Two types of radon detectors are used by Building Performance, charcoal canisters and alpha track detectors. These operate quite differently, resulting in different sampling times. Charcoal canisters normally sample for 1-7 days, and alpha track detectors for 1-6 months.

5.8.1 Directions for use

Sampling times and laboratory addresses are given in Table 7, and some specific instructions are included with the detectors themselves. This section covers procedures common to both types of detectors.

- Do not remove the protective covering from the detector until ready to start sampling.
- Read the instructions that come with detector carefully.
- During sampling, detectors should be located near suspected radon sources (within 3 feet if possible). They should not be placed on the floor, or in places where they are likely to get wet. They can be hung on walls or from pipes.
- Always fill out your name and address on the paper accompanying the detector, for return of the results.
- Always include details of the sampling start and stop times, otherwise the analyst cannot determine the concentration.
- Always note the detector code number on your own data sheet, and keep the data sheet. If the results go astray, you will need the code number to trace them at the analysing laboratory.
- No payments are necessary. The analyses are all prepaid by Building Performance.
- When a sampling time of only a few days is used, get the detector to the analysing laboratory quickly (by priority post or courier), or the radon concentration will not be determined accurately.

Table 7 **Details of individual radon detectors**

Detector type	Recommended sampling time	Address for analysing laboratory
charcoal canister	2 days	alphaNUCLEAR Company Services Division 1125 Derry Road East Mississauga, Ontario, Canada L5T 1P3
charcoal canister alpha track detector	2 days 6 months	Bubble Technology Industries Consumer Products Division P.O. Box 100 Chalk River, Ontario, Canada K0J 1J0
alpha track detector	at least 1 month	Barringer Laboratories 5735 McAdam Road Mississauga, Ontario, Canada L4Z 1N9

5.9 THE GASTEC PUMP AND TUBES

The Gastec pump is designed to draw in the same volume of air each time it is operated. A tube containing special reagents is attached to the inlet at the front of the pump, and air is drawn through the tube (Illustration 7). A chemical in the air will react with the reagents to produce a colour. The distance the colour moves up the tube indicates the quantity of the chemical in the air. The tubes with their reagents are made so that each type will detect only one, or a small group of chemicals. The volume of air needed to measure the chemicals varies. Different volumes of air are obtained by varying the number of pump strokes. The pump will pull in 50 ml of air if the handle is pulled out half way to the first red line (1/2 stroke), or 100 ml if the handle is pulled out all the way (1 stroke). Usually chemicals are present in indoor air in such small quantities that the 100 ml setting is used. The strokes can be counted off on the ring on the pump body. It is necessary to wait between strokes to allow all of the pumped air to move through the tube. The finish indicator beside the inlet used to determine when this process is complete.

5.9.1 Directions for use

- Choose the appropriate tube (Table 8). Check the colour change it will show and the number of pump strokes required.
- Check the position of the red float in the finish indicator. It should be sitting just at or above the blue line.
- Rotate the blue counter ring until the red guide mark is lined up with the blank (zero) panel to the left of the number 1 panel.
- Make sure the pump handle is pushed all the way in. Line up the red guide marks on the pump body and handle.
- Break both ends off the tube using the tube tip breaker near the front of the pump body (Illustration 7). Shake the glass chips out and dispose of them.
- Insert the tube securely into the pump inlet with the arrow on the tube pointing towards the pump (Illustration 8; all of the chemicals of interest here need only the analyzer tube).
- Without removing the tube from the pump, repeat the procedure below until the necessary number of pump strokes have been completed:
  - Pull the pump handle all the way out (this may be hard work!). It will click twice, at 50 ml and at 100ml.
  - Move the counter ring left so that the next higher number lines up with the guide mark. The ring will click into position.
  - The red float in the finish indicator will have been pulled in almost to the pump body. Wait for it to return to its initial position.
  - Unlock the pump handle by rotating it a quarter turn, and push it all the way in.
  - Rotate the handle back to realign the guide marks.
- When you have completed the pump strokes, inspect the tube to find

the division beween the original colour and the newly developed colour. Read the concentration of chemical at this point using the ppm scale on the tube
- Carefully pull the tube out of the pump inlet and dispose of it.

Table 8 Details of individual Gastec tubes

Chemical detected	Detection range (ppm)	Tube no.	Original colour	Colour developing	Number of pump strokes
carbon dioxide	300-5000	2LL	white	purple	1
carbon monoxide	1-50	1LL	yellow	dark brown	2
formaldehyde	0.1-5	91L	yellow	red-brown	5
toluene	5-300	122	white	brown	1
hydrocarbon solvents	0.1-14 mg/L	106	dark brown	dark green	1

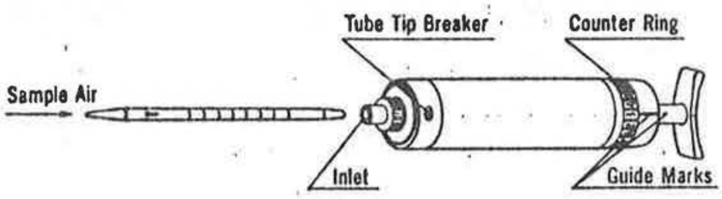


Illustration 7

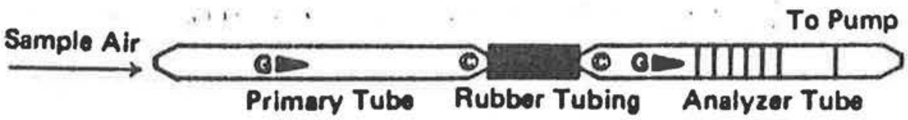


Illustration 8

5.10 THE VAISALA MODEL HMI 31 RH & T MONITOR

The monitor measures relative humidity (RH) and temperature (T) using a small sensor located on the end of the probe, which normally sits in a cylindrical slot at the right of the instrument. The sensor is protected by a black cage. When the monitor is in use, the probe is either moved forward to expose the sensor to the surrounding air, or removed completely from its slot to monitor conditions up to three feet away from the instrument with the cable fully extended. Either T (in ^oC) or RH (in %) is displayed digitally on a screen. The ranges of operation are T: -40 to +80 °C; RH: 0 to 100%.

5.10.1 Directions for use

- Switch the unit on using the red ON/OFF button at the left side of the instrument below the display screen. The number will appear on the screen.
- Check the right side of the display screen to see whether RH or T is being displayed. You can switch between the two using the black button just above the ON/OFF button. Button in gives T, button out RH. The monitor will give accurate readings as soon as it is switched on.
- Before starting to record data, either move the probe forward until the black cage on the probe end is clear of the monitor body, or take the probe out of its slot. If using the probe out of its slot, hold it near the cable to prevent the heat of your hand from affecting the temperature sensor.
- When recording at a new locations or switching between RH and T, wait about five seconds for the number to stop changing.
- When recording is complete, switch off the monitor using the red button.

5.10.2 Calibration

- not required.

5.10.3 Maintenance

The unit is powered by a 9-V battery, which is installed in the battery case at the back of the instrument. A battery lasts about 20 hours, and should be replaced when the word "BAT" appears at the upper left of the display.

Always store the unit with the probe in the slot. The sensor can be damaged by impact, water or excessive heat.

5.10.4 Troubleshooting

- If the display screen remains blank when the monitor is switched on, the battery is probably dead.

- If the display screen shows the number -1 when switched on, the battery is okay. Check the connector linking the probe cable to the monitor body. If the locking nut is loose, tighten it. If this does not solve the problem, the sensor may need to be replaced (see Maintenance Manual).

5.11 THE GASTEC SMOKE TUBE KIT

Unlike the other equipment in the Test Kit, the smoke tubes cannot make exact measurements. However, they can provide useful qualitative data. When air is pumped through an open smoke tube, it gives off smoke like a cigarette, and the movement of the smoke indicates the direction and speed of air movement. These observations can be used to evaluate or compare the performance of diffusers, exhaust louvers, etc., and to test whether air is circulating at a workstation.

Do not use the smoke tube in occupied areas unless really necessary. The smoke can cause irritation of eyes, nose and throat.

5.11.1 Directions for use

- Use a tube that has already been opened, or open one by inserting the tube ends in the zipper hole on the case, and snapping them off.
- Insert one end of the open tube into the red rubber bulb.
- Put your thumb over the hole in the bulb and squeeze. This will drive smoke out of the free end of the tube. Take your thumb off the hole to allow air to re-enter the bulb. Note where the smoke is going and how fast.
- When finished using the smoke tube, place the rubber caps (supplied) on both ends for storage.

5.11.2 Maintenance

- Each tube will last for about 50 tests.
- Some of the rubber caps must be re-used, since the box of tubes contains only six caps, and two are needed for each open tube.
- Inside the tube, there are plugs at either end that keep the chemical in place. If in high humidity the tube becomes clogged, warm the plugs at either end of the chemical with a match or lighter flame.
- To dispose of a used tube, run cold water through it to neutralize the chemicals inside (note: the tube gets hot). The tube can then safely be placed in the garbage.

5.12 THE RCS BIOTEST CENTRIFUGAL AIR SAMPLER

The RCS Biotest centrifugal air sampler is a portable battery-operated instrument which weighs about 1 kg (2.5 lb). It uses 4 standard D cell batteries. The air being tested is drawn into the sampler head and around inside the head by a fan. Particles contained in the air are impacted by centrifugal force onto a plastic strip containing agar which is placed on the inside wall of the head.

After sampling, the strip is taken out and sent to a laboratory for analysis. The laboratory incubates the strips to allow any fungal spores to reproduce to form spots (colonies) on the surface of the agar. The colonies are counted. Using the volume of air sampled, the concentration of fungal spores is expressed as the number of colony-forming units per cubic metre of air (CFU/m^3). Identification of the spore type may be necessary to determine whether the count is acceptable or not. This must be carried out by a trained biologist.

5.12.1 Directions for use

These directions cover collection of samples and safe return of agar strips to PWC:

- Remove the plastic cover of the RCS sampler and sterilize the fan blades and inside of the head with an ethanol swab or suitable disinfecting solution. This procedure must be carried out at the beginning of sampling and between each floor of a large building
- Tear open the rounded end of the plastic wrapper containing the agar strip. Pull the plastic back only far enough to allow the strip to be pulled out (about 4 cm or 1 1/2 inches). Carefully remove the strip without touching the surface of the agar with your fingers. Insert the strip immediately in the slot at the side of the sampler head, with the agar facing inwards. Make sure that the strip protrudes enough for it to be removed easily at the end of the sampling time
- Set the sampling time switch to four minutes
- Place the instrument at the required location and turn on by moving the main switch from 0 to 1 (the light will come on). Start the fan by depressing the start button at the bottom of the panel. Do not move the instrument while a sample is being taken. It will stop automatically at the end of the sampling time
- When the fan has stopped, pull out the strip without touching the agar with your fingers, and return it to its wrapper with the agar facing the bulged surface of the wrapper
- seal the open end of the wrapper with scotch tape, making sure that the tape extends past the section that was opened. It is important that no additional fungi get a chance to get inside the wrapper before the sample is analyzed, or the results will be invalid. Note that masking tape should <u>not</u> be used, since it is not sterile, and it does not seal as well as scotch tape
- label the sample (with a ballpoint pen or small label) on the top (opened) end of the wrapper, so that the information does not obscure any of the pink agar squares. The analyst needs to be

able to see these to count the number of fungi after incubation

- The samples must be kept cool (2-5 °C) until they reach the analyzing laboratory. It is best to use a cooler containing icepacks. Make sure that the strips are separated from the icepacks by at least half an inch of paper towelling. This will protect the agar from freezer burn which can completely destroy the samples

5.12.2 Maintenance and Troubeshooting

- always carry a spare set of batteries, because one set only allows about twenty minutes sampling time. Replace the batteries if the control light does not come on when the instrument is switched on.
- samples should be delivered to PWC HQ or the analyzing laboratory within twenty-four hours of collection

6.0 DATA SHEETS

Data sheets are provided to make the recording of information convenient and consistent, and to simplify assessment. Make as many copies as needed from the originals in the Appendix before starting to collect data.

The top part of the data sheets requests identification information and calibration results. Fill out this part before starting measurement.

Space is provided on the sheets for all the information you need to include while recording data.

The space headed "Comment" or "Additional Information" should be used to list anything you see that might affect the measurements being made. An example for carbon dioxide measurements might be: "12 people here, door closed."

CARBON DIOXIDE (CO2) - DATA SHEET

sheet no. ______

Instrument: Fuji / Horiba

Zero Calibration (0 ppm):

Span Calibration (ppm):

Building:

User:

Date:

Floor	Place	Time	CO2 ppm	Comment

CARBON MONOXIDE (CO) - DATA SHEET sheet no. ______

Instrument: CO260 / Dynamation Building:

Zero Calibration (0 ppm): User:

Span Calibration (ppm): Date:

Floor	Place	Time	CO ppm	Comment

FORMALDEHYDE (H2CO) - DATA SHEET

sheet no. _____

Instrument: STC kit no.:

Building:

%T of water (before):

User:

%T of water (after):

Date:

Samp id	Floor	Place	Start Time	Stop Time	Total Time (mins)	%T	H2CO (ppm)	Net H2CO (ppm)

Comment / Additional Information

RADON - DATA SHEET FOR PASSIVE DETECTORS sheet no. ______

Detector type: Building:

Recommended exposure: User:

Detector number	Floor	Place	Start time and date	Stop time and date	Radon (pCi/L or WL)

Comment / Additional Information

GENERAL GAS AND VOC - DATA SHEET

sheet no. ______

Instrument: Gastec pump & tubes

Tube part number:

Gas:

Building:

User:

Date:

Floor	Place	Time	gas ppm	Comment

TEMPERATURE (T) AND RELATIVE HUMIDITY (RH) - DATA SHEET no. ______

Instrument: Vaisala HMI 31 Building:

User: Date:

Floor	Place	Time	T °C	RH %	Comment

AIR MOVEMENT - DATA SHEET

sheet no. _____

Instrument: Gasteo smoke tube kit

Building:

User:

Date:

Floor	Place	Time	Comment on Air Movement

BIOLOGICAL MATERIAL (FUNGI) - DATA SHEET

sheet no. ______

Instrument: RCS Biotest sampler

Building:

User:

Date:

Samp id	Floor	Place	Time	Comment

7.0 DATA ASSESSMENT

Because the types of measurements made with this kit may be unfamiliar to some, Table 8 gives the following ranges of acceptable and unacceptable values for each type of data.

(1) normal outdoor measured values. The readings obtained at the outdoor control locations should be in this range.
(2) normal indoor measured values. These values should not be associated with complaints about the air.
(3) possible problem values. Measured values in this range are not high enough to justify recommending immediate remedial action if obtained at test locations. However, they may be associated with complaints, and further investigation may be needed to verify whether a problem really does exist.
(4) values that should not be exceeded indoors if the building systems are operating properly, and if occupants are to be comfortable. These are based mainly on the indoor air quality standards set by ASHRAE (American Society of Heating, Refrigeration and Air-conditioning Engineers). In general these standards are much stricter than those found in federal and provincial occupational health and safety laws. If measured values fall into this category, it is likely that only comfort is affected, not health. Where doubt exists, it should be assumed that a health risk may be present, and the situation should immediately be referred to Health and Welfare Canada for resolution.

For each type of measurement, compare the numbers recorded on the data sheets with the numbers in the table. Several situations are possible:

- If all control and test location data fall in the normal outdoor and indoor ranges, any existing problems are not due to this cause/pollutant (provided that the equipment is working properly).
- If control locations give numbers in the normal ranges, and one or more test locations give numbers in the "do not exceed" range, there is a problem that should be corrected.
- If the control location data are in the normal ranges, and one or more test locations give numbers in the "possible problem" range, more detailed tests may be necessary.
- If test and control locations give numbers in the "possible problem" range, the problem could lie with the outdoor air, or with the equipment (check the calibration).

If some of the numbers fall into the "possible problem" or "do not exceed" categories, Section 8.0 lists some solutions to problems identified in the Checklist. Building Performance personnel can advise on suitable courses of action. Details of tests available are given in Section 9.0.

Table 9 **Data assessment - table of good and bad numbers**

POLLUTANT (measurement units)	MEASURED CONCENTRATIONS normal outdoor	normal indoor	possible problem	do not exceed
carbon dioxide (ppm)	330-400	330-800	800-1000	1000
area-area CO2 variations **		± 50	± 75	
carbon monoxide (ppm)	0-4	0-4	4-9	9
formaldehyde (ppm)	0-0.02	0-0.1	0.1-0.4	0.4
radon (WL)	0	0-0.01	0.01-0.027	0.027
radon (pCi/L)	0	0-2	2-4	4

** where measurements are made at the same time

The measured values of temperature and relative humidity should also be compared to the ranges allowed by ASHRAE. These are:
winter temperature: 19.5-24.6 °C summer temperature: 22.6-27.2 °C
winter humidity: 25-85% summer humidity: 25-70%
In regions with cold, dry winters and hot, damp summers, the humidity limits are effectively: not less than 25% RH in winter, and not more than 70% in summer.

If temperatures or humidities at the extremes of these ranges are recorded, a "possible problem" is indicated; measured values outside the extremes are effectively in the "do not exceed" column of the Table.

Where any doubt exists concerning thermal comfort, the Building Performance Thermal Comfort Test Kit may be used for problem resolution.

There are no standards for fungi at present. Species identification is important to the interpretation. However, some general guidelines can be provided:

- The presence of certain pathogens (such as A. fumigatus) and certain toxigenic fungi (such as S. atra) should be considered as unacceptable.
- Up to 50 CFU/m^3 should be considered acceptable if there is only one species present.
- Up to 150 CFU/m^3 should be considered acceptable if there is a mixture of species present.
- Up to 500 CFU/m^3 should be considered acceptable if the species present are primarily cladosporium or other phylloplane fungi.

8.0 SOLUTIONS TO PROBLEMS

Indoor air quality problems in large buildings can have several different causes including:
- building or HVAC design faults
- poor maintenance
- operating the building differently from design
- changes in space usage
- lack of fresh air
- presence of pollutant sources

Solutions include:
- clean or repair the offending part of the building or HVAC system
- operate the systems in the way that they were designed to perform
- change the HVAC system to reflect changes in building use
- ensure that enough fresh air enters the building to deal with occupants' needs and weak pollutant sources
- ensure that the fresh air actually reaches the places which need it
- provide special ventilation for strong pollutant sources
- isolate or seal pollutant sources

Sometimes a problem may have several possible solutions. Selection of the most appropriate can depend on the size and age of the building, on the combination of causes responsible for the problem and on the cost/benefit relationship.

The possible solutions are listed below in the order in which the problems appear in the Building Checklist.

Problem	Possible solutions
Enclosed parking garage / Internal loading dock	
carbon monoxide	unblock air intakes and exhausts, increase fresh air rate, recalibrate carbon monoxide sensors.
carbon monoxide leakage into building	reduce carbon monoxide, keep pressure negative with respect to pressure in building, block air movement into stairwells, block air movement into elevators, seal any other openings linking this area to the building, eliminate exhaust entry into building air intakes.
Enclosed parking garage - additional points	
carbon monoxide in checkout booth	booth must have its own air supply and be under positive pressure relative to garage
Internal loading dock - additional points	
carbon monoxide in dock	get drivers to turn off motors while trucks in the dock, install hose and exhaust system to attach to truck exhausts, keep outer doors open.
carbon monoxide in reception office	office must have its own air supply and be under positive pressure relative to dock.
Gas stoves in kitchen	
carbon monoxide or odours in kitchen	install stove exhaust hoods, repair faulty exhaust hoods, always use hoods when using stoves.
carbon monoxide or odours elsewhere	seal leaking exhaust ducts, ensure adequate exhaust fan capacity, ensure that exhaust ducts are under negative pressure until just before exhaust from building, prevent exhaust return into building.

Problem	Possible solutions
Gas-fired heating system	
leakage of carbon monoxide	have the system checked by experts immediately.
Free-standing gas heaters	
leakage of carbon monoxide	have combustion efficiency checked, if air supply inadequate, increase air.
Basement areas	
radon	seal cracks in walls or floor and cap pipes, install device that prevents gas entry, seal off infrequently used areas with dirt floors, cover floor with vapour barrier, negatively ventilate subfloor area, limit the time people spend in the area, increase ventilation.
Shower areas	
fungi (mould and mildew)	clean affected areas with solution of 1 part bleach to 3 parts water, replace damaged caulking with mould-resistant caulking, increase ventilation to avoid condensation.
radon	increase ventilation
Wet-process photocopiers	
VOC (hydrocarbon solvents)	ensure that there is both supply air and exhaust in the room housing the copier, if open office, place copier near exhaust, if high usage, vent direct to outdoors, if copiers on every floor, vent to outdoors.
Printshop	
VOC (mostly hydrocarbon solvents)	each machine should have its own exhaust hood, vent machines direct to outdoors, vent printshop direct to outdoors, exhaust hood should be operated when cleaning machine with solvent, solvent-soaked waste should be stored in explosion-proof containers until disposal, cans and bottles should be capped when not in use.

Problem	Possible solutions
Laboratory which uses volatile chemicals	
VOC	use chemicals only in fume hood, if fume hood inappropriate, use respirator, vent direct to outdoors.
Room or cabinet containing stored chemicals	
VOC	make sure all cans and bottles are tightly capped, if cabinet, install small duct and fan direct to outdoors, increase ventilation to the area.
New plywood or particleboard shelves	
formaldehyde	seal shelves with 2 coats of urethane varnish or other barrier paint, increase ventilation to the area, age shelving before installation.
Smoking room	
VOC and particulates	install fan. This should draw air from the corridor and exhaust it to outdoors (adjust balance of HVAC if necessary, room should be at negative pressure compared to surrounding areas) Note: electronic air cleaners only remove particulates, the VOC in smoke are unaffected.
Large amounts of paper stored or handled	
particulates	circulate air locally through filters
Large amounts of stored textiles	
formaldehyde, VOC	increase ventilation
Too little fresh air	
carbon dioxide (high throughout the building)	increase fresh air to 10 L/sec/person to achieve compliance with ASHRAE 62-1981R

Problem	Possible solutions
<u>Variable air volume (VAV) boxes</u>	
poor air distribution, low air circulation rates	VAV boxes respond to heat load not pollutants. ensure there is a minimum air set-point position on the boxes, check the controls, raise the air supply temperature, install local exhaust for VOC source.
<u>Main hot water tank</u>	
legionella bacteria in hot water	raise tank temperature to 55 °C
<u>Fresh air intakes</u>	
variety of pollutants	remove any obstructions from intakes. intakes should be above the second floor, at least 10 m from loading dock entrance, at least 10 m from garage entrance or exit, at least 10 m from any pollution source (such as cooling tower), at least 10 m from any type of exhaust (such as washroom, building, laboratory, garage). If intakes are not properly placed, seal the pollutant source, deflect the exhaust or install cleaning device on the air intake.
<u>Particulate (dust) filter system</u>	
particulate escape	install filters if missing, change filters if dirty, wet or damaged, repair frame if filters do not fit properly, install pressure drop indicator.
<u>Reduced overnight ventilation</u>	
VOC from furnishings, fungi, odours	schedule start-up 2 hours before the start of the workday (3 hours on Mondays), schedule shut-down 2 hours after the end of the workday.
<u>Spray humidifiers</u>	
no or low humidity	switch humidifier on, repair broken components, fix leaks in pans, recalibrate sensors.

Problem	Possible solutions
Spray humidifiers	
fungi (mould and slime)	unplug humidifier pan drains, ensure that the humidifier pans drain dry, clean and disinfect humidifier pans, fix leaks.
particulates	hard water deposits should be dissolved and washed off, do not use too much biocide (follow manufacturer's instructions).
Steam humidifiers	
no or low humidity	switch humidifier on, repair broken components, recalibrate sensors.
VOC	choose protective chemicals which are not volatile
Air-chilling system	
fungi (mould and slime)	clean and disinfect the condensate trays, clean and disinfect the cooling coils, fix leaks, do not let water stand for more than a week.
Ventilation ducts/plenums insulated on the inside	
particulates	replace with ducts insulated on the outside
Dirty ventilation ducts	
particulates, fungi	clean the inside surfaces of the ducts
Missing documentation	
various fit-up, maintenance and operation problems	obtain new copies of design diagrams, develop building maintenance program, prepare HVAC maintenance and operations manuals.
Changes in floor layout or occupant density with no system changes	
carbon dioxide	increase air supply and exhaust, rebalance HVAC.
temperature	adjust or adapt systems to match heat loads or new layouts, repair system as necessary.

Problem	Possible solutions

Poor air circulation

carbon dioxide (local highs), low air flow rates in the workstation	unblock diffusers, unblock exhausts, repair non-functioning components, test VAV boxes, upgrade air distribution system, reduce amount of furniture, use screens no more than 1.5 m (5 feet) high, elevate screens 6 inches from floor, screens should only enclose areas larger than 10 m^2 if used on all 4 sides of a space, rearrange screens to allow the HVAC system to work as designed, rearrange diffusers and exhausts and rebalance.

Repainting or recarpeting

VOC	work should be carried out overnight, increased fresh air while work in progress, use specialized (i.e. charcoal) air cleaner to remove solvents during work, increase fresh air for 2 weeks to a month while paint/glue dries out.

Foam insulation in building walls

VOC or formaldehyde, possibly fungi	install vapour barrier on the building side of the insulation, replace the insulation.

Odours

many possible sources	identify source: if sporadic, smell may come from outdoors or be due to occasional indoor activities; if continuous, odour may come from building structure, furnishings or HVAC; if possible, remove, seal or exhaust source, if odour appears far from source, test to determine migration route, then seal or exhaust, increase ventilation.

9.0 FOLLOW-UP

9.1 FURTHER ASSISTANCE

Building Performance can provide the following assistance:

- We maintain a number of other instruments besides those in the Kit. These include:

  simple instruments which yield real-time data for:
  VOC
  particulates
  nitrogen dioxide
  radon

  dataloggers and chart recorders which enable time-resolved or time-weighted average data to be recorded for:
  carbon dioxide
  particulates

  complex methods for:
  VOC (separation and identification of individual chemicals)
  determination of pollution migration paths in a building using tracer gases and a gas chromatograph (GC)

- If you are not sure whether more investigation is needed, we may be able to advise you.

- If more investigation seems warranted in a building, we can supply equipment, and someone to operate it if necessary.

- If you have definitely identified a problem, but are not sure of the best way to fix it, we have some experience in that area as well.

- We can put you in touch with people who can advise or offer measurement or analysis for other pollutants or environmental problems such as asbestos, (the PWC inventory and control program) thermal comfort, acoustics and lighting.

9.2 LIST OF EQUIPMENT SUPPLIERS

INSTRUMENTS

Fuji ZFP5 (carbon dioxide) - Safety Supply

Horiba APBA-210 (carbon dioxide) - Analygas or Safety Supply

ISD CO260 (carbon monoxide) - Analygas or Safety Supply

Dynamation 104 (carbon monoxide) -

STC chemical kit (formaldehyde) - Air Technology Laboratories

Gastec pump (VOC) - Levitt Safety

Vaisala HMI 31 (RH/temperature) - Hoskins Scientific

Gastec smoke tube kit (air movement) - Levitt Safety

RCS Biotest (microbials) - Gelman Sciences

CONSUMABLE ITEMS

calibration gases (certified standard) - Matheson Gas
for carbon dioxide and monoxide monitors

rose bengal agar strips for RCS Biotest - Gelman Sciences

chemicals for formaldehyde kit - Air Technology Laboratories

Gastec chemical tubes and smoke tubes - Levitt Safety

radon passive detectors
- alphaNUCLEAR Company
- Barringer Laboratories
- Bubble Technology Industries

COMPANY ADDRESSES (January 1989)

Air Technology Laboratories 209-435-3545
548 East Mallard Circle
Fresno
CA 93710
USA

alphaNUCLEAR Company 1125 Derry Road East Mississauga Ontario, L5T 1P3	416-564-1383
Analygas Systems Ltd. 215 Nantucket Blvd. Scarborough Ontario, M1P 2P2	416-759-2241
Barringer Laboratories 5735 McAdam Road Mississauga Ontario, L4Z 1N9	416-890-8566
Bubble Technology Industries Consumer Products Division P.O. Box 100 Chalk River Ontario, K0J 1J0	613-589-2456
Gelman Sciences 2535 Deminiac Street Montreal Quebec, H4S 1E5	514-337-2744
Hoskins Scientific Ltd. 4210 Morris Drive Burlington Ontario, L7L 5L6	416-333-5510
Levitt Safety 210 Colonnade Road, Unit #6 Nepean Ontario, K2E 7L5	613-225-9550 several branches in Canada
Matheson Gas 266 Mack Street Ottawa Ontario, K1V 8V1	613-526-0208 several branches in Canada
Safety Supply 1060 Belfast Road Ottawa Ontario, K1B 3S3	613-745-0055 several branches in Canada

9.3 KIT EVALUATION

Building: Date:

1) Did the Kit enable you to discover the main cause(s) of problems in this building? Yes / No

   If Yes, list the cause(s) (If more than one, place them in order of importance) ________________
   ____
   ____

2) Is the equipment easy to use? Yes / So-So / No

3) Is this manual easy to follow? Yes / So-So / No

4) List anything you find particularly good about the Kit:

5) List anything about the Kit that you find is bad / difficult to use / difficult to understand:

6) List any suggestions you have for improving the Kit:

7) Would you like to see Sections 3.0 and 4.0 computerized, so that all you have to do is collect data and enter it at the keyboard, and the computer will give you a list of times and places to collect data? Yes / No

   If Yes, what make and model of computer would you be using?

PLEASE RETURN A COPY OF THIS EVALUATION TO BUILDING PERFORMANCE. THIS WILL HELP US TO IMPROVE THE KIT.

APPENDIX - COPIES OF NON-REUSABLE MATERIAL

These are included here because experience has shown how easy it is to deface the last copy of an important paper before remembering to photocopy it.

These copies are printed on yellow paper to avoid confusion with the copies you will use while testing a building.

To make things easier, the material here has been prepared as a package. Photocopying the whole package should provide all the documents needed for a building investigation. The package contains:

- The Building Checklist (Section 3.0), with 6 copies each of the occupant complaint sheet and the complaint area observation sheets;
- Section 6.0, with 3 copies of the carbon dioxide data sheet;
- The Kit Evaluation sheet Section 9.3.

3.0 PRELIMINARY ASSESSMENT: BUILDING CHECKLIST

This section covers the preliminary assessment stage of the investigation of a building. Two activities are involved:

- collection of information about the building
- interpretation of this information to provide evidence for or against the various causes of problems

The Checklist consists of a questionnaire plus an assessment summary, which indicates how the answers relate to the various problem causes.

This preliminary stage is essential to any investigation because on its completion:

- the cause(s) of the air quality problems may be apparent with near certainty, and other causes eliminated;
- even if causes are not clearly identified, it should be apparent which measurements are the most important;
- the best places for collecting data will have been identified.

The first task is to answer the questions on the Checklist. Some answers will already be known. Getting the rest involves talking to people and inspecting different places in the building. The questions are straightforward - most requiring a simple "Yes" or "No" answer. For some, space is provided for filling out the relevant locations. These are places to collect data later.

The six parts of the Checklist deal with the following problems:

- carbon monoxide/combustion byproducts
- radon
- other pollutant sources
- mechanical systems and HVAC operation
- building usage, maintenance and design
- occupant complaints and complaint area observations

Each paragraph of questions in Parts 1 to 5 deals with a possible source or cause of indoor air pollution. Answer the numbered questions by circling "YES" or "NO". If the answer is "NO", go to the next numbered question. If the answer is "YES", answer the rest of the questions in the paragraph before going to the next numbered question.

3.1 CARBON MONOXIDE / COMBUSTION BYPRODUCTS

1) **Does the building contain an <u>enclosed parking garage</u>?**	**YES / NO**
Is the garage's ventilation system controlled by carbon monoxide sensors?	Yes / No
Is it more than six months since the carbon monoxide sensors were recalibrated?	Yes / No
Are there any obstructions in the exhaust or fresh air?	Yes / No
Are there cars coming and going most of the day?	Yes / No
Are there elevator shafts or stairwells that open into the parking garage?	Yes / No
Does the checkout booth lack its own ventilation?	Yes / No
2) **Does the building contain an <u>internal loading dock</u>?**	**YES / NO**
Is there an outer door that is closed after a truck's arrival?	Yes / No
Do the drivers keep their motors running in the dock when the outer door is closed?	Yes / No
Are there elevator shafts or stairwells that open into the parking garage?	Yes / No
Are there usually more than ten deliveries each day?	Yes / No
Are doors to other parts of the building kept open?	Yes / No
Is the reception office open to the loading dock?	Yes / No
Does the reception office lack its own ventilation?	Yes / No
3) **Does the building contain <u>a kitchen with gas stove(s)</u>?**	**YES / NO**
Are the exhaust hoods above the stoves missing or faulty?	Yes / No
Are the stoves often operated without the exhausts switched on?	Yes / No
4) **Does the building contain a <u>gas-fired heating system</u>?**	**YES / NO**
Are there any signs of leaks in the furnace or chimney?	Yes / No
Is there a smell of gas or burning in the furnace room?	Yes / No
Is the furnace room hot, humid or stuffy?	Yes / No
5) **Does the building contain any <u>small free-standing gas heaters</u>?**	**YES / NO**
Is there a smell of gas or burning around the heaters?	Yes / No
Is the exhaust from any of the free-standing heaters not vented?	Yes / No
Is the exhaust vented into the building ventilation system rather than direct to outdoors?	Yes / No

3.2 RADON

The parts of the building below ground level should be inspected for possible entry points for this pollutant.

6) Are there basement or sub-basement areas or crawlspaces with <u>dirt floors</u>? **YES / NO**
Are there people who work more than ten hours a week nearby (i.e., in the next room)? Yes / No
If <u>YES</u>, describe locations:

____

Do these spaces lack ventilation? Yes / No
Are there musty odours in these areas or nearby? Yes / No

7) Are there rooms with sizeable holes in the walls or floor, such as <u>sump pits or gas and water entrances</u>, in which there is exposed soil? **YES / NO**
Are there people who work more than ten hours a week nearby (i.e., in the next room)? Yes / No
if <u>YES</u>, describe location(s):

____

Do these spaces lack ventilation? Yes / No
Are there musty odours in these areas or nearby? Yes / No

8) Are there <u>cracks in the walls of the basement</u> that could allow soil gases to seep into the building (for example, dissolved in groundwater that leaks in)? **YES / NO**
Are there people who work more than ten hours a week nearby (i.e., in the next room)? Yes / No
if <u>YES</u>, describe location(s):

____

Do these spaces lack ventilation? Yes / No
Are there musty odours in these areas or nearby? Yes / No

3.3 OTHER POLLUTANT SOURCES

Possible sources of volatile organic compounds, formaldehyde, biological material and particulates are covered here.

9) **Are there <u>showers</u> in the building?** **YES / NO**
Are the showers used more than ten hours a week? Yes / No
Is there any mould visible on the floor or walls of the shower stalls, the shower heads or shower curtains? Yes / No
Are there mouldy odours in the stalls or nearby? Yes / No

10) **Does the building contain <u>wet-process photocopiers?</u>** **YES / NO**
(Note: such as the photocopiers made by Savin)
If <u>Yes</u>, describe location(s):

____

Are any of these machines in small rooms with no air supply or exhaust? Yes / No

11) **Does the building contain a <u>printshop</u>?** **YES / NO**
Are solvents used regularly (at least once a week) to clean the printing equipment? Yes / No
Are the waste rags or paper used during cleaning disposed of in an open garbage can? Yes / No
Are any of the bottles or cans of chemicals usually left open or with the lids loose? Yes / No
Do any of the machines lack an exhaust hood? Yes / No
Are there any exhaust hoods that vent into the building's ventilation system? Yes / No

12) **Does the building contain a <u>laboratory that uses chemicals (for cleaning, processing, conservation etc.)?</u>** **YES / NO**
Does the laboratory use the same ventilation system as the rest of that area of the building? Yes / No
Is there a persistent chemical odour in the laboratory area? Yes / No
Are chemicals that evaporate quickly used often? Yes / No
Are these volatile chemicals used without the protection of a fume hood? Yes / No

13) **Does the building contain <u>stored chemicals</u> (pesticides, waste solvents etc.)?** **YES / NO**
Is the storage area or storage cabinet unventilated? Yes / No
Is there a persistent chemical odour in the storage area? Yes / No
Do any of these chemicals evaporate quickly? Yes / No
Are any of the bottles or cans storing these chemicals left open or with the lids loose? Yes / No

14) **Does the building contain a storeroom or storage area with <u>shelves made of fairly new plywood or particleboard</u> (under four years old)?** **YES / NO**
Is the plywood or particleboard used as bought, without a coat of paint or varnish? Yes / No
Is the storage area unventilated? Yes / No
Is there a persistent chemical odour in the storage area? Yes / No

15) **Is smoking allowed in this building?** **YES / NO**
Is smoking restricted to special smoking rooms? Yes / No
Do any of these have neither a window fan nor an electronic air cleaner? Yes / No
If <u>Yes</u>, describe location(s):

____

Do any of these have a fan or window fan that blows the smoky air into the rest of the building? Yes / No
If <u>Yes</u>, describe location(s):

____

16) **Are large amounts of <u>paper</u> stored or handled in this building?** **YES / NO**
If <u>Yes</u>, describe location(s):

____

Is paper often moved into and out of the storage area? Yes / No
Is there dust on surfaces in this area? Yes / No

17) **Are large amounts of textiles stored in this building?** **YES / NO**
If <u>Yes</u>, describe location(s):

____

Are many of these textiles permanant press? Yes / No

3.4 MECHANICAL SYSTEMS AND HVAC OPERATION

If the building contains two or more towers or wings, each controlled by a different HVAC system, a copy of this sheet should be filled out for each.

18) Is the amount of fresh air used by the ventilation system the same all year round? **YES / NO**
What is the percentage of fresh air used? ______ **%**

19) Does the HVAC system use an economiser cycle? **YES / NO**
What is the maximum percentage of fresh air used? ______ **%**

What is the minimum percentage of fresh air used? ______ **%**

What is the fresh air percentage just now? ______ **%**

**20) Is air supplied to the floors by:
constant volume boxes / variable air volume (VAV) boxes / heat pumps / other or unknown ?**

21) At what temperature is the tank supplying hot water to the building maintained? ______ ^{o}C

22) Are there distinct fresh air intakes for the building HVAC system ? **YES / NO**
Are there intakes below third floor level and above a busy street ? Yes / No
Are there intakes within 10 metres (30 feet) of the entrance to a loading dock? Yes / No
Are there intakes within 10 metres (30 feet) of the entrance or exit to a parking garage? Yes / No
Are there intakes within 10 metres (30 feet) of the exhausts of this or an adjacent building? Yes / No
Are there any other pollution sources near any of the intakes? Yes / No
If Yes, briefly describe the pollution source:

____

Are there obstructions (such as birds' nests) lodged in any of the air intakes? Yes / No

23) Does this building have a <u>particulate (dust) filter</u> system installed in the fresh air intake? **YES / NO**

Are the filters missing? Yes / No

Are the filters changed less frequently than recommended by the manufacturer? Yes / No

Do the filters fit so poorly that air bypasses them at the edges? Yes / No

Are the filters matted or dirty? Yes / No

Are the filters wet? Yes / No

Does the dust filter system lack a pressure drop indicator? Yes / No

24) Is the <u>ventilation in the work areas</u> decreased or shut off overnight or on weekends? **YES / NO**

If <u>decreased</u>, to what percentage of the daytime rate does the system drop? ____________ %

At what time is the ventilation system turned off or down? __________ p.m.

At what time is the ventilation system turned back on or up? __________ a.m.

When does the normal workday start? __________ a.m.

When does the normal workday end? __________ p.m.

25) Are <u>spray humidifiers</u> used in this building? **YES / NO**

Are the spray humidifiers supposed to operate at this time of year? Yes / No

Are the spray humidifiers operating just now? Yes / No

If <u>Yes</u>, answer the questions below:

Are the spray humidifier pans plugged so that they are not draining properly? Yes / No

Is there slime in the humidifier pans? Yes / No

Are there mouldy odours? Yes / No

Is there mould in the ducts near the humidifiers? Yes / No

Is there evidence of foaming in the humidifiers? Yes / No

Is the water hard in this region? Yes / No

If so, are there hard water deposits on the vanes? Yes / No

Are the hard water deposits removed by scraping the vanes and blowing the dust into the ducts? Yes / No

26) Are <u>steam humidifiers</u> used in this building? **YES / NO**
Are the steam humidifiers supposed to operate at this time of year? Yes / No
Are the steam humidifiers operating just now? Yes / No
If <u>Yes</u>, answer the questions below:
Are chemicals used in the boiler or the pipes to protect against corrosion? Yes / No
If <u>Yes</u>, state names of chemicals:

____

27) Does this building have an <u>air-chilling system</u>? **YES / NO**
Is the chilling system supposed to operate at this time of year? Yes / No
Is the chilling system operating just now? Yes / No
If <u>Yes</u>, answer the questions below:
Are the condensate trays cleaned less often than once a week? Yes / No
Is there slime in the condensate trays? Yes / No
Is there dirt on the cooling coils? Yes / No
Are there mouldy odours in the system? Yes / No

28) Are the ventilation ducts or plenums <u>insulated</u>? **YES / NO**
Is the insulation on the inside and directly exposed to the moving air? Yes / No
Is it more than five years since the ducts or plenums were last cleaned? Yes / No

3.5 BUILDING USAGE, MAINTENANCE AND DESIGN

29) What year was the building constructed? ____________

Are the as-built design diagrams for this building missing? Yes / No
Are the current design diagrams for this building missing? Yes / No
Are the operating and maintenance manuals for the building's HVAC system missing? Yes / No
Is there no routine maintenance program for the HVAC system? Yes / No

30) Can the windows in the work areas be opened? **YES / NO**
Do the occupants frequently open the windows? Yes / No

31) Have there been any changes in the floor layout since the building was opened (i.e. open office spaces converted to closed offices, partitions put up, walls added or removed)? **YES / NO**
If YES, describe location:

____

Was the original ventilation retained in this areas? Yes / No
Do most of the closed offices lack working thermostats? Yes / No

32) Is the occupant density higher than originally planned anywhere in the building (i.e. due to conversion of office space to boardrooms or waiting rooms)? **YES / NO**
If Yes, describe location:

____

Was the original ventilation retained in this space? Yes / No
Does this space lack a working thermostat? Yes / No
Is this space used for more than two hours each day, or ten hours each week? Yes / No

What is the maximum number of people normally occupying this space? ____________

What is the area (in square metres) of this space? ____________

33) **Have any work areas been <u>recarpeted</u> recently?** **YES / NO**
Did odours persist for more than a week after the carpet was laid? Yes / No
If <u>Yes</u>, describe location(s):

____

34) **Have any work areas been <u>repainted</u> recently?** **YES / NO**
Did odours persist for more than a week after the paint was applied? Yes / No
If <u>Yes</u>, describe location(s):

____

35) **Is there <u>foam insulation</u> in the walls of the building?** **YES / NO**
The type of insulation is polyurethane / polystyrene / urea formaldehyde / unknown

3.6 OCCUPANT COMPLAINTS AND COMPLAINT AREA OBSERVATIONS

Often problems can develop locally so that only one person or a small group of people is affected. These people may be able to supply useful information about the problem, and the investigator can supplement this by inspecting the complaint area. Therefore, this part of the Checklist consists of two short questionnaires, one to be filled out by the person making the complaint, and one to be filled out by the investigator. Both should be completed for each space investigated. If several people in an area are complaining, it may be appropriate for each to fill out a complaint sheet. If necessary, identification numbers can be entered at the top right to distinguish the sheets.

3.7 OCCUPANT COMPLAINT SHEET no. ______

Where in the building are your complaints worst? Please give the Floor, room or workstation number, or briefly describe (e.g. main lobby, everywhere): ______________________

Your answers to the questions below apply to this location. Where a choice is given, please circle the most appropriate answer. Enter your own answer where requested. Space for comment is provided.

1) **Describe the usual temperature here:**
okay / too hot / too cold / sometimes too hot, sometimes too cold

2) **How would you usually describe the air here?**
okay / drafty / stagnant / stuffy / stale

3) **Are you bothered by odour here?** **YES / NO**
If <u>YES</u>, how often do you smell this odour?
rarely / occasionally / frequently / all the time
Which of the following best describes the odour?
auto exhaust / diesel fumes / furnace smell / heating system
body odour / mouldy or musty / chemical / like solvent
(wet) cement or plaster / dusty or chalky smell
What do you think causes the odour? ______________________

4) **Do you have a history of allergies?** **YES / NO**
If <u>YES</u>, the type of allergy is: respiratory / skin / food / other
Are your allergies worse while you are in this building? Yes / No

5) **Which of the following do you suffer from that you think are due to the building?**
headache / tiredness / faintness / dizziness
nausea / stomach problems / skin irritation
dry eyes / itching eyes / watery eyes / blurred vision
stuffy nose / runny nose / sneezing
sore throat / dry throat / bad chest / coughing / asthma

6) **What time of day are your complaints worst?**
morning / afternoon / the same all day
What day of the week are your complaints worst?
Monday / mid-week / Friday / the same all week
What season of the year are your complaints worst?
spring / summer / fall / winter / the same all year

7) **Do the symptoms coincide with or follow cleaning or maintenance activities in this area?** **YES / NO**
If <u>YES</u>, describe this activity: ______________________

<u>Comments:</u>

3.8 COMPLAINT AREA OBSERVATION SHEET no.______

Where in the building do these observations apply? Please give the Floor, room or workstation number, or briefly describe (e.g. main lobby, everywhere):

____

Please answer all questions by circling or filling in the answers as required.

1) General observations

Is there damp or mould on the walls or ceiling?	Yes / No
Are there many potted plants in this area?	Yes / No
Is there mould on the plants or their pots or soil?	Yes / No
Are there odours here?	Yes / No
Which of the following best describes the odour? auto exhaust / diesel fumes / furnace room / heating system body odour / mouldy or musty / chemical / like solvent (wet) cement or plaster / dusty / chalky	
Are people using fans to create more air movement?	Yes / No
Is there much dust visible on flat surfaces?	Yes / No
Is there evidence of condensation on windows or walls?	Yes / No

2)

Is this an enclosed office (with walls and door)?	**YES / NO**
If YES, does it lack a working thermostat?	Yes / No

3)

Is this an open office area?	**YES / NO**
If NO, go to question 4	
Are screens used to divide the area?	Yes / No
If NO, go to question 4.	
Are the screens five or more feet high?	Yes / No
Do the screens extend all the way to the floor?	Yes / No
What is the average area in square metres enclosed by the screens?	______

4)

Check the air supply diffusers:	
Does this area lack supply air?	Yes / No
Can you see any of the following around the diffusers? mould / chalky dust / dirt marks	
Are any of the air supply diffusers blocked by furniture, paper or other obstruction?	Yes / No

5)

Are there any air exhaust louvers?	**YES / NO**
If NO, go to question 6.	
Are there dirt marks around the air exhaust louvers?	Yes / No
Are any of the air exhaust louvers blocked by furniture, papers or other obstruction?	Yes / No

6) **Are any of the following <u>pollutant sources</u> within 10 metres (30 feet) of this room/workstation:**

Wet-process photocopier?	Yes / No
A printshop?	Yes / No
A room where chemicals are used?	Yes / No
A room where chemicals are stored?	Yes / No
An area with plywood or particleboard shelves?	Yes / No
A room for smoking?	Yes / No
An area with a large amount of stored paper?	Yes / No
An area with a large amount of stored textiles?	Yes / No

<u>Comments</u>:

3.9 ASSESSMENT SUMMARY

Three factors must be assessed before it is decided whether an air quality problem warrants further investigation with simple instruments. One can remember them as PIP - People, Inadequate ventilation and Pollutants. The presence of people is important, for problems can sometimes be tolerated in unoccupied areas such as basement mechanical rooms. Ventilation that is adequate in one situation, such as a large office, may be inadequate in another, such as a printshop. It all depends on the balance between the capacity of the ventilation system and the strength of the pollutant sources.

An assessment procedure is described below for each of the parts of the Checklist questionnaire. Most of the questions have been worded so that a "Yes" answer means a possible problem. The simplest assessment procedure consists of counting the number of "Yes" answers. Sometimes it is necessary to refer to the answers of other questions to obtain an effective assessment.

Section 3.1 Carbon monoxide/combustion byproducts

Each numbered question refers to a possible source of carbon monoxide/combustion products in the building. For each of these that the building contains (i.e. each "YES" answer), problems are likely only if there are one or more "Yes" answers to other questions in the same paragraph. The more "Yes" answers, the more chance of a problem.

Section 3.2 Radon

Each numbered question refers to a possible source of radon in the building. These sources tend to be in unoccupied areas. Therefore, for each of these that the building contains (i.e. each "YES" answer), both the nearby presence of people and evidence of poor ventilation (odours or absence of air supply and exhaust) are required before the situation needs further investigation.

Section 3.3 Other pollutants

Each numbered question refers to a possible pollutant source in the building. For each of these that the building contains (i.e. each "YES" answer), problems are likely in practice only if "Yes" answers are obtained for other questions in the same paragraph. The more "Yes" answers, the more chance that this pollutant source will be causing problems. The pollutant sources that the numbered questions refer to are:

9) fungi if mould is visible anywhere, or mouldy odours are present
   radon if the area is used more than ten hours each week
10) volatile organic compounds (VOC)
11) VOC
12) VOC

13) VOC
14) formaldehyde
15) particulates
16) particulates
17) formaldehyde

Section 3.4 Mechanical systems and HVAC operation

For questions 22, 23, 25, 26, 27 and 28, a "YES" answer indicates that problems are likely if "Yes" answers are obtained for other questions in the same paragraph. The more "Yes" answers, the more chance of a real problem.

The types of problems indicated by the answers are described below:

18) and 19) Less than 15% fresh air is likely to result in non-compliance with ASHRAE standards.

20) VAV boxes respond to temperature, and may not deal effectively with strong local pollution sources.

21) If the temperature is higher than 60°C, legionella bacteria are unlikely to survive and breed.

22) Carbon monoxide may be a problem if the intakes are either just above a busy street or close to a loading dock or parking garage that has been identified as a potential problem source (check answers to questions (1) and (2)).
Particulates may be a problem if there are obstructions in the intake <u>and</u> if particulate filters either are not used in the HVAC system, or are poorly maintained (check question (23)).
Contaminated air from the exhausts can re-enter the building if intakes and exhausts are too close together. This will increase concentrations of all pollutants.

23) See reference to particulates in question (22)

24) The ventilation system should be turned on (or up) at least two hours before the start of the workday, and turned off (or down) at least two hours after the end of the workday. It is particularly important to allow enough lead and lag time if the system is turned off completely at night.

25) Biological contamination can be caused by spray humidifiers if the pans are not kept clean.
Particulate problems can be caused by spray humidifiers if the water contains dissolved material that will form dust when the water evaporates. This will occur if local water is hard, or if large quantities of solid biocide are added (this may cause foaming). Problems are most likely to occur when local water is hard <u>and</u> the humidifier cleaning procedure blows solids scraped off the vanes into the ventilation ducts.

26) Chemicals used to protect the boiler or steam pipes may enter the ventilation system and be distributed around the building. Amines (a type of VOC) are noted for this problem.

27) Biological contamination can result if the air-conditioning system is not cleaned regularly. Most outbreaks of legionellosis are caused in this way, and fungal contamination is also possible.

28) Particulates originating in ducts and plenums can be accumulated dirt, or insulation fibres (if the insulation is on the inside of the duct or plenum). If the insulation appears to be a problem,

check to see whether it is asbestos. Building Performance can supply information on PWC's asbestos program.

Section 3.5 Building usage, maintenance and design

A "YES" answer to a numbered questions indicates that a problem is possible. The likelihood is increased if one or more "Yes" answers are obtained to other questions in the same paragraph.

The types of problems indicated are described below:

29) the absence of design diagrams suggests alterations or refit might have been performed without taking into account the effects on the HVAC system.
The absence of operating/maintenance information suggests HVAC operation could be incorrect, and maintenance is likely to be inadequate.

30, 31 and 32: either inadequate temperature control or inadequate ventilation (fresh air or air circulation). Inadequate ventilation is likely to cause elevated carbon dioxide levels in these locations.

33) VOC

34) VOC

35) urea formaldehyde points to a possible formaldehyde problem. Polyurethane and polystyrene can release other types of VOC. If the answer here is "do not know," check the building plans, which should contain this information. If this is unsuccessful, extract a small piece of the insulation from the wall cavity, and send it to Building Performance for testing.

Section 3.6 Occupant complaints and complaint area observations

Assessment sheets are provided for both the occupant complaint questionnaire and the complaint area observation questionnaire. Table 3, which provides common descriptions of odours, can be used as an aid for both assessments.

Section 3.7 Occupant Complaint Sheet

To do the assessment, relate the points below to the corresponding question and answer on the OCCUPANT COMPLAINT SHEET.

1) Any answer except "okay" indicates poor temperature control. This could be due to faults in the HVAC, blocked intake or exhaust, or lack of a thermostat. Check the OBSERVATION sheet, also Section 3.5, questions (30), (31) and (32).
2) Any answer except "okay" indicates poorly controlled air movement. "stagnant," "stuffy" or "stale" suggest inadequate ventilation and a carbon dioxide problem.
3) If there are odours here, check Table 3 to see if they match any description. An odour that is present all the time is probably associated with the building structure or furnishings. An occasional odour can be due to intermittent occupant activities, intermittent HVAC control, or weather conditions. It may be necessary to get more information here to decide which is the most likely cause.
4) Someone with a history of severe allergies may be affected by pollutant concentrations that do not bother other people, and that are much less than required by building performance standards. If this situation is suspected, ask a health professional for advice.
5) Most symptoms can be linked to several possible sources:
   carbon dioxide: headache, tiredness
   carbon monoxide: headache, tiredness, dizziness, nausea
   formaldehyde: eye irritation, nausea, headaches
   particulates: sneezing, coughing, dry nose and throat, allergies
   VOC: headache, eye, nose, throat or skin irritation
   biological material: allergies (runny nose, stuffy nose, sneezing, asthma)
   low humidity: sneezing, coughing, dry eyes, nose and throat
   high temperature and humidity: tiredness, headache
6) The timing of the appearance of the symptoms can help in identifying the source of the problem. Symptoms caused by pollutants from daily occupant activities (for example, carbon dioxide, and VOC from photocopiers or printshops) will be worst in the afternoons, possibly on Fridays, and in winter and summer if the building is on an economiser cycle. Pollutants from the structure or furnishings (for example, formaldehyde or VOC from furnishings, biologicals) will be worse mornings and Mondays if the ventilation is off during silent hours.
7) A VOC problem is likely if products containing solvents or other volatile chemicals are used.

Section 3.8 Complaint Area Observation Sheet

To do the assessment, relate the points below to the corresponding question and answer on the COMPLAINT AREA OBSERVATION SHEET.

1) general observations
   Yes = biological material
   Yes = biological material (mould)
   Yes increases the probability of a biological problem
   Yes = almost any pollutant. To try to determine which one, check descriptions against Table 3 and enter the most likely source:

   ____

   Yes = ventilation (likely to cause high carbon dioxide)
   Yes = particulates
   Yes = too much humidity

2) enclosed office = YES
   Yes (no thermostat) = temperature / ventilation (carbon dioxide)

3) open office = YES

   Yes = poor local air circulation (and high carbon dioxide)

   Yes increases probability of local air circulation problem
   Yes increases probability of local air circulation problem
   average area less than 10 m^2 (100 sq. ft.) increases the probability of problems

4) air supply diffusers
   Yes = fresh air / ventilation (carbon dioxide)
   mould = biological material; chalky dust = particulates from structural alterations or spray humidifier; dirt marks = particulates in the ventilation system
   Yes = fresh air / ventilation (carbon dioxide)

5) air exhaust louvers
   Yes = particulates in the room or nearby
   Yes = ventilation (carbon dioxide)

6) **pollutant sources** within 10 metres (30 feet)

Yes - check question 10 for likely source strength (VOC)
Yes - check question 11 for likely source strength (VOC)
Yes - check question 12 for likely source strength (VOC)
Yes - check question 13 for likely source strength (VOC)
Yes - check question 14 for likely source strength (formaldehyde)
Yes - check question 15 for likely source strength (particulates)
Yes - check question 16 for likely source strength (particulates)
Yes - check question 17 for likely source strength (formaldehyde)

Table 3 Odours that can occur in office buildings

Possible descriptions of the odour	Problem indicated	Other indicators of of this problem
auto exhaust, diesel fumes, furnace room smell, heating system,	carbon monoxide	symptoms: headaches, nausea, dizziness, tiredness
body odour	carbon dioxide (low ventilation rates)	symptoms: headaches and tiredness complaints: lack of air, stagnant air, stuffiness
mouldy, musty	biological material	mould may be visible, symptoms of allergy
chemical smell, like formalin	formaldehyde	presence of unpainted pressed wood products symptoms: eye irritation, nose and throat irritation
solvent smell, chemical smell	VOC	presence of chemicals, or products containing them, symptoms of allergy
(wet) cement, (wet) plaster, dusty smell, chalky smell	particulates (from humidifier)	hard water in this area, spray humidifiers used, white dust on diffusers

CARBON DIOXIDE (CO2) - DATA SHEET

sheet no. ______

Instrument: Fuji / Horiba

Zero Calibration (0 ppm):

Span Calibration (ppm):

Building:

User:

Date:

Floor	Place	Time	CO2 ppm	Comment

CARBON MONOXIDE (CO) - DATA SHEET

sheet no.

Instrument: CO260 / Dynamation

Building:

Zero Calibration (0 ppm):

User:

Span Calibration (ppm):

Date:

Floor	Place	Time	CO ppm	Comment

FORMALDEHYDE (H2CO) - DATA SHEET

sheet no. _____

Instrument: STC kit no.:

%T of water (before):

%T of water (after):

Building:

User:

Date:

Samp id	Floor	Place	Start Time	Stop Time	Total Time (mins)	%T	H2CO (ppm)	Net H2CO (ppm)

Comment / Additional Information

RADON - DATA SHEET FOR PASSIVE DETECTORS sheet no. ___

Detector type: Building:

Recommended exposure: User:

Detector number	Floor	Place	Start time and date	Stop time and date	Radon (pCi/L or WL)

Comment / Additional Information

GENERAL GAS AND VOC - DATA SHEET

sheet no. _____

Instrument: Gastec pump & tubes

Building:

Tube part number:

User:

Gas:

Date:

Floor	Place	Time	gas ppm	Comment

TEMPERATURE (T) AND RELATIVE HUMIDITY (RH) - **DATA SHEET** no. _____

Instrument: Vaisala HMI 31 **Building:**

User: **Date:**

Floor	Place	Time	T °C	RH %	Comment

AIR MOVEMENT - DATA SHEET

sheet no. _____

Instrument: Gastec smoke tube kit

Building:

User:

Date:

Floor	Place	Time	Comment on Air Movement

BIOLOGICAL MATERIAL (FUNGI) - DATA SHEET

sheet no. _____

Instrument: RCS Biotest sampler

Building:

User:

Date:

Samp id	Floor	Place	Time	Comment

9.3 KIT EVALUATION

Building: Date:

1) Did the Kit enable you to discover the main cause(s) of problems in this building? Yes / No

   If Yes, list the cause(s) (If more than one, place them in order of importance) ____________

   ____

   ____

2) Is the equipment easy to use? Yes / So-So / No

3) Is this manual easy to follow? Yes / So-So / No

4) List anything you find particularly good about the Kit:

5) List anything about the Kit that you find is bad / difficult to use / difficult to understand:

6) List any suggestions you have for improving the Kit:

7) Would you like to see Sections 3.0 and 4.0 computerized, so that all you have to do is collect data and enter it at the keyboard, and the computer will give you a list of times and places to collect data? Yes / No

   If Yes, what make and model of computer would you be using?

PLEASE RETURN A COPY OF THIS EVALUATION TO BUILDING PERFORMANCE.
THIS WILL HELP US TO IMPROVE THE KIT.