A STANDARDIZED EPA PROTOCOL FOR CHARACTERIZING INDOOR AIR QUALITY IN LARGE OFFICE BUILDINGS

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF APPENDICES

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

TABLE OF CONTENTS (Continued)

LIST OF ABBREVIATIONS AND ACRONYMS

AHU	air handling unit
BASE	Building Assessment Survey and Evaluation
CO	carbon monoxide
CO_2	carbon dioxide
DNPH	dinitrophenyl hydrazine
EH&E	Environmental Health & Engineering, Inc.
EPA	U.S. Environmental Protection Agency
FL	field team leader
HCHO	formaldehyde
HVAC	heating, ventilating, and air-conditioning
IADCS	Indoor Air Data Collection System
IAQ	indoor air quality
m	meters
ORD	Office of Research and Development
ORIA	Office of Radiation and Indoor Air
$PM_{2.5}$	inhalable particles with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10}	inhalable particles with an aerodynamic diameter less than or equal to 10 microns
ppm	parts of vapor or gas per million parts of air by volume
QA	quality assurance
QA/QC	quality assurance and quality control
QC	quality control
SA	survey administrator
TIME	Temporal Indoor Monitoring Evaluation Study

1.0 INTRODUCTION

1.1 BACKGROUND

A significant data gap exists regarding baseline indoor air quality (IAQ) in public and commercial buildings. The U.S. Environmental Protection Agency (EPA) has attempted to fill in this gap by conducting a major study of IAQ in those buildings. The Office of Radiation and Indoor Air (ORIA) and the Office of Research and Development (ORD) funded complementary large building studies to collect this information. The primary goal of the studies is to define the status of existing building stock with respect to determinants of IAQ and occupant perceptions. The studies will also provide basic support for indoor air researchers and the data will form the basis for future building studies, as well as provide guidance on design, construction, operation, and maintenance of buildings.

A steering committee of federal and non-federal experts met to provide opinions on the design, planning, and implementation of this major program. Program activities and research needs were evaluated in the following areas: study design; building and heating, ventilating, and air conditioning (HVAC) characteristics; human response and questionnaires; environmental measurements; diagnostics and mitigation; and program integration. The experts were asked to identify key parameters that should be measured at a minimum in each building.

This integrated protocol was developed based upon these discussions and incorporates three major areas of investigation: comfort and environmental measurements; building and HVAC characterization; and an occupant questionnaire. Certain aspects of the entire building and its HVAC system(s) will be characterized. Due to cost and time limitations, one or more representative sampling spaces in each building will be more intensively characterized (including sampling space HVAC characterization, environmental monitoring, and occupant response) rather than the entire building. The sampling space(s) will be selected based upon a targeted minimum occupancy of 50 full-time employees in a space served by no more than two air handling units (AHUs). The protocol specifies the schedule of measurements, the specifications of the measurement equipment, how to select the representative space(s), and how to select the sampling sites in that space. The protocol is very specific so that data collected among all of the buildings in the ORIA and ORD studies will be comparable. Automated data collection programs have been developed to allow entry of the majority of the data into a portable computer and entry of the findings in a readily accessible database. The details specified in the protocol provide researchers the opportunity to collect and compare the results of non-EPA sponsored large building studies.

After being quality assured, the data will reside in a publicly accessible database. It is expected that the data will be used by any interested party for a number of applications. EPA will initially monitor access to the database and ensure that users are aware of the limitations and appropriate use of the data. Applications might include developing distributions of IAQ/building/HVAC characteristics, developing new hypotheses, establishing standardized protocols, examining the relationship of symptoms to building characteristics, and developing guidance on building design, construction, operation, and maintenance. Until the data are analyzed, the strength of these correlations cannot be predicted.

ORIA's Building Assessment Survey and Evaluation (BASE) study is a cross-sectional study that collected information on the core parameters in each building over a one-week period in either the summer or winter. Transition seasons are not included in the BASE Study. The ORD longitudinal study, the Temporal Indoor Monitoring Evaluation (TIME) Study, followed the same week-long regime but returned to the same buildings at randomly selected intervals covering each of the four seasons over a three-year period.

Buildings included in the sample were not intended to be complaint buildings, although some complaint buildings may have been included. However, complaint buildings that had been highly publicized by the media were excluded. The sampling strategy randomized the sample to the extent possible, based upon the success in gaining access to buildings. Regional variation was included in the sample, as well as seasonal variation from winter and summer. Over the five-year period from 1994 to 1998, 100 buildings were studied in the BASE program. The TIME Study includes 56 buildings studied from 1995 to 1998. All of the TIME Study buildings were U.S. Government-owned, and were a statistically selected sample, stratified by region and based upon the occupancy rate. The decision to use Government buildings was made because of the potential difficulties in gaining repeated access to commercial buildings over a three-year period.

A strategy for gaining access to buildings was developed using focus groups consisting of building owners and managers, tenants, and occupants. The strategy appoints a building-level study coordinator who acts as a single point of contact for all of the building participants. The study coordinator oversees all activities associated with the study in a particular building. He or she makes all recruitment contacts and conducts the face-to-face recruiting. The coordinator answers any questions or complaints about the measurements and may distribute and collect the occupant questionnaires.

After permission was obtained to conduct the study from the building owner, permission was obtained from any tenant(s) whose space(s) might be evaluated. Results of the building level data were made available only to building managers. Focus-group findings indicating non-compliance with this procedure would have frequently resulted in denial of permission to conduct the study in the building. ORIA and ORD realize that the tenants will be interested in the study data, but the focus groups agreed that the occupants would probably agree to participate even if they were not provided specific information.

The following protocol contains the specific details of the procedures that were employed in the EPA BASE Study. While conducting the study, specific changes were made to the original draft protocol.[1] The following protocol documents those changes. This document reflects the procedures that were used over the life of the BASE Study. Other EPA large building studies (such as the TIME Study) were implemented using procedures outlined in the 1993 draft protocol. To retain the information contained in the original March, 1993 draft protocol, footnotes are used within the text of this document to indicate the specific changes and the period when those changes occurred. An overall summary of the changes made to the 1993 draft protocol is documented in Section 1.3.

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[1] L. Sheldon, R. Fortman, Research Triangle Institute, EPA Large Building Studies Integrated Protocol, dated March 3, 1993.

1.2 OVERVIEW

This protocol describes the procedures that were used to implement EPA's large building investigations. The six basic activities that were performed are summarized and further described below.

Figure 1-1 Basic Activities for Implementing EPA Building Investigations

1	Select and Recruit Buildings
2	Physically Characterize Buildings
3	Select Study Area(s) and Monitoring Locations within the Area(s)
4	Monitor Study Area(s)
5	Survey Occupants of Study Area(s)
6	Validate data by Field and Research Organization and Combine Data in EPA Database

1. Buildings selected and recruited for monitoring represent both public and commercial office buildings in the United States. Both complaint and non-complaint buildings were included in the study.

2. Each selected building was physically characterized in terms of location, physical structure, ventilation, occupant activities, and potential indoor pollutant sources.

3. Study areas within each building were defined, then one or more study area(s) were randomly selected for more extensive evaluation. Within the selected study area(s), locations for taking physical and chemical measurements were selected based upon a set procedure.

4. Monitoring was performed in the study area(s) during a one-week period to generate data on HVAC operation, environmental pollutants, and comfort factors. All building characterization and monitoring was performed using standard procedures. Standard measurement and strict quality assurance and quality control (QA/QC) procedures were used to ensure the collection of high quality and comparable data.

5. Occupants in the study area(s) were surveyed on perceived IAQ and health symptoms using a self-administered questionnaire on Thursday of the week of field monitoring.

6. Data were validated and combined in a user-friendly database containing all of the ORIA and ORD building studies data.

This document provides a detailed protocol for conducting the building investigations and occupant surveys as described directly above. Activities described in this protocol are initiated after the building has been selected for study and consent to study the building has been given by the appropriate parties. This protocol covers data flow through data collection, reduction, validation, and quality assurance (QA) review. The software developed to collect information in the field defines and ensures that the data entry format is compatible with the EPA database. Information regarding this software, the *Indoor Air Data Collection System (IADCS)*, is contained in Appendix H.

The activities and time schedule described in the protocol are outlined in Table 1-1.

Table 1-1 Overview of Field Data Collection Activities

Activity	Time
Initial Visit	As soon as possible after building is selected
Study Area(s) Selection	During initial visit
Selection of Monitoring Locations within Study Area(s)	Monday
Study area(s) verification	Monday
Field Monitoring	
Equipment preparation, setup, and calibration	Monday and Tuesday
Supply air and diffuser flow measurements	Tuesday
Building and study area(s) characterization	Tuesday to Thursday
Measurement of environmental pollutants and comfort parameters	Tuesday to Thursday
HVAC measurements	Monday to Thursday
Questionnaire administration	Thursday
Field data check for completeness and validation	Thursday and Friday
Equipment take down, packing, and shipment	Thursday and Friday

As indicated in the table, pre-monitoring coordination with the building owner(s), building manager(s), and tenant(s) should be performed as soon as possible after a building is selected. It is important that the suitability of a building be established well ahead of monitoring so that a field monitoring schedule can be developed. Study area(s) selection is made at the building during the initial visit. Activities associated with the building and HVAC characterization, as well as the comfort and environmental monitoring, are performed during a one-week period. These activities begin with a building walkthrough and equipment preparation on Monday and conclude with packing and shipment of equipment on Friday. On the Monday when field monitoring is initiated, the field team leader meets with the building manager(s), tenant(s), and occupants, as appropriate, in the selected study area(s) to explain the objectives and conduct of the study and monitoring activities. The occupant questionnaire will be administered to the study area(s) participants on Thursday of the monitoring week. The protocol assumes that the buildings will be sequentially monitored on a weekly basis.

This protocol has been divided into seven sections as follows:

- Section 1—Introduction
- Section 2—Study Team Organization and Responsibility
- Section 3—Initial Building Visit
- Section 4—Selection of Study Area(s) and Monitoring Locations
- Section 5—Building Characterization and Monitoring
- Section 6—Administration of the Occupant Questionnaire
- Section 7—Sample and Data Management

Each section will provide information on the procedures that are to be used. Supporting information and a sample questionnaire are provided in the Appendices.

1.3 SUMMARY OF CHANGES TO MARCH 1993 DRAFT PROTOCOL

The original protocol for EPA's large building studies was dated March 1993. In February 1994, specific changes were made to the protocol that were documented in an updated protocol with an effective date of June 1, 1994. The changes presented in the June 1, 1994 protocol were documented in a section at the front of the protocol entitled "*Summary of Changes – Feb 1 94.*" Over the course of the field-monitoring portion of ORIA's large building study (BASE), specific changes and procedural variations were made to the June 1, 1994 protocol and were presented in an updated protocol with an effective date of August 1, 1999. The changes presented in the August 1, 1999 protocol were documented in a section at the front of the protocol entitled "*Summary of Changes – Aug 1 99.*"

In the June 1, 1994 and August 1, 1999 protocols, the summary of changes were documented only in the protocol section entitled "Summary of Changes," while the body of these protocol versions remained unchanged. For this protocol, changes and procedural variations made throughout the course of the study are included directly within the text of this document. It is possible that other previously implemented EPA-sponsored building studies (such as the TIME Study) may have conducted studies following the activities documented in the March 1993 and June 1994 protocols. Therefore, for informational purposes, a summary of these changes is presented for each section of the protocol listed below:

- Section 4.0, Selection of Study Area(s) and Monitoring Locations
- Section 5.0, Building Characterization and Monitoring

Note that there were no changes made to the study team organization and responsibilities (Section 2.0), to procedures to follow when implementing the initial building visit (Section 3.0), to the administration of the occupant questionnaire (Section 6.0) or to the sample data and management (Section 7.0).

1.3.1 Changes to Section 4.0, *Selection of Study Area(s) and Monitoring Locations*

- Section 4.2.1 of the 1993, 1994, and 1999 protocols specified that the selection of monitoring sites within the study area would be conducted after the building preliminary visit but prior to the field monitoring week. However, this protocol has been updated to specify that the site selection (fixed and mobile) will occur as early as possible on the Monday morning of the field monitoring week.

- The 1994 and 1999 protocols specified procedures for establishing the siting of mobile monitoring locations within the test space. Section 4.2.1, *Selection of Monitoring Locations*, specifies that three to ten indoor locations will be selected for monitoring based on the number of occupants and/or the overall area of the space. The selection procedure also specifies that mobile indoor monitoring locations be established for every increase of ten occupants over the minimal 25, or for every increase of 1,500 square feet over an estimated base of 10,000 square feet.

This protocol has been updated to specify that the number of mobile monitoring sites will be independent of the number of occupants in the test space. Five mobile sites will be selected, which encompass three indoor fixed sites and an augmented fourth site, designated as Fixed Site 2.

- The 1993, 1994, and 1999 protocols specified procedures for establishing the siting of outdoor monitoring locations. Section 4.2.3, *General Guidelines for Citing Outdoor Monitoring Locations*, specified that if the outdoor monitoring location at the air intake site cannot be secured, then real-time measurements were to be made in the morning and afternoon of the monitoring day using the mobile monitoring cart. In this case, the monitoring location for integrated samples was to be moved to a secured site, such as a rooftop location.

  This protocol has been updated to specify that the monitors and sensors placed outdoors must be secured to prevent tampering or loss; however, if the outdoor location at the air intake site cannot be secured, an appropriate location as close to the outdoor air intake as possible should be chosen. Deviations from the siting guidelines should be appropriately documented.

- In the 1993 and 1994 protocols, Table 4-2 specified monitoring location 2 as only a mobile monitoring location designated as M2. In June 1997 this site was added as an augmented site where continuous monitoring of selected comfort parameters is specified. Table 4-2 of this protocol has been updated to specify Fixed Site 2 (F2) as an augmented site.

- In the 1993 and 1994 protocols, Table 4-2 specified that all of the duplicate samples should be collected at site F5. This protocol specifies that duplicate samples be collected at a single indoor fixed site (F1, F3, or F5) and shall be placed based on physical site restrictions.

- In the 1994 and 1999 protocols, Table 4-2 specified that all duplicate samples should be collected at site F1. Further, it was specified that if physical restrictions or other limitations preclude this collocation of sampling devices, then the duplicates may be collected across all of the fixed indoor sites. For example, volatile organic compound

(VOC) duplicates may be collected at F1, particles at F3, and other duplicate samplers at F5. This protocol specifies that duplicate samples be collected at a single indoor fixed site (F1, F3, or F5) and shall be placed based on site physical restrictions.

1.3.2 Changes to Section 5.0, *Building Characterization and Monitoring*

- Section 5.2 of the 1993, 1994, and 1999 protocols, *Environmental Measurements*, did not specify the measurement of viable and non-viable fungal spores as an augmented parameter for integrated sampling. This protocol has been modified to include the measurement of viable and non-viable fungal spores as an augmented parameter. Starting in June 1997, viable and non-viable fungal spores were collected using a Burkard spore trap sampler. Sampling locations are identical to those for air biological sampling, as described in Section 5.3.3.

- Table 5-3 of the 1993, 1994, and 1999 protocols specified that sound level measurements were to be taken at selected workstations in the study space. Section 5.3.5 of the 1993 protocol specified that sound level measurements be made at the five indoor locations on Tuesdays of the study week at 10:00 a.m. and 3:00 p.m. Section 5.3.5 of the 1994 and 1999 protocols specified that real-time sound level measurements were to be made during the mobile cart monitoring rounds at each indoor site. It was further stated that the sound level measurements were to be recorded at the center of a workstation adjacent to the monitoring location. This protocol has been updated to specify that sound level measurements are to be performed only at indoor fixed sites (F1, F3, and F5) using continuous monitoring methods.

- Table 5-3 of the 1993 protocol did not specify a sampling strategy for radon. Table 5-3 of the 1994 and 1999 protocols specified that radon samples be collected at selected ground floor locations, elevator shafts, and stairwells on the floor(s) of the test space and at the fixed site sampling locations. The radon sampling strategy was altered in the Winter of 1998. The current protocol specifies that radon samples now be collected only at the fixed indoor sites (F1, F3, and F5) and study floor areas designated as potential pathways of soil gas from lower levels (stairwells, elevators, exits, etc.).

- Section 5.3.1 of the 1993 protocol, *Real-Time Measurements- Mobile Cart*, specified that Luminance measurements are made during the mobile monitoring rounds. Section 5.3.6 of the 1994 and 1999 protocols, *Luminance Measurements*, specified that real-time luminance measurements be made during the mobile cart monitoring rounds at each indoor site. The 1994 and 1999 protocols further stated that the luminance level measurements were to be recorded at the center of a workstation adjacent to the monitoring location. This protocol has been updated to specify that luminance level measurements are to be performed only at indoor fixed sites (F1, F3, and F5) using continuous monitoring methods.

- The 1994 and 1999 protocols specified procedures for conducting mobile monitoring at sampling sites within the test space. Section 5.3.1 of the 1994 and 1999 protocols, *Real Time measurements- Mobile Cart*, specified the following procedures for mobile monitoring.

  When more than three indoor monitoring sites are being characterized in a test space, one or more mobile carts will be configured with battery powered, real-time monitors for CO, CO_2, temperature, relative humidity, noise, and illuminance. The cart(s) will be configured so that measurements are conducted at a height of 1.1 m (43.3 inches) above the floor. The monitors will be interfaced with a datalogger for recording minute-by-minute instrument output on a continuous basis. The dataloggers must be compatible with a portable computer so all the data can be easily downloaded in the field.

  The mobile cart(s) will be used for making measurements at all the indoor locations. The cart will be moved to the first site no later than 9:30 a.m. and will remain there for approximately ten minutes, after which it will be moved to the second location, etc. The first five-to-seven minutes of each ten-minute period are for movement between locations and instrument stability. Averaged measurement values for the last 3 minutes will be stored in the datalogger

The sequence will be repeated in the afternoon, starting no later than 2:30 p.m., with the sites visited in the identical sequence. The measurements will initiate immediately upon arrival at the location and will be recorded directly into the portable computer. When not used for mobile monitors, the cart will be collocated with the fixed-site continuous monitors to collect data on measurement precision.

The current protocol specifies that mobile monitoring be conducted at each of the five mobile sites located within the test space. Measurements will be made with real-time monitors measuring carbon dioxide (CO_2), temperature, relative humidity and air diffuser volume flow rates. All measurements will be made at the supply air diffuser closest to the given mobile site as described in Section 5.3.1.

- Section 5.3.2 of the 1993 protocol specified that continuous monitoring of selected parameters be conducted at a single indoor fixed site. This protocol specifies that continuous monitors be placed at each indoor fixed site.

- Section 5.3.2 of the 1994 and 1999 protocols specified that real-time monitors for carbon monoxide (CO), CO_2, temperature, relative humidity, noise, and light will be placed at the three indoor fixed sites (F1, F3, and F5). Section 5.3.1 of the 1993, 1994, and 1999 protocols, *Real Time measurements- Mobile Cart*, specified duplicate continuous monitoring be implemented. In June 1997, continuous monitoring at the duplicate site was discontinued as it was deemed redundant given calibration frequencies. As a result, the duplicate sensors were moved to Mobile Site 2 (M2) (creating Fixed Site 2 [F2]), allowing for a better understanding of interspatial variability within the study space. Continuous monitoring parameters at Fixed Site 2 included: CO_2, CO, relative humidity, and temperature (at four elevations). These changes are reflected in the current protocol.

- Figure 5-1 of the 1994 and 1999 protocols specified measurements to be made at the indoor mobile cart locations. The 1994 and 1999 protocols specified that CO, CO_2, temperature, relative humidity, luminance, and noise were to be measured at each of the mobile monitoring locations. The current protocol specifies that CO_2, temperature, relative humidity, and diffuser airflow be measured at the supply air diffuser closest to the mobile monitoring site. The parameters of CO, luminance, and sound have been excluded.

- Figure 5-1 of the 1993, 1994, and 1999 protocols specified measurements to be made at the indoor fixed site locations. The 1994 and 1999 protocols specified that $PM_{2.5}$ sampling be conducted at one indoor and one outdoor site. The 1993 protocol did not include $PM_{2.5}$ sampling. The current protocol specifies that $PM_{2.5}$ sampling be conducted at each fixed indoor site (F1, F3, and F5) and at the outdoor site.

- Section 5.3.3 of the 1994 and 1999 protocols, *Integrated Samplers*, specified that microbiological source samples will be collected from the air handler drip pans, from the carpet near the indoor fixed sites, and from other obviously biologically contaminated areas. The samples were to be pooled by sample type and analyzed for fungi and bacteria. Table 5-4 of the 1993 protocol specified that microbiological source samples be collected as needed. The current protocol also specifies that biological samples be collected from these sources; however, samples will be analyzed individually as opposed to pooled to create a single sample. Further, the current protocol specifies that samples be analyzed for fungal and bacterial content. Bacteria samples will be cultured at incubation temperatures that target mesophilic and thermophilic bacteria.

- Section 5.3.3 of the 1994 and 1999 protocols, *Integrated Samplers*, specified that integrated air bioaerosol samples be collected and characterized for fungi and bacteria. Table 5-5 of the 1993 protocol specified that air bioaerosol samples be collected and characterized for fungi and bacteria. The current protocol clarifies that bacteria samples will be cultured at incubation temperatures that target mesophilic and thermophilic bacteria.

- The 1993, 1994, and 1999 protocols did not include antigen characterization as an augmented parameter in samples of dust collected from floors or carpeting at each of the three indoor fixed sites (F1, F3, and F5). The current protocol reflects the addition of antigen analysis from dust samples as an augmented parameter.

- The 1993, 1994, and 1999 protocols specify volatile organic compounds (VOCs) as a core measurement parameter using the SUMMA® canister sampling method. These protocol versions did not include the Multisorbent tube sampling method as an additional method to use for the collection of VOC samples. VOC results from these samples may be used to supplement those from the SUMMA® canister sampling method. The current protocol reflects the addition of the Multisorbent tube sampling method as an additional method of collecting VOC samples. The current protocol specifies that VOCs will be collected as a core measurement parameter collected using both the SUMMA® canister and Multisorbent tube sampling method.

- The 1993, 1994, and 1999 protocols did not include the continuous measurement of CO_2 concentrations in the supply and return air streams of the AHU serving the test space as an augmented parameter. Section 5.4, of the current protocol, *HVAC Measurements*, reflects these changes.

2.0 STUDY TEAM ORGANIZATION AND RESPONSIBILITIES

The activities described in this protocol may be performed by a potentially large number of study teams. Each study team will be responsible for all data collection, data reduction, and data entry activities associated with individual buildings or a group of buildings monitored as part of EPA's large building studies. A conceptual study team's internal organization and its relationship to EPA's program management are illustrated in Figure 2-1. Each study team must designate a study team leader, field team leader, analysis team leader, sample custodian, survey administrator, data management specialist, and QA officer prior to field monitoring activities. In small organizations the same individual can be designated to perform several of these functions. However, the QA officer must be independent of the study team technical staff and routine sampling and analysis activities to avoid the potential for conflict of interest.

Program management of EPA's large building studies was performed by an EPA project manager with support, as required, from a designated EPA contractor. Responsibilities for members of a study team's organization are listed in Table 2-1. The experience requirements for each team member necessary to ensure program success are also provided. EPA recognizes that differences in research organizations and individuals may require changes to this proposed organization and alignment of responsibilities. Figure 2-1 merely identifies those qualifications determined to be essential for successfully conducting EPA's large building studies. Implementing the field portion of the study suggests that an ideal field team would be comprised of four people: a field team leader, a field technician, a sample custodian, and a ventilation or mechanical systems measurement specialist. Qualifications and responsibilities of a four-person field team may often overlap.

Figure 2-1 Study Team Organization

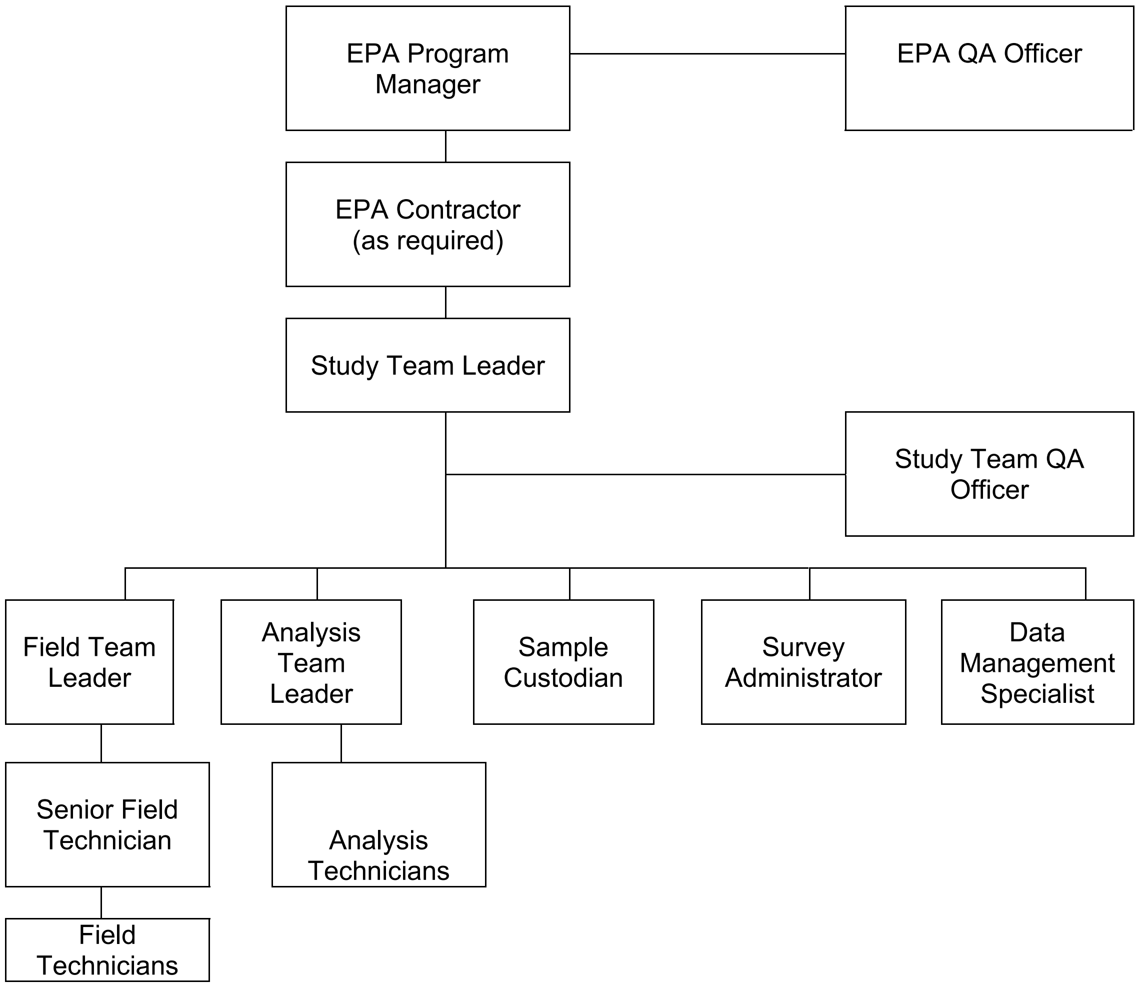

Table 2-1 Responsibilities And Qualifications For Study Team Members

Member	Responsibility	Qualifications
Study Team Leader	Project management	Fiscal and technical management experience for indoor air quality projects Indoor air quality field monitoring expertise for large buildings Data processing and analysis expertise Quality assurance/quality control expertise
Field Team Leader	Manage field measurement activities	Fiscal and technical management experience for indoor air quality projects Experience in coordination of field monitoring programs for indoor air quality studies Experience in characterization of HVAC systems in large buildings and performance of core HVAC measurements Experience in field measurement of core parameters in large buildings Experience with field monitoring instrumentation Experience in data collection, documentation, and field data processing
Senior Field Technician	Sample collection and field monitoring; collection of information on HVAC system(s) and performance of core HVAC measurements	Experience in field measurement of core parameters in occupied buildings Experience with field monitoring instrumentation Experience in characterization of HVAC systems in large buildings and performance of core HVAC measurements Experience in the implementation of study protocols and quality control procedures

Table 2-1 Continued

Member	Responsibility	Qualifications
Field Technicians	Perform sample collection and monitoring	Experience in field measurement of core parameters in occupied buildings Experience with field monitoring instrumentation Experience in the implementation of study protocols and quality control procedures
Analysis Team Leader	Manage data processing and analysis task	Fiscal and technical management of tasks involving processing and analysis of complex data sets Expertise in indoor air quality as related to field sample collection and monitoring of chemical and physical parameters, methods of chemical analysis, and data analysis Experience in quality assurance/quality control
Analysis Technicians	Process and verify data	Experience in processing and analysis of physical and chemical measurement data Experience in quality assurance/quality control
Sample Custodian	Maintain inventory of all materials required for field sampling; transfer unexposed and exposed samplers between field and laboratories; maintain chain of custody for all samples, checklists, questionnaires, documentation forms, and data	Experience in the management of sample and data custody for large field monitoring programs
Quality Assurance Officer	Provide QA review and documentation for field operations, sample analysis, data reduction, and reporting	Experience with field monitoring for core parameters Experience with measurement methods for core parameters Experience with quality assurance/quality control

Table 2-1 Continued

Member	Responsibility	Qualifications
Survey Administrator	Administer questionnaire to building occupants; collect questionnaires	Experience in management of survey projects Experience in recruiting study participants and administering questionnaires
Data Management Specialist	Manage research team's database	Experience in technical data management of projects involving field measurements of physical and chemical parameters

HVAC heating, ventilating, and air-conditioning

3.0 INITIAL BUILDING VISIT

The field team leader or senior field technician makes an initial visit to each building as soon as possible after the building is selected and recruited into the study. The objectives of this visit are to verify the suitability of the building for the study, to identify potential study areas for monitoring, to select one or more study areas for monitoring, and to collect information that can be used to select monitoring locations within the study area(s). Information on the whole building, including space use, occupancy, climate and site, building equipment, and building envelope, is collected during the initial visit using the Building Description Checklist included as Form A-1 in Appendix A of this document. Information on pollutant sources are collected with a Source Information Checklist (Appendix A, Form A-2). The *IADCS* allows direct entry of the checklist information on a portable computer.[2]

The initial site visit includes the activities shown in Figure 3-1.

Figure 3-1 Activities for Initial Building Visit

1	Meet with building owner/manager
2	Collect background information on building
3	Collect information to identify potential study area(s)
4	Identify potential study areas
5	Randomly select study area(s)
6	Collect information on study area(s) to be used for selecting monitoring locations

1. Meet with the building owner/manager to describe the overall study, monitoring activities, time schedules, and information required to characterize the building.

2. Collect background information on the building.

   - Meet with the building HVAC engineer or other knowledgeable individual for an overview of the HVAC system(s).

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[2] A 386 laptop computer was used with the IADCS data collection software. The performance of this software on portable computers with higher processing speeds should be evaluated prior to its use in the field.

- Collect available documentation, such as updated floor plans and HVAC plans (may be obtained prior to initial visit, if possible).
- Identify on floor plans the HVAC systems and air handlers serving each floor and/or major area.
- Perform a walkthrough to include the following activities:

  - Complete Building Description Checklist (Form A-1)
  - Complete Building Source Information Checklist (Form A-2)

3. Collect information on walkthrough to identify potential study areas.

   - Prepare general diagram (sketch) of layout of each floor. This may be done using a computer graphic program that allows information to be entered directly into a portable computer. Alternately, the building floor plans may be used.
   - Estimate the number of occupants per floor.
   - Note low and high occupant density areas.
   - Note relative amounts of open and closed space and hallways on each floor.
   - Note special use areas (e.g., cafeterias, print shops, labs, etc.).
   - Verify HVAC systems and the number of AHUs serving each floor.

4. Identify and number potential study areas within the building as specified in Section 4.

5. Randomly select study area(s) (with replacements) as specified in Section 4.

6. Collect information on selected study area(s) to be used for selecting monitoring locations.

   - Verify number of occupants in study area(s) by counting desks or workstations.
   - Use available floor plan (or sketch a floor plan) to mark the following:

     - Areas served by HVAC system or systems.

- Special use areas (i.e., elevators, restrooms, conference rooms, storage areas, copier rooms, and hallways).

Based on the initial visit, a building will be considered suitable for inclusion in the monitoring study if it has at least one space that meets the criteria for the study area(s) as outlined in Section 4.

4.0 SELECTION OF STUDY AREA(S) AND MONITORING LOCATIONS

4.1 STUDY AREA(S)

Figure 4.1 outlines the basic activities followed in selecting a study area in a building. A study area is defined as the area in a building where occupant work space, HVAC characterization, comfort and environmental measurements, and occupant response data will be collected as part of this protocol. Table 4-1 shows the general criteria for designating a building space as a study area. Included with each criterion is an indication of whether it is a necessary or a preferred criterion. In each building, the study area(s) will be randomly selected during the initial visit, as outlined in Table 4-1 and described below.

Figure 4-1 Basic Activities for Selection of a Study Area in a Building

1	Gather information at building
2	Identify probable study areas
3	Identify all potential study areas
4	Assign all potential study areas a number
5	Select study area(s) using random number selection

1. Collect information on the building's physical characteristics. Information will be collected during the initial visit to the building, as described in Section 3.

2. Identify probable study areas that meet criteria using the building floor plans, HVAC information, and average occupant densities estimated for each floor.

3. Identify all potential study areas that meet Table 4-1 criteria. Potential study areas will be defined with no overlap between study areas. To the extent possible, all occupied floor space within the building should be accounted for in the potential study areas. Wherever possible, potential study areas should be selected using the preferred criteria. All areas that meet either the necessary or preferred criteria will be included for selection.

4. Assign each potential study area a number. Number assignments will be sequential. Number one will be assigned to the space in the northernmost section of the lowest floor. Numbers will then be assigned in a clockwise fashion on each floor. After all numbers are assigned to potential study areas on one floor, the next number will be given to an area on the next highest floor, again starting in the northernmost corner. Remaining numbers will be assigned in a clockwise fashion. This procedure is repeated on all floors until all potential study areas have been assigned numbers.

5. Select the study area for monitoring from the potential study areas using a random number generator. Two backup study areas will also be selected. These areas may be used if conditions within the building have changed since the initial visit or if it appears that a potential study area does not meet all criteria after more detailed information is obtained.

Table 4-1 Criteria for Designating a Building Space as a Study Area(s)

Characteristic	Criteria	
	Necessary	**Preferred**
Number of Occupants	25 occupants who work for 20 or more hours/week and are accessible to questionnaire	50 to 60 occupants who work for 20 or more hours/week and are accessible to questionnaire
Air Supply	Provided by no more than two air handling units	Provided by one air handling unit
Test Space	Totally contained in a maximum of three floors	Totally contained on one floor
Test Area	---	Not to exceed 20,000 square feet [a]

[a] Can be larger; however, deviation should be documented.

4.2 MONITORING LOCATIONS

4.2.1 Selecting Monitoring Locations

The selection of monitoring locations within the selected study space will be conducted as soon as possible on Monday morning of the study week. Two types of monitoring locations will be established: fixed and mobile. Integrated measurements will be collected at three of the four fixed sites. Continuous measurements will be collected at the four fixed sites. Real-time measurements will be collected at the five mobile sites. Four of the mobile sites will be co-located with the fixed indoor sites.[3]

Four fixed indoor monitoring locations will be established in each building. For three of these fixed sites, integrated, continuous, and real-time monitoring will be conducted. At the fourth fixed site, only continuous monitoring will be conducted. A fixed outdoor monitoring location will also be selected during the initial field visit and should be as close as possible to the fresh air intake of the primary AHU serving the test space. Equivalent sample sets are collected at the three fixed indoor and fixed outdoor locations.

Five mobile indoor monitoring locations will be established and will be co-located with the fixed indoor monitoring locations.[4] The selection of monitoring locations will be conducted on the Monday morning of the field monitoring week.

The specific indoor locations are selected using the identification and random selection process shown in Figure 4-2 and described below.

Figure 4-2 Procedure for Siting Monitoring Equipment

1	Divide the study area into 5m x 5m tiles
2	Remove individual tiles from study area, as required
3	Number tiles
4	Randomly select tiles that define monitoring locations
5	Site monitoring equipment within selected tiles

3 This is a change from the 1994 and 1999 protocols. These protocols specified that three mobile sites were to be collocated with the fixed indoor sites and specified three indoor fixed sites instead of four. In the 1993 protocol, siting requirements were not specifically called out in this section. The current protocol description reflects changes made in June 1997. See Section 1.3 for more details regarding protocol changes.

4 This is a change from the 1994 and 1999 protocols. These protocols specified that mobile monitoring locations were to be established based on variations in the study space occupancy or variations in the study space floor area. In the 1993 protocol, these requirements were not specified in this section. For consistency, only five mobile sites were selected (which encompass three indoor fixed sites and an augmented fourth: fixed site 2). The current protocol description reflects these changes. See Section 1.3 for more details regarding protocol changes.

1. Divide the study area into 5 meter (m) × 5 m tiles. Each tile represents a potential monitoring location. Tiles will be defined so that there is no overlap between tiles and all the space in the study area is defined within the tiles.

   Although most of the study area should be defined in this manner, the size of some tiles may require slight adjustment to accommodate the actual dimensions and shape(s) of the study area.

2. Remove tiles from consideration as monitoring locations, as specified by the following criteria. In general, for a tile to be considered valid for potential selection, more than 50% of the tile must include areas where full-time occupants are assigned and conduct their normal work activities. Tiles that are comprised solely of bathrooms, hallways, stairs, elevators, laboratories, cafeterias, conference rooms, and other special use areas where full-time occupants are not assigned should be removed from the tile selection process. This may require some minor modification to the actual tile size as noted in step 1 above.

3. Assign each valid tile a unique number in a sequential order. Number one will be assigned to the tile in the northernmost section of the lowest floor in the study area. Numbers will be assigned using a clockwise inward spiral on each floor. After all numbers are assigned to tiles on one floor, the next number will be given to the area on the next higher floor. Remaining numbers on the floor will be assigned using the same clockwise inward spiral procedure.

4. Select tiles that define the indoor monitoring locations using the following systematic random sampling scheme. The potential number of tiles for monitoring (x) is divided by the total number of indoor monitoring sites (y) to establish the interval between monitoring sites (i). For example, for a study area with 100 tiles (x) and five indoor monitoring sites (y), every 20th tile (i) will be selected (100 ÷ 5 = 20). Use a randomly generated start number to establish the base tile number. Using the calculated interval number, establish the location for the remaining monitoring sites in a sequential fashion. For example, using the 100-tile scenario above, the randomly generated base number was 47; therefore, tile 47 is the base monitoring site. Monitoring sites two, three, four, and five will then be located at tiles 67, 87, 7, and

27, in that order. The first, second, third, and fifth randomly selected tiles will be designated fixed indoor monitoring sites F1, F2, F3, and F5, respectively.[5] All five sites will be designated as mobile monitoring sites (M1, M2, M3, M4, and M5) with M1, M2, M3, and M5 being co-located with F1, F2, F3, and F5, respectively.

5. If one or more of the randomly selected tiles are determined to be unusable, then replacement tiles will be selected. Replacement tiles will be selected and assigned as monitoring locations by using tile x – 1, then x + 1, etc. until a suitable tile is found. Table 4-2 shows the type of monitoring that will be performed at the monitoring locations 1 to 5 for this example.

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[5] This is a change from the 1994 and 1999 protocols. These protocols specified three fixed sites where both integrated and continuous sampling were to be performed (F1, F3, and F5). The 1993 protocol specified three fixed sites for integrated sampling of which one site was used for continuous monitoring. The current protocol adds an augmented sampling site, F2, reflecting changes made in June 1997. See Section 1.3 for more details regarding protocol changes.

Table 4-2 Monitoring Performed at Specific Indoor Monitoring Locations		
Monitoring Location	**ID Code**	**Type of Monitoring Performed[a]**
1	M1 F1	Mobile Fixed-site continuous Fixed-site integrated Fixed-site integrated duplicates[b]
2	M2 F2	Mobile Fixed-site continuous (augmented)[c]
3	M3 F3	Mobile Fixed-site continuous Fixed-site integrated Fixed-site duplicates[b]
4	M4	Mobile
5	M5 F5	Mobile Fixed-site continuous Fixed-site integrated Fixed-site duplicates[b]

[a] Details for monitoring are described in Section 5.
[b] Indoor duplicate samples may be collected at either site F1, F3, or F5 and may be placed based on site physical restrictions. Indoor duplicate samples shall not be collected across multiple fixed indoor sites, (e.g. VOC duplicates at F1, particles at F3, and other duplicate samplers at F5).[6]
[c] This is a change from the 1993, 1994, and 1999 protocols. These protocols did not specify monitoring at fixed site 2. The current protocol description reflects changes made in June 1997. See Section 1.3 for more details regarding protocol changes.

4.2.2 General Guidelines for Siting Indoor Monitoring Locations Within a Tile

During field data collection, monitors may be sited at any location in the selected tile using the following general guidelines.

- Monitoring/sampling should be conducted at a location within the tile that represents the primary workstation layout and work activities.

[6] This is a change from the 1994 and 1999 protocols. These protocols specified that duplicate samples be collected at site F1. These protocols further specified that physical restrictions existed, duplicate samples may be collected across multiple sampling sites. The 1993 protocol specified duplicate samples to be collected at site F5. See Section 1.3 for more details regarding protocol changes.

- Locations should be selected to minimize impact on work activities within the tile.

- Locations should be at least one-half (0.5) meter from corners or windows. In cases where it is not possible to locate a monitoring site at least one-half (0.5) meter from a corner, the placement issues should be appropriately documented. In all cases, however, the monitoring site shall be at least one-half (0.5) meter from a window.

- Locations should be at least one-half (0.5) meter from walls, partitions, and other vertical surfaces (e.g., file cabinets). Again, it is understood that meeting this preference may be difficult in some office spaces, given the limitations in typical office environments. In cases where this preference cannot be met, the placement issues should be appropriately documented.

- Locations should not be directly under or in front of air supply diffusers, induction units, floor fans, or heaters (personal), etc.

- Locations should not be where direct sunlight will impact instrumentation.

- Locations in hallways or passageways are not preferred.

- Locations should not be within one (1) meter of localized sources such as photocopiers, printers, or cigarette smokers.

- Locations may not obstruct or interfere with occupant egress from the study area under normal or emergency situations.

- Inlets of samplers at indoor locations should be placed at a height of 1.1 m above the floor (see protocol for temperature measurements for additional sampling heights for this parameter).

4.2.3 General Guidelines for Siting Outdoor Monitoring Locations

- One outdoor location will be selected at each building.

- The location should be in close proximity to the outdoor air intake of the primary AHU serving the study area. The location will be dependent on the HVAC system design and accessibility.

- If possible, the location should have access to a 110V AC power supply; alternatively, batteries can be used to operate all of the pumps and instrumentation.

- The location may be on a roof or at ground level, whichever allows proximity to the outdoor air intake.

- If monitors and sensors are placed outdoors, they must be enclosed in an appropriate shelter to shield them from direct sunlight and moisture. Even if poor weather is not forecasted, the shelter must be used in order to maintain consistent collection conditions.

- Monitors and sensors placed outdoors must be secured to prevent tampering or loss. If the outdoor location at the air intake site cannot be secured, an appropriate location should be chosen as close to the outdoor air intake as possible. Outdoor continuous monitoring and integrated sampling should be conducted at the outdoor fixed site.[7]

- Monitor inlets and sensors should not be placed directly in front of the outdoor air intake. They should be located approximately one meter away from the edge of the air intake. Monitor inlets and sensors should be at least 1.8 m (6 feet) above ground level or the roof.

4.2.4 Deviation From Siting Guidelines

- Document all deviations from the siting guidelines on documentation form for the measurement parameter.

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[7] This is a change from the 1993, 1994, and 1999 protocols. These protocols specified that when the outdoor monitoring equipment could not be secured, a mobile cart was used to record outdoor parameters at the intake at specific periods of the day. The current protocol description reflects the changes made. See Section 1.3 for more details regarding protocol changes.

5.0 BUILDING CHARACTERIZATION AND MONITORING

The measurement of various physical, comfort, and environmental parameters in the study area(s) is an important component of EPA's large building studies. This section describes the core parameters to be measured, the measurement protocols, and the schedule of activities at each building.

Measurement parameters have been categorized as core or augmentation parameters. Core parameters are those parameters for which measurements were required for all EPA-sponsored building studies and met the following general criteria. First, they should provide physical, comfort, or environmental information pertaining to the study area(s) that is considered necessary for characterizing the overall quality of the indoor environment. Second, standard methods should be employed that provide measurement data with sufficient sensitivity, selectivity, precision, and accuracy to adequately characterize the indoor environment as it exists in a range of large buildings. Third, measurement methods for core parameters should be easy to implement in the field and create minimal burden on the building space and occupants during monitoring. Finally, methods for core parameters should be relatively inexpensive to perform. Augmentation parameters are additional parameters that were measured at some of the buildings in the program. Measurements of augmentation parameters were considered for inclusion at selected buildings based on considerations of the research objectives, historical data, potential for integration of the measurement results with other studies, and other factors, as deemed appropriate by the EPA Program Manager. Table 5-1 summarizes the core parameters and sample collection methods that were measured during EPA's large building studies. Information on augmentation parameters is given in Appendix B.

Table 5-1 Core Parameters and Sample Collection Methods	
Parameter	**Sampling Method/Device**
Real-Time Monitors	
Air Temperature (Dry Bulb)	Sensor
Relative Humidity	Sensor
CO_2	Monitor/Pump
CO	Monitor/passive diffusion or pump
Sound Level	Sensor (microphone)
Illuminance	Sensor (light)
Integrated Samples	
Inhalable Particles ($PM_{2.5}$)	Pump/size selective impactor, filter
Inhalable Particles (PM_{10})	Pump/size selective impactor, filter
Volatile Organic Compounds	Pump, Multisorbent cartridge and SUMMA® canister
Formaldehyde	Pump, DNPH cartridge
Bioaerosols	Pump/size selective impactor, agar media
Radon	Passive diffusion charcoal canister
Other Samples	
Bulk Biologicals [a]	Sterile disposable pipettes, sterile sampling bottles, sample collection bags
HVAC Measurements	
Supply/Return Airflow Rate	Duct traverse/pitot tube[b]
Supply/Return Air Temperature	Sensor
Supply/Return Air Relative Humidity	Sensor
Percent Outdoor Air Intake—Outdoor, Supply, Return Air	CO_2 monitor
Outdoor Air Intake Rate	Duct traverse/pitot tube[b]
Exhaust Fan Airflow Rate	Flow capture hood, duct traverse/pitot tube[b]
Supply Diffuser Airflow Rate	Flow capture hood
Supply Diffuser Temperature	Sensor
Supply Diffuser Relative Humidity	Sensor
Supply Diffuser Carbon Dioxide	Sensor

CO_2 carbon dioxide
CO carbon monoxide
$PM_{2.5}$ inhalable particles with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10} inhalable particles with an aerodynamic diameter less than or equal to 10 microns
DNPH dinitrophenyl hydrazine

[a] Bulk samples from obviously contaminated sources (i.e., drip pans, ducts) are also collected for determination of bacteria and fungi.
[b] May be performed with pitot tube, hot-wire anemometer, or comparable sensor.

5.1 COLLECTION OF INFORMATION ON THE BUILDING AND STUDY AREA(S)

A set of checklists have been developed (Table 5-2) to consistently collect information on the whole building and on the study area(s). A copy of the checklists developed to collect the information is included in Appendix A. Although the data may be entered directly into the *IADCS* on a portable computer (see Appendix H), it is generally advisable to also document this information in a hard copy format to ensure that a backup is maintained. Information can readily be entered into the *IADCS* software shortly after the initial visit.

Information on the whole building is collected using the Building Description portion of the Building Survey section of the *IADCS*. This information is completed during the initial visit to the building, as described previously in Section 3. When the field team returns to the building to perform the monitoring, the field team leader reviews the entries to these checklists to verify the previous information collected and to record any changes that may have occurred since the previous site visit.

Table 5-2 Checklists for Collecting Information on the Building and Study Area

Data Collection Instrument	Form Number
Building Description Checklist	A-1
Building Source Information Checklist	A-2
Test Space Description Checklist	B-1
Test Space Source Information Checklist	B-2
Test Space HVAC System Description Checklists	
• Central Air Handling and Distribution System	C-1
• Perimeter Zone Units	C-2
• Unitary Systems	C-3
• Evaporative Cooling Systems	C-4
• Outdoor Air Intake Control	C-5
• Natural Ventilation Systems	C-6
• Air Handler Specifications	C-7A
• Exhaust Fan Specifications	C-7B
• Filtration and Air Cleaning Systems	C-8
• Air Washers	C-9
• Humidification Systems	C-10
• Maintenance	C-11
• Inspection	C-12

* Checklists are adapted for collection and storage using the *IADCS* on a portable computer.

Information on the study area(s) (sometimes referred to as the test space) and specific sources will be collected during the week of measurements at the building using the appropriate sections of the *IADCS* Building Survey. It is preferred that these checklists are initiated early in the week to allow time for completion while still in the building. The data should be completed at all buildings by the same team member, preferably either the field team leader or senior field technician, to ensure consistency.

5.2 ENVIRONMENTAL MEASUREMENTS

Environmental monitoring includes measurements for both comfort factors and environmental pollutants. Table 5-3 summarizes information on the environmental measurements included in EPA's large building studies. The type of monitoring to be performed and general considerations for inclusion as a core parameter are also given. Monitoring will be performed with both real-time and integrated measurement methods, as described below.

Abbreviated protocols for each parameter are included in Appendix C of this document. Each protocol describes the measurement method, performance requirements, instrument requirements, calibration requirements, and QA/QC requirements.

Core comfort parameters include temperature, relative humidity, CO_2, sound level, and illuminance. All of these parameters can be measured with portable, "real-time" monitors. Quality of light (luminance and color) is considered to be an augmentation parameter. Although measurements of lighting quality parameters may be useful, their measurement and interpretation are complex, and standardized protocols that are applicable to large building studies have not been developed and validated. Although standard procedures are not available to quantitatively measure odor and odor perception, qualitative information related to odors will be collected by the research team during the monitoring period using the standardized checklist described in Section 5.3.7.

CO, particles ($PM_{2.5}$ and PM_{10}), VOCs, formaldehyde (HCHO), bioaerosols (fungi, mesophilic bacteria, and thermophilic bacteria) and radon are included as core parameters in the pollutant category. For VOCs, measurements are conducted using the SUMMA® canister and Multisorbent tube sampling method. The measurement of fungi and bacteria in bulk source samples collected from areas with noticeable biological growth is also a core parameter. Although there continues to be controversy with regard to the appropriate measurement protocols and the utility of the microbiologicals data, it is important that a database of bioaerosol measurements be developed. This study provides an opportunity for developing such a database. The measurement of viable and non-viable fungal spores is included as an augmented parameter.[8] Nicotine and acetaldehyde may be included as augmented parameters (Appendix B). Several pollutants, including ozone and oxides of nitrogen, were considered but not recommended for inclusion in the program.

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8 This is an addition to the 1993, 1994, and 1999 protocols. This change was made in June 1997. See Section 1.3 for more details regarding protocol additions.

Table 5-3 Core Environmental Measurement Parameters

Parameter	Monitoring Method	Comment
Comfort Factors		
Temperature	Real-time monitor	Air temperature (dry bulb) will be measured. Important comfort factor; easy to measure.
Relative humidity	Real-time monitor	Important comfort factor; easy to measure.
Carbon dioxide (CO_2)	Real-time monitor	Provides information on building ventilation; easy to measure.
Sound level	Real-time monitor	Sound level characteristics.[9] Easy to measure.
Illuminance	Real-time monitor	Illuminance is a measure of light intensity. Easy to measure.
Pollutants		
Carbon monoxide (CO)	Real-time monitor	A moderately important pollutant for large buildings; few sources. May be significant outdoor sources at some buildings. Relatively easy to measure.
Particles ($PM_{2.5}$ and PM_{10})	Collection/analysis	Particles will be collected on filters and mass determined. $PM_{2.5}$ and PM_{10} can be related to NAAQS.
Volatile organic compounds (VOCs)	Collection/analysis	VOC levels have been related to health and comfort concerns. VOCs will be collected in SUMMA® canisters, and using the multisorbent tube sampling technique. Samples will be analyzed by GC/MS, using relatively standardized methods. Total VOCs, aromatics, aliphatics, and selected chemicals will be quantitated.
Formaldehyde	Collection/analysis	Common emission sources in many buildings. Implicated in health concerns that are occasionally observed in buildings, including headache and fatigue. Standard methods are available. Acetaldehyde may be measured as an augmentation parameter.

9 This is a change from the 1993, 1994, and 1999 protocols. The 1993 protocol specified sound measurements to be conducted at the fixed sites only on Tuesday of the monitoring week. The 1994 and 1999 protocols specified sound measurements to be made during the mobile monitoring rounds at workstations near the fixed sites. The current protocol description reflects the changes made. See Section 1.3 for more details regarding protocol changes.

Table 5-3 Continued

Parameter	Monitoring Method	Comment
Bioaerosols	Collection/analysis	Culturable air spora will be sampled. An expanded high quality database reflecting the spatial and temporal variability for bioaerosols is needed. Non-culturable spores may be measured as an augmentation parameter.
Radon	Collection/analysis	Samples will be collected at possible entry points to the study area such as elevator shafts and stairwells and at the fixed indoor sampling locations. Methods and sampling protocols will follow EPA/NAREL recommendations.[10]
Biological agents in bulk samples	Collection/analysis	Integrated bulk samples will be collected from the air handler drip pans, from the carpet near the fixed indoor sites, and from other obviously biologically contaminated areas within the test space. Dust will be collected from a minimum of one square meter of carpet near fixed indoor sites. These samples will be analyzed for bacteria and fungi. Antigen analysis of bulk carpet dust samples may be added as an augmented parameter.

5.3 MEASUREMENT METHODS AND MONITORING REGIME

As shown in Table 5-3, the monitoring and measurement methods can be categorized as either real-time or integrated measurements. Methods that use real-time instruments are used to sample and measure the parameter continuously. Instantaneous measurements may be recorded or they may be averaged over a designated time interval. When these monitors are portable, they can be moved throughout the test space to perform measurements at several locations. Other parameters (e.g., VOCs) require methods for collection of samples over a selected (integrated) time period in the field. The collected sample is then sent to a laboratory for analysis. These methods are used to collect samples at fixed sites. For this study, integrated samples will be collected

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[10] This is a change from the 1994 and 1999 protocols. These protocols specified that radon canisters were to be placed primarily at ground contact floors with at least one canister per 5,000 square feet. The current protocol description reflects changes made in Winter 1998. See Section 1.3 for more details regarding protocol changes.

during a nominal nine-hour period equating to the normal occupant working hours. Integrated bioaerosol samples are also collected over an integrated period, but over a very short (minutes vs. hours) time period.

5.3.1 Real-Time Measurements—Mobile Cart[11]

A mobile cart will be used for making measurements at all of the indoor mobile locations during the periods between 9:30 – 10:30 a.m. and 2:30 – 3:30 p.m. on both Wednesday and Thursday. Typically, there will be five mobile sites collocated with four fixed indoor sites. The mobile cart will be configured with battery powered, real-time monitors for CO_2, temperature, and relative humidity. In addition, the mobile monitoring cart will include an airflow capture hood that will be used to record the supply air delivery from the air outlet diffuser(s) closest to the mobile monitoring site.

The cart will be moved to the first site no later than 9:30 a.m. At the first site, measurements will be taken of CO_2, temperature, and relative humidity at the air outlet diffuser(s) closest to the indoor fixed site. Sensors will remain at the air outlet diffuser for approximately three to five minutes to allow the readings to stabilize. Air volume delivery will be measured from the air outlet using an airflow capture hood. Qualitative information related to odors, cleanliness, and noise are collected at each mobile site using the standardized checklist described in Section 5.3.7. All real-time data and qualitative information is recorded on appropriate log sheets and is subsequently entered into *IADCS* on a portable computer. The process and collection of data is completed at each of the indoor fixed sites. The sequence will be repeated in the afternoon, starting no later than 2:30 p.m., with the sites visited in the identical sequence.

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[11] This is a change from the 1993, 1994 and 1999 protocol. These protocols specified that a single mobile cart was to be used at each mobile site. The cart would remain at the site for a period of ten minutes collecting data on parameters such as CO, CO_2, temperature, relative humidity, noise, and illuminance. (the 1993 protocol did not specify noise monitoring) In each of these protocols, it was specified that monitoring would be conducted at the mobile site instead of at the air outlet diffuser closest to the site. The current protocol description reflects the changes made. See Section 1.3 for more details regarding protocol changes.

A typical layout of measurement locations and comfort/environmental parameters for four fixed indoor, five mobile indoor (four being at the identical locations of the four fixed indoor sites), and one outdoor monitoring location are diagrammed in Figure 5-1.

5.3.2 Real-Time Measurements—Indoor and Outdoor Fixed Sites

Real-time monitors for CO, CO_2, relative humidity, noise, and light will be placed at the height of 1.1 m above the floor at three fixed indoor sites (F1, F3, and F5) as shown in Figure 5-1.[12] Real-time monitors for CO, CO_2, temperature, and relative humidity will be placed at fixed site 2. Temperature measurements will be recorded at heights of 0.1, 0.6, 1.1, and 1.7 m above the floor. Each parameter will be continuously recorded over an approximate three-day period at the building (Tuesday, a.m., to Thursday, p.m.). The real-time data will be output to a datalogger, with five-minute averages collected for future processing. Data will be downloaded each day using a portable computer.

At the outdoor location, which should be near the outside air intake for the study area(s) (see Section 4 for details on siting), a fixed-site monitoring station will be established with CO, CO_2, temperature, and relative humidity or dew point monitors. Data will be recorded continuously with a datalogger using a five-minute average as a collection frequency. At the end of each day, the data will be downloaded into the portable computer. In situations where the fixed-site monitoring equipment cannot be secured at the outdoor site and meet the requirement for being near the outdoor air intake (e.g., ground level intakes), the fixed site monitoring equipment shall be located in a secure outdoor location as close as possible to the AHU outdoor air intake.[13] Deviations from the siting requirements shall be appropriately documented.

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[12] This is a change from the 1994 and 1999 protocols. These protocols specified that light measurements were considered an augmented parameter to be implemented when possible. Also, real time monitoring was specified to occur at three indoor fixed sites instead of four. The 1993 protocol specified that continuous monitoring be implemented at only one fixed site. The current protocol reflects the changes made. See Section 1.3 for more details regarding protocol changes.

[13] This is a change from the 1994 and 1999 protocols. These protocols specified that when the outdoor monitoring equipment could not be secured, a mobile cart was used to record outdoor parameters at the intake at specific periods of the day. The current protocol description reflects changes made. See Section 1.3 for more details regarding protocol changes.

Routine hourly meteorological parameter data (wind direction, wind speed, ambient temperature, ambient relative humidity, precipitation, and solar radiation) will be collected from the local National Weather Service activity and reported for inclusion in the EPA database.

Figure 5-1 Diagram of the Measurements to be Made at the Indoor Mobile Cart and Fixed Site Locations and Outdoors[b]

Study Area

M2	F2
CO_2	CO
T	CO_2
RH	T
DIFF	RH

M1	F1	F1-DUP[a]
CO_2	CO	VOC
T	CO_2	HCHO
RH	T	PM_{10}
DIFF	RH	$PM_{2.5}$
	LUX	BIO
	NOISE	
	VOC	
	HCHO	
	PM_{10}	
	$PM_{2.5}$	
	BIO	

M3	F3
CO_2	CO
T	CO_2
RH	T
DIFF	RH
	LUX
	NOISE
	VOC
	HCHO
	PM_{10}
	$PM_{2.5}$
	BIO

M4
CO_2
T
RH
DIFF

M5	F5
CO_2	CO
T	CO_2
RH	T
DIFF	RH
	LUX
	NOISE
	VOC
	HCHO
	PM_{10}
	$PM_{2.5}$
	BIO

Outdoors

OUTDOOR		OUTDOOR-DUP
CO	VOC	VOC
CO_2	HCHO	HCHO
T	PM_{10}	PM_{10}
RH	$PM_{2.5}$	$PM_{2.5}$
	BIO	BIO

ABBREVIATIONS

Monitoring Sites
M=Mobile
F=Fixed
BIO = Bioaerosols
LUX = Illuminance
DIFF = Diffuser airflow

[a] Indoor duplicate samples may be collected at either site F1, F3, or F5 and may be placed based on site physical restrictions. Indoor duplicate samples shall not be collected across multiple fixed indoor sites (e.g., VOC duplicates at F1, particles at F3, and other duplicate samplers at F5).

[b] Changes were made to the 1993, 1994, and 1999 protocols regarding measurements to be made at the indoor fixed and mobile sites. For mobile monitoring sites, the measurement of CO, Illuminance, and noise was excluded while site diffuser measurements were added. At the fixed sites, $PM_{2.5}$ sampling was added for all sites. See Section 1.3 for more details regarding protocol changes.

5.3.3 Integrated Samplers

As described in Section 4, integrated air samples for VOCs, formaldehyde, and particles (PM_{10} and $PM_{2.5}$) will be collected on one day (Wednesday) at a height of 1.1 m above the floor at the three fixed sites (F1, F3, and F5) within each building study area and the outdoor fixed-site location. Figure 5-1 shows that duplicate samples will be collected at one fixed indoor site and the outdoor site. The integrated samples will be collected over a nominal nine-hour period from approximately 8:00 a.m. to 5:00 p.m., ±30 minutes, equating to the anticipated normal daytime working hours. The start and end time may require adjustment based on the normal working hours within the test space.

At the outdoor location, integrated samples for VOCs, formaldehyde (and acetaldehyde if applicable), PM_{10}, and $PM_{2.5}$ will be collected in duplicate from approximately 7:30 a.m. to 5:30 p.m. on Wednesday. Outdoor sampling should always be initiated before the indoor monitoring starts and should end after the completion of the indoor integrated samplers. The collection of duplicate outdoor samples should substantially improve data completeness.

Bioaerosol samples (fungi, mesophilic bacteria, and thermophilic bacteria) will be paired as two and five minute samples and will be collected at the three indoor fixed-site locations and at the outdoor location. The samples will be collected on Wednesday (only) at approximately 10:30 a.m. and 3:30 p.m. (±30 minutes) following completion of the mobile cart monitoring. As shown in Figure 5-1, samples will be collected in duplicate at one indoor and the outdoor location.

The measurement of viable and non viable spores may be collected as an augmented parameter. Samples will be collected on Wednesday (only) at approximately 10:30 a.m. and 3:30 p.m. in coincidence with bioaerosol samples described above.

Integrated source samples for microbiological contamination will also be collected from: AHU drip pans, interior AHU sections or coils, and areas with obvious water damage and biological contamination. Samples will be analyzed individually for fungi, mesophilic bacteria, and thermophilic bacteria. These source samples can be collected at any time during the Tuesday to Friday period, but preferably on Thursday, as no other integrated sampling is conducted on that day. Dust samples within a 1 square meter area will be collected in close proximity to each of the three indoor fixed sites where integrated sampling is conducted. Samples will be analyzed individually for bacteria, fungi, and thermophilic bacteria. Dust samples will be collected on Thursday. As an augmented parameter, a portion of the dust collected at each fixed site may be split from the sample and sent out for antigen analysis.

5.3.4 Radon Sampling

Radon will be sampled using diffusion-barrier charcoal canisters. The canisters will be deployed on Monday soon after arrival of the field team. They will be retrieved 72 hours after being deployed and shipped to the laboratory on Thursday for analysis on Friday. The canisters will be deployed at each of the three indoor fixed sites and at entry locations to the study space, such as stairwells, elevator lobbies, etc.[14]

5.3.5 Sound Level Measurements

Sound level measurements will be made continuously at the three fixed indoor locations designated as F1, F3, and F5. Measurements will be made at a height of 1.1 m.

5.3.6 Illuminance Measurements

Illuminance measurements will be made continuously at the three fixed indoor locations designated as F1, F3, and F5.[15] Measurements will be made at a height of 1.1 m.

5.3.7 Monitoring Period Observations Checklist

During the two daily mobile cart monitoring periods, the researcher will record observations made at each location related to odors, noise, housekeeping, and pollutant

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14 This is a change from the 1994 and 1999s protocol. The 1994 and 1999 protocol specified that radon samples be collected at selected ground floor locations, elevator shafts, stairwells on the floor(s) of the test space and at the fixed site sampling locations. See Section 1.3 for more details regarding protocol changes.

15 This is a change from the 1993, 1994, and 1999s protocol. The 1993 protocol specified that illuminance measurements were to be made at all mobile sites during the mobile monitoring rounds. The 1994 and 1999 protocols specified that illuminance measurements were to be made during the mobile cart monitoring round at a workstation adjacent to the site. See Section 1.3 for more details regarding protocol changes.

sources using a standardized checklist (see Appendix D). These observations, although subjective, may aid in the interpretation of the measurement data. The observations will be entered into a checklist in the portable computer.

5.3.8 Number of Measurements to Be Made

The number of measurements to be made at each building is presented in Table 5-4. Two mobile cart measurements are made each day at the indoor locations. At the fixed-site indoor and outdoor locations, data will be collected continuously for various parameters during the two to three day monitoring period. Five-minute averages will be downloaded from the datalogger. In naturally ventilated buildings, CO_2 measurements will also be calculated as 15-minute averages (see Section 5.4).

Integrated samples will be collected on only one day at the three fixed indoor locations (F1, F3, and F5) and one fixed outdoor location. Bioaerosol samples will be collected at all three fixed indoor locations and at the outdoor location, twice on one day (Wednesday morning and afternoon). Grab samples of biologically contaminated bulk samples will be collected on Thursday from the HVAC drip pans, the carpeting or flooring at the three fixed indoor sites, and at other locations where noticeable biological contamination is observed. The number of radon samplers to be deployed will be a function of the study area size and the number of possible entry points to the study area.

In addition to the field samples, various quality control (QC) samples will be analyzed. These will include the QC samples provided by the research organization and those provided by EPA. The minimum number of field and QC samples to be analyzed per building are listed in Table 5-5. At each building, one field blank and one duplicate sample are required for each type of integrated sample. As described previously, $PM_{2.5}$, PM_{10}, HCHO, and VOC samples will be collected and analyzed in duplicate at the outdoor location to maximize data completeness. Table 5-6 shows the samples that must be analyzed before the program is initiated as an initial demonstration of laboratory capability.

Table 5-4 Number of Measurements to be Performed for Comfort and Environmental Characterization

Measurement Type/ Parameter	Number of Indoor Locations	Number of Measurements per Indoor Location			Number of Outdoor Measurements			Total Number of Measure-ments [a]
		Tue.	Wed.	Thu.	Tue.	Wed.	Thu.	
Real-Time (Mobile) Monitoring[b]								
Temperature	5	--	2	2	--	--	--	20
Relative Humidity	5	--	2	2	--	--	--	20
CO_2	5	--	2	2	--	--	--	20
Diffuser Air Volume	5	--	2	2	--	--	--	20
Fixed-Site Continuous Monitoring								
Temperature	3 – 4	C	C	C	C	C	C	48 – 54[c]
Relative Humidity	3 – 4	C	C	C	C	C	C	48 – 54[c]
CO	3 – 4	C	C	C	C	C	C	48 – 54[c]
CO_2 [d]	3 – 4	C	C	C	C	C	C	48 – 54[c]
Noise	3	C	C	C	--	--	--	48[c]
Light	3	C	C	C	--	--	--	48[c]
Fixed-Site Integrated Samples								
$PM_{2.5}$	3	0	1	0	0	1	--	4
PM_{10}	3	0	1	0	0	1	--	4
VOCs[e]	3	0	1	0	0	1	--	4
Formaldehyde	3	0	1	0	0	1	--	4
Radon	3+ [f]	--	--	--	--	--	--	--[f]
Bioaerosol (air)	3	--	6	0	0	6	--	24
Bioaerosol (fungal spores)	3	--	2	0	0	2	--	8
Biological Grab Samples[g]								
Bulk Samples	--	--	--	--	--	--	--	3

CO_2 carbon dioxide
CO carbon monoxide
C continuously monitored using five-minute averages
$PM_{2.5}$ inhalable particles with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10} inhalable particles with an aerodynamic diameter less than or equal to 10 microns
VOC volatile organic compound

[a] Field measurement samples only. Does not include duplicates or quality control samples.
[b] Real-time measurements performed at the five indoor locations once in the morning and once in the afternoon on each day.
[c] Minimum number of hourly averages.
[d] Number of samples for environmental characterization. CO_2 measurements will also be made for the HVAC characterization.
[e] Samples will be collected using the SUMMA canister and multisorbent tube sampling technique.
[f] Three radon samples will be collected at the indoor fixed sites. Additional samples will be deployed based on study space size and the number of possible entry points to study space.
[g] Bulk samples (AHU drip pans, carpet, other obviously contaminated areas).

Table 5-5 Number of Integrated Samples to be Analyzed from Each Building					
Parameter	**Number of Samples**				
	Field Samples	**Field Blanks**	**Duplicates**[a]	**QA**[b]	**Total**
$PM_{2.5}$	4	1	2	1[g]	8
PM_{10}	4	1	2	--[e]	7
VOCs (canister)	4	0	2	1	7
VOCs (multisorbent tube)	4	1	2	1	8
Formaldehyde/ Acetaldehyde	4	1	2	1	8
Radon	--[c]	--[c]	--[c]	--	--[c]
Bioaerosols-Fungi	16	2[d]	8	--	26
Bioaerosols-Mesophilic Bacteria	16	2[d]	8	--	26
Bioaerosols-Thermophilic Bacteria	16	2[d]	8	--	26
Bioaerosols-Fungal Spores	8	0	1		9
Bulk Samples (biologicals)	As Needed				

$PM_{2.5}$ inhalable particles with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10} inhalable particles with an aerodynamic diameter less than or equal to 10 microns
VOC volatile organic compound

[a] One indoor and outdoor duplicate will be collected and analyzed.
[b] Quality assurance (QA) samples may either be performance evaluation samples submitted to the analysis laboratory by EPA or duplicate samples that are collected and submitted to an independent laboratory for analysis.
[c] The number of samples depends on study space. Duplicates should be placed at 10% of all measurement locations. The number of blanks is 5% of the number of samplers deployed.
[d] Includes one field blank and one shipping blank
[e] For PM samples, a single field blank is collected. The field blank may be loaded in either a $PM_{2.5}$ or PM_{10} impactor.

Field samples, field blanks, and duplicates will be collected by the research teams. In addition to these samples, laboratory blanks and controls will be prepared by the analytical laboratory for each building. These samples will only be analyzed if contamination or poor recovery is found on the field blanks.

Table 5-6 Samples Required for Initial Demonstration of Laboratory Capability

Sample	Number	Purpose
Laboratory blanks	3	Demonstrate low background contamination
Laboratory control—spiked at moderate level	3	Demonstrate adequate recovery
Laboratory control—spiked at low level	7	Calculate method quantitation limit

5.4 HVAC MEASUREMENTS

Core HVAC measurement parameters are shown in Table 5-7. Measurement protocols and forms for data collection are included in Appendix E of this document. These forms emulate the computer screen mock-ups as contained in the *IADCS* software.

Supply airflow rate, percent outdoor air intake rate, outdoor air intake rate, and supply air temperature will be measured for each AHU that serves the study area(s) in mechanically ventilated buildings. HVAC and diffuser measurements will be conducted as outlined below.

a. Monday and Tuesday. The HVAC system will be characterized as outlined in Appendix E, Form E-1, and the ductwork prepared (as necessary) for airflow measurements and system monitoring to be performed. Measurement of all test space exhaust fan(s) airflow rates will be measured with a flow capture hood once during the week, either on Monday or Tuesday. As an augmented measurement parameter, continuous CO_2 concentration measurements may also be made simultaneously in the AHU supply and return air stream and at the AHU outdoor air intake.[16] If these measurements are to be performed, the monitoring systems should be setup on Monday and monitoring initiated on Tuesday afternoon.

b. Tuesday, 1:00 – 5:00 p.m. The performance of the AHUs supplying air to the test space will be determined by simultaneously measuring the supply air flow and the flows from preferably all of the diffusers in the test space. In some buildings, the number of diffusers within the selected test space may require resources exceeding

16 This is an addition to the 1993, 1994, and 1999 protocols. This change was made in Winter 1995. See Section 1.3 for more details regarding protocol additions.

those available. When this occurs, a random sample consisting of a minimum of 50% of the diffusers in the test space will be monitored, including the diffusers nearest to each of the indoor monitoring locations. This activity should be appropriately scheduled and completed within this four-hour period to minimize the potential influence by a variable air flow system.

c. Wednesday and Thursday. HVAC system performance measurements will be made at the same time that environmental measurements are made with the mobile cart, i.e., 9:30 a.m. and 2:30 p.m. on Wednesday and Thursday. Each measurement is briefly described in Table 5-7 and is described in detail in Appendix E. Outdoor, return, and supply air flow stream temperatures, relative humidity levels, CO_2 levels, and flows will be measured. During this same period, the temperature, relative humidity, CO_2, and flow from the diffuser closest to each mobile site will also be measured. The technician performing the mobile monitoring will also check to see if the exhaust fans are operating at approximately 10:30 a.m. and 3:30 p.m.

d. Thursday and Friday. Additional information pertaining to the AHU(s) may be collected during this period to complete the Appendix E, E-form narratives.

In naturally ventilated buildings, the core parameters to be measured include: (1) continuous carbon dioxide measurements, (2) measurements of exhaust fan airflow rate, and (3) the twice-daily check of exhaust fan operation. The continuous CO_2 measurements, described in Form E-5 of Appendix E, consist of measurements of CO_2 at three indoor locations throughout the day on both days of monitoring. CO_2 monitors will be available for measurements at fixed sites F1, F2, F3, and F5 (See Figure 5-1). Data will be recorded continuously with the datalogger.

Research teams may propose protocols for air infiltration rate measurements (such as using sulfur hexaflouride as a tracer gas) at specific buildings. These measurements, described in Form E-6 of Appendix E, will be considered augmented parameters (Appendix B) and will not be performed at all of the buildings in the study.

Table 5-7 HVAC Measurement Parameters

Parameter	Monitoring Method	Comment	Appendix E Form No.
Supply Airflow Rate	Duct traverse	Perform for each air handler unit (AHU) serving study area. Pitot tube or hot-wire anemometer.	E-1
Percent Outdoor Air Intake	CO_2 measurements	Measure CO_2 in outdoor air and the supply and return air of each AHU serving the study area. Continuous monitoring of these parameters may also be used to supplement real time instantaneous measurements	E-1
Outdoor Air Intake Rate	(1) Duct traverse or (2) Calculation	For each AHU serving the study area, perform duct traverse in outside air intake duct, if possible. Otherwise calculate based on measured supply and return air volume	E-1
Supply Air Temperature and Relative Humidity	Monitor in duct	Perform measurement in supply air duct for each AHU serving the study area.	E-1
Exhaust Fan Operation	Observation	Recorded by technician mornings and afternoons of monitoring days.	E-3
Exhaust Fan Airflow Rate	Flow capture hood/Duct traverse	Measure airflow rates of all exhaust fans serving the test space, measure individual exhaust grilles within the test space; one time measurement.	E-4
Local Ventilation Performance-Airflow Rate	Flow capture hood	Measure airflow rate from all supply diffusers in the study area (preferred). Measure a minimum of 50% of the supply diffusers in the study space	E-2
Natural Ventilation-Continuous Carbon Dioxide	CO_2 monitor	Core parameter only for the naturally-ventilated buildings. Measurements of CO_2 at three locations throughout the day.	E-5

CO_2 carbon dioxide

5.5 SCHEDULE OF ACTIVITIES FOR EACH BUILDING

Activities are described in this section as they relate to data collection at a building. Pre-data collection activities, such as building selection and recruitment are not addressed here. The activities related to data collection, beginning with the initial site visit and ending with travel is summarized in Table 5-8.

Table 5.8 General Schedule for Data Collection Activities

Day	Activity
Pre-Monitoring	
	Initial Site Visit (described in Section 3)
Week of Monitoring	
Monday a.m.	Travel Meeting with building manager Supply information to study area occupants
Monday p.m.	Verify monitoring locations Deploy radon samplers Unpack and assemble instruments Prepare ducts for traverse measurements
Tuesday a.m.	Measure airflow rate of exhaust fans Calibrate real-time monitors Set up fixed-site sampling locations and AHU sampling locations if applicable Start fixed-site continuous monitoring and AHU continuous monitoring if applicable
Tuesday p.m.	Measure airflow rate of AHU(s) serving test space Measure airflow rate of test space diffusers Download data(optional)
Wednesday	Collect integrated samples (8:00 a.m. to 5:00 p.m.) Continue fixed-site continuous monitoring Perform mobile monitoring (9:30 a.m. and 2:30 p.m.) Perform HVAC measurements (9:30 a.m. and 2:30 p.m.) Perform biological monitoring (10:30 a.m. and 3:30 p.m.) Ship biological samples (overnight) Retrieve integrated samplers Download data (optional)
Thursday	Continue continuous monitoring Administer questionnaires Perform mobile monitoring (9:30 a.m. and 2:30 p.m.) Perform HVAC measurements (9:30 a.m. and 2:30 p.m.) Collect bulk biological samples Pack integrated sampling equipment Download data Retrieve and ship radon samplers Ship bulk biological samples Ship all other integrated samples
Friday a.m.	Check for data completeness Retrieve unaccounted questionnaires Perform quality control checks on field data Pack equipment
Friday p.m.	Travel

AHU air handling unit
HVAC heating, ventilating, and air-conditioning

The field team will arrive at the building by 9:00 a.m. on Monday morning. The field team leader will meet the building manager, verify the appropriateness of the study area(s) selected, and make preparations for meeting with the occupants of the study area(s) late Monday morning. The field team leader will then meet with the occupants of the study area(s) to briefly explain the study and the monitoring regime. Information pamphlets on the study will also be distributed at this time. The field technicians will devote Monday morning to equipment unpacking and preliminary equipment setup.

For the technicians, Monday afternoon and Tuesday will be devoted to: (1) preparation and calibration of monitoring equipment, (2) preparations for the required HVAC measurements, (3) measurements of airflow rates of diffusers and exhaust fans in the study area(s), and (4) set up and flow check of the instrumentation at the fixed outdoor and indoor sites. The flow of the AHU(s) and diffusers serving the test space will be measured on Tuesday afternoon. Environmental and comfort monitoring will be performed on Tuesday afternoon, Wednesday, and Thursday, with the integrated samples being collected only on Wednesday. Monitoring with the mobile cart at the indoor mobile sites and HVAC performance measurements will be performed on both Wednesday and Thursday. Continuous monitoring at the four indoor fixed sites and at the outdoor site will be initiated on Tuesday afternoon and will continue through late Thursday afternoon. If continuous CO_2 concentrations are monitored in the AHU air streams, this monitoring will also be initiated on Tuesday afternoon and continue through late Thursday afternoon.

Radon samplers will be deployed on Monday afternoon, retrieved 72 hours after deployment, and shipped to the laboratory for Friday analysis. Friday will be devoted to data validation, checks for data completeness, instrument packing, shipping, and team travel.

A more detailed day-by-day schedule of activities is presented in Table 5-9. Activities are listed for the field team leader (FL), two technicians (T-1 and T-2), and a survey administrator (SA). A team of four should be able to complete all activities at a building during the five-day week. Initially, during the pre-test or during monitoring at the first one or two buildings, a fifth team member might be included to ensure that there is no data loss due to time constraints. However, after gaining experience at some buildings, the four-person team can probably complete all the activities identified in this protocol. Because of the requirements for a nine-hour monitoring period, the team should expect to be at the building site at least 11 hours on the two monitoring days (Wednesday and Thursday).

The field team leader's primary responsibilities relate to supervisory, coordination, quality control, data processing, sample handling, and documentation activities. It is anticipated that the field team leader will complete most of the building and study area(s) (test space) description checklists and the HVAC checklists. In the allocation of activities, the field leader's time has not been delineated on an hour-by-hour basis. The field team leader will be available to provide support and assistance to the technicians on an as-needed basis.

Table 5-9 Schedule of Day-by-Day Activities

Day/Time	Activity	Team Member[b]
MONDAY		
a.m.	Travel Meet with building manager Review and verify building characteristics and study area Meet with study space occupants	 FL, T-1, T-2 FL FL
p.m.	Deploy radon samplers Verify monitoring locations Unpack and prepare instrumentation Prepare HVAC ducts for traverses	T-1, T-2 FL FL T-1, T-2
TUESDAY		
a.m.	Finish preparation of ducts Finish preparation of instrumentation	T-2 T-2
p.m.	AHU(s) and diffuser flow measurements Exhaust fan airflow rate measurements Calibrate all real-time monitors Set up outdoor sampling site (and shelter) Set up indoor mobile and fixed sites Start fixed site, real-time monitoring Download (optional)	T-2 T-2 T-1, FL T-2, FL T-1, FL T-1, T-2, FL T-1
WEDNESDAY		
7:00 – 8:00 a.m.	Zero and span outdoor monitors; set-up integrated outdoor samplers	T-2
8:00 – 8:30 a.m.	Set up indoor fixed-site integrated sampling locations	T-1
8:30 – 9:30 a.m.	Zero and span instruments on mobile cart; misc. activities	T-1
9:00 – 9:30 a.m.	Prepare for HVAC measurements; misc. activities	T-2
9:30 – 10:20 a.m.	Perform mobile monitoring at 5 locations; perform diffuser measurements	T-1, FL

Table 5-9 Continued

Day/Time	Activity	Team Member[b]
9:30 – 11:00 a.m.	Perform HVAC measurements	T-2
10:20 a.m.	Check exhaust fan operation; move cart to fixed site	T-1
10:30 a.m. – 12:00 p.m.	Perform bioaerosol sampling	T-1
11:30 a.m. – 12:00 p.m.	Verify all pumps and monitors operating at indoor and outdoor fixed sites	T-2
12:00 – 2:30 p.m.	Lunch; misc. activities	T-1, T-2
2:30 – 3:20 p.m.	Mobile monitoring; diffuser measurements	T-1, FL
2:30 – 4:00 p.m.	HVAC measurements	T-2
3:20 p.m.	Check exhaust fan operation; move cart to work area	T-1
3:30 – 4:30 p.m.	Perform bioaerosol sampling	T-1
4:30 – 5:00 p.m.	Ship bioaerosol samples to laboratory for delivery on Thursday morning	T-1
4:30 – 5:30 p.m.	Retrieve indoor integrated samplers; retrieve outdoor integrated samplers; zero and span outdoor monitors; download datalogger	T-2, FL
5:00 – 6:00 p.m.	Zero and span fixed-site indoor monitors; download data loggers	T-1
5:00 – 6:30 p.m.	Pack and store samples; complete documentation; misc. activities	FL, T-1, T-2
THURSDAY		
7:00 – 8:00 a.m.	Zero and span indoor fixed-site monitors	T-1
8:30 – 9:00 a.m.	Zero and span outdoor fixed-site monitors	T-2
9:00 – 9:30 a.m.	Zero and span mobile cart monitors; prepare for measurements	T-1, T-2
9:30 – 10:20 a.m.	Perform mobile monitoring; diffuser measurements	T-1, FL
9:30 – 11:00 a.m.	Perform HVAC measurements	T-2
10:00 a.m.	Distribute questionnaires	SA
10:20 a.m.	Check exhaust fan operation; move cart to fixed site	T-1
10:30 a.m. – 2:30 p.m.	Pack integrated sampling instrumentation; lunch; and misc. activities	T-1, T-2
2:30 – 3:20 p.m.	Mobile monitoring; diffuser measurements	T-1, FL
2:30 – 4:00 p.m.	HVAC measurements	T-2
3:00 – 4:00 p.m.	Retrieve questionnaires	SA
p.m.	Retrieve radon samplers (72 hours after deployment); ship to laboratory for Friday analysis	T-1, T-2
3:20 p.m.	Check exhaust fan operation	T-1
3:30 – 4:30 p.m.	Zero and span mobile cart monitors	T-1
4:30 – 5:00 p.m.	Retrieve outdoor monitors; zero and span	T-2
5:00 – 6:00 p.m.	Download dataloggers	T-1
6:00 p.m. –	Computer data completeness and quality control check	FL
6:00 p.m.	Ship other samples to laboratories	T-2

Table 5-9 Continued

Day/Time	Activity	Team Member[b]
FRIDAY		
	Data Quality Check Retrieve remaining questionnaires Pack and ship instrumentation Travel	FL SA FL, T-1, T-2

[a] Activities are generally not delineated for the field team leader (FL). The FL may complete the Test Space Description checklists (Forms B-1 and B-2, Appendix A) and the Test Space HVAC Description Checklists (Forms C-1 through C-12, Appendix A) on Wednesday or Thursday. The FL will assist in set-up and retrieval of instrumentation, as required. The FL will devote a substantial amount of time to supervisory, quality control, data processing, sample handling, and documentation activities at the building. Note that team responsibilities may often overlap.

[b] Team members designated as:

FL field team leader
T1 technician 1
T2 technician 2
SA survey administrator

6.0 ADMINISTRATION OF OCCUPANT QUESTIONNAIRE

Collecting information on occupants' perception of IAQ and health symptoms will be completed on Thursday of the sampling week. This information will be obtained using the Indoor Environmental Quality Questionnaire given in Appendix F. The questionnaire will be administered to the occupants in the study area(s). Only those full-time individuals (20 or more hours per week) whose primary workstation is in the study area(s) are eligible to participate. This approach is taken so that environmental monitoring and survey data will be applicable to the same group of people. Every attempt will be made to collect data from all eligible occupants.

Although the survey will be conducted using a self-administered questionnaire, one member of the field team will be designated as a survey administrator. The survey administrator will enlist occupant participation, provide the elements of informed consent, and distribute and collect the questionnaire. All survey administration and data handling activities will be performed using procedures that maintain confidentiality of the results. A schematic of questionnaire administration activities is given in Figure 6-1. Specific procedures for recruiting participants, administering the questionnaire, entering the data onto computer files, and maintaining confidentiality are described below.

Figure 6-1 Questionnaire Administration Activities

1	Initiate Contact and Inform Test Space Occupants of the Questionnaire and Its Importance
2	Pass Out Questionnaires
3	Collect and Validate Questionnaires (Thursday p.m.)
4	Follow-up Missing Questionnaires
5	Batch and Ship Questionnaires (Friday a.m.)
6	Enter Questionnaires into Database and Validate Data (Week Following Collection)
7	Transfer Validated Data to EPA

6.1 PARTICIPANT RECRUITMENT

Participant recruitment will take place on the Thursday morning of the monitoring week. Early that morning (~9:00 a.m.), the survey administrator will distribute the questionnaire to all of the occupants in the study area(s). The occupants will have previously received an informational brochure that explains the study objectives and the need for their participation.

The questionnaire will have a tear-off sheet that will be returned to the survey administrator to assist the administrator in accounting for the return of the questionnaires. As the survey administrator distributes the questionnaire, they will provide the following information.

- Reiterate the purpose of the study and describe background information
- Describe the components of the questionnaire and its relationship to the study
- Cover areas of informed consent
  - Voluntary
  - Can refuse any questions
  - Can stop at any time in the survey
  - No negative impact of non-participation
  - Review benefits/risks
  - Data confidentiality
- Explain logistics of survey data collection

6.2 SURVEY ADMINISTRATION

The survey administrator will distribute questionnaires by no later than 10:00 a.m. on Thursday morning. The cover page of the questionnaire will be numbered prior to distribution. The survey administrator will have a cross-reference sheet between those numbers and where the questionnaire is distributed. The questionnaire will be distributed by going to each work area and individually distributing the questionnaires. All of the occupants in the study area(s) who are at work must be contacted prior to Thursday to make them aware of the questionnaire, the purpose of the BASE Study in general, and what will be done with the responses. Participant recruitment activities may continue until 2:00 p.m. on Thursday.

At the time that the questionnaires are handed out, the survey administrator should briefly discuss the contents of the questionnaire's four major sections:

- The work place in general—questions about the physical setting of the work area.

- General health and well being—questions about health symptoms experienced over the last four weeks at work and what happens to those symptoms when away from work.

- Work place conditions regarding thermal comfort and noise.

- Characteristics of the respondent's job—questions regarding stress and other factors. Inform the participants that these questions are asked because many factors can combine in the office environment to affect how you feel.

The survey administrator will answer any questions about the study or participation, make sure the participants are aware that they are available for questions throughout the day, emphasize that any responses will be completely confidential and will not be discussed with management or union representatives, and indicate that when the respondent is finished he/she should return the questionnaire by no later than 4:00 p.m. at a pre-determined drop-off point.

The questionnaire drop-off point will have two separate secured boxes. At the drop-off point, the respondent will detach the numbered cover page from the remainder of the questionnaire. The cover page will be placed in the first box, the questionnaire in the second box. This approach completely separates any identification of the respondent from the questionnaire and, as a result, ensures confidentiality of the participant's responses.

At 4:00 p.m. on Thursday, the survey administrator will collect the cover page sheets from the drop-off point and determine which occupants still have not returned the questionnaires. The survey administrator will then contact these individuals and prompt them to complete and return their questionnaires.

Individuals absent on Thursday, but who were present on Monday, Tuesday, Wednesday, and Friday may complete the questionnaire on Friday morning before noon. Questionnaires distributed or returned on Friday must be flagged to note when they were returned.

Once the questionnaires are retrieved, the survey administrator will verify that the questionnaires and cover pages have been separated and there is nothing that can link a participant with a questionnaire. Questionnaires will then be assigned an ID number. A chain-of-custody list with all questionnaire ID numbers will then be generated.

The questionnaires and original chain-of-custody list will be returned to the study team's data processing center using a commercial overnight delivery service.

6.3 DATA ENTRY

All data returned from the field will be logged in; all questionnaires must be accounted for. Each questionnaire will be reviewed to assure the consistent handling of responses. Responses on the questionnaires will then be transferred to a file using EPA-provided software. The transferred data must be checked for completeness. Once all the data has been checked, the data file will be directly downloaded for entry into the EPA database.

6.4 DATA CONFIDENTIALITY

All data collected as part of the occupant questionnaire must be treated as confidential data. The following procedures will be used to ensure confidentiality.

- Survey administrators who administer questionnaires must sign a pledge of confidentiality. As specified in the Privacy Act of 1974, breaches in confidentiality will result in fines and/or imprisonment.
- All identifiers such as the respondent's name must be removed from the questionnaire.
- All hard-copy data must be stored in a locked area.
- Data can only be provided in composite form, so that individual identifiers are hidden.
- Individual data files will not be turned over to the government unless subpoenaed.

7.0 SAMPLE AND DATA MANAGEMENT

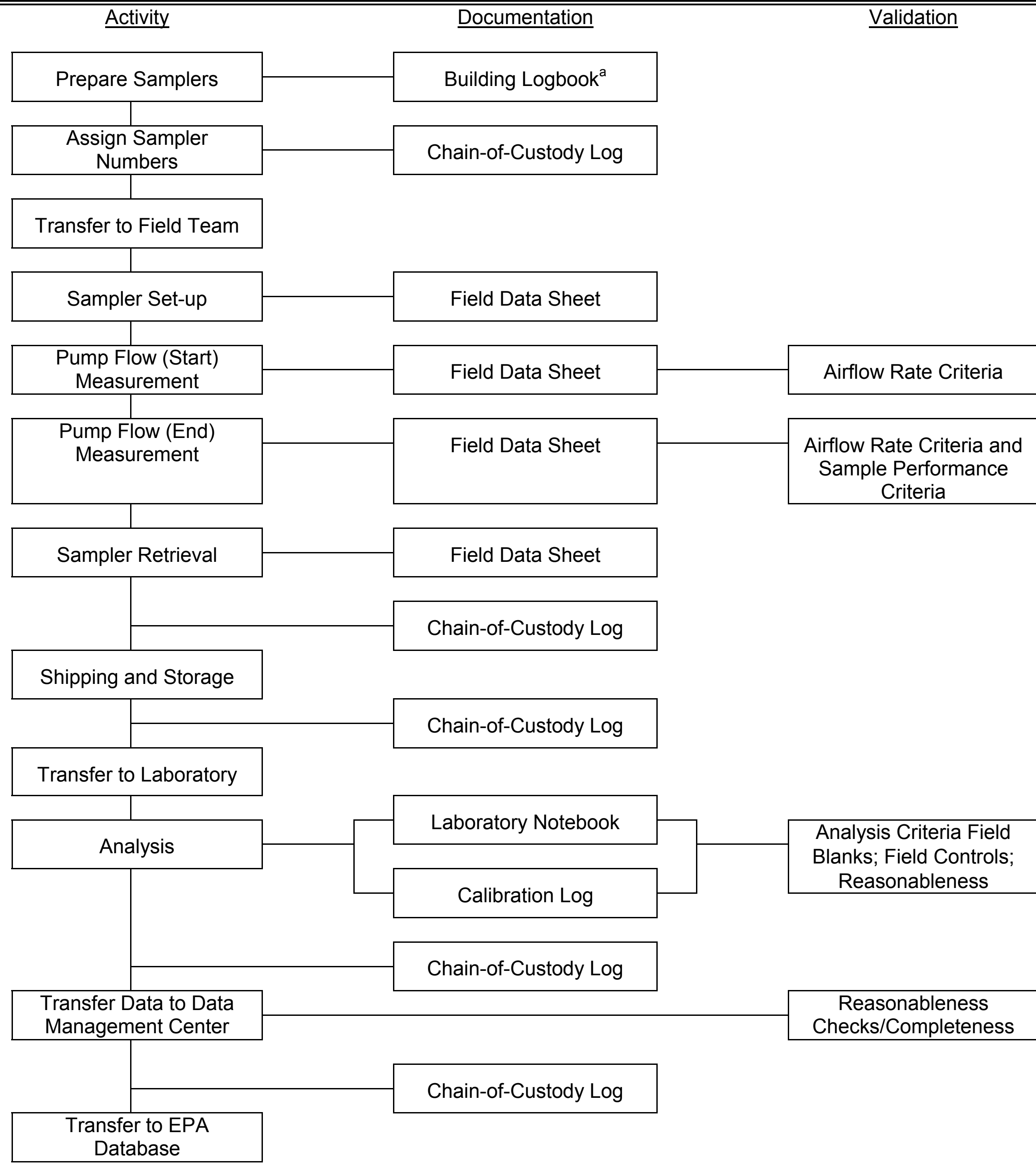
Several types of samples as well as electronic and hard copy data will be generated for each study area and building. The comfort and environmental monitoring involves collecting both integrated samples and real-time measurements. The building and HVAC characterization involves entering checklist and measurement data onto hard copy forms and entering this data into a computer file. Occupant questionnaires will be hard copy forms administered using paper and pencil techniques, and the results will be subsequently entered into data files. Figures 7-1 to 7-4 outline the collection, documentation, and validation activities for each category. The procedures used to implement these activities are described below.

7.1 SAMPLE MANAGEMENT

7.1.1 Integrated Sample Management

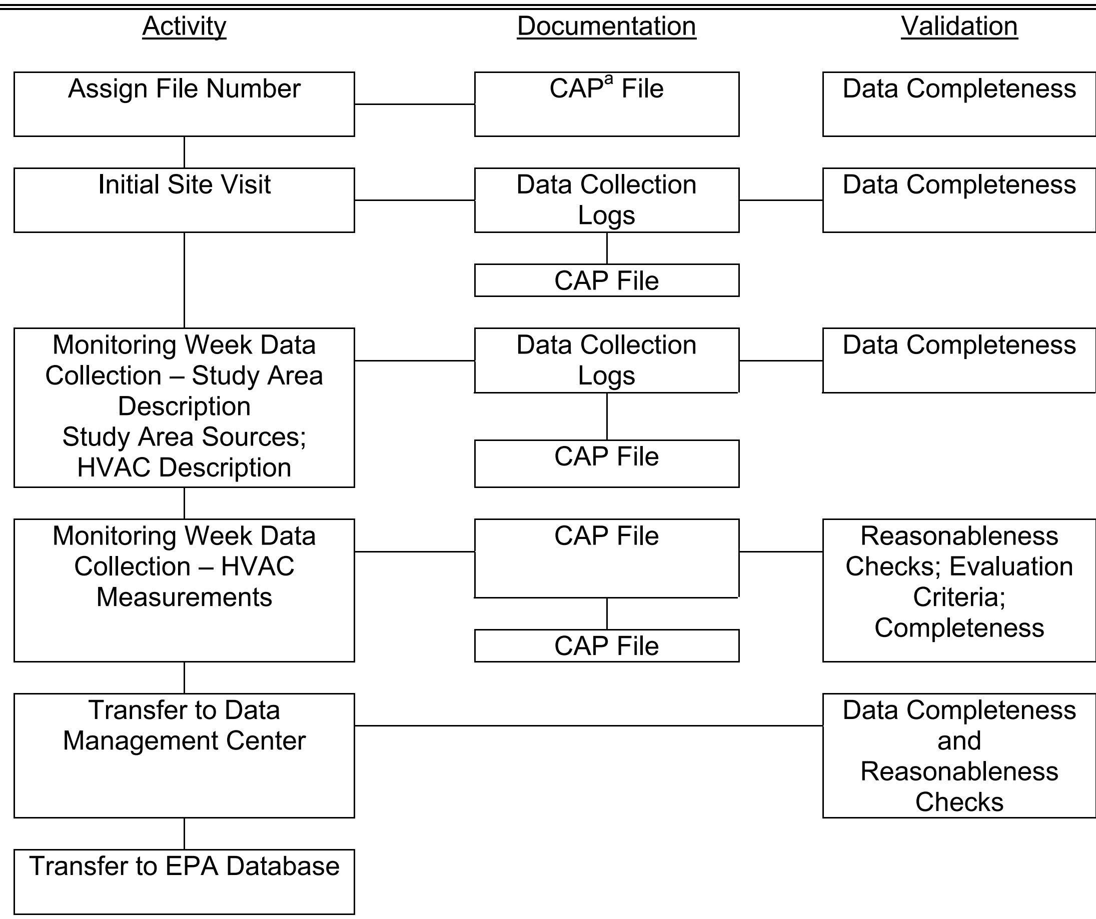
A unique alphanumeric identification code will be assigned to each sample collected. These identification codes will indicate the type of sample (VOCs, particles, formaldehyde, etc.). Labels printed with these codes will be generated and placed either directly on each sample cartridge or on the container in which the individual sample will be stored. Direct or indirect labeling of the sample will be dependent on the analysis method (i.e., extraction or desorption of the entire cartridge, or just the sorbent material). In addition to labeling, documentation of sample location, building, primary or duplicate, sampling equipment IDs, pump air flow rates, start/stop times, sampling conditions, technician IDs, and other appropriate sample collection information will be necessary. This information will be recorded on hard copy forms and is later entered into the field data computer system. Information for all of the samples collected will be recorded on a field data sheet and later entered into a computer spreadsheet. The spreadsheet will perform the necessary calculations (sampling times, sampled volumes, etc.), generate a computer data file for data processing, and generate a listing for sample tracking and chain-of-custody. A file backup of the original entry data must be made at the time of collection as protection against a computer failure.

Figure 7-1 Management of Data for Integrated Samples



[a] A logbook should be maintained for each building being studied. This logbook may consist of a single binder containing all information pertaining to the study building. This information includes sample preparation notes, field data logs, chain of custody logs, and instrument calibration logs.

Figure 7-2 Management of Building, Study Area, and HVAC Descriptions and HVAC Measurements



[a] Computer assisted program; direct entry to electronic file with a portable computer.

Figure 7-3 Sample Management for Real-Time Monitoring Data

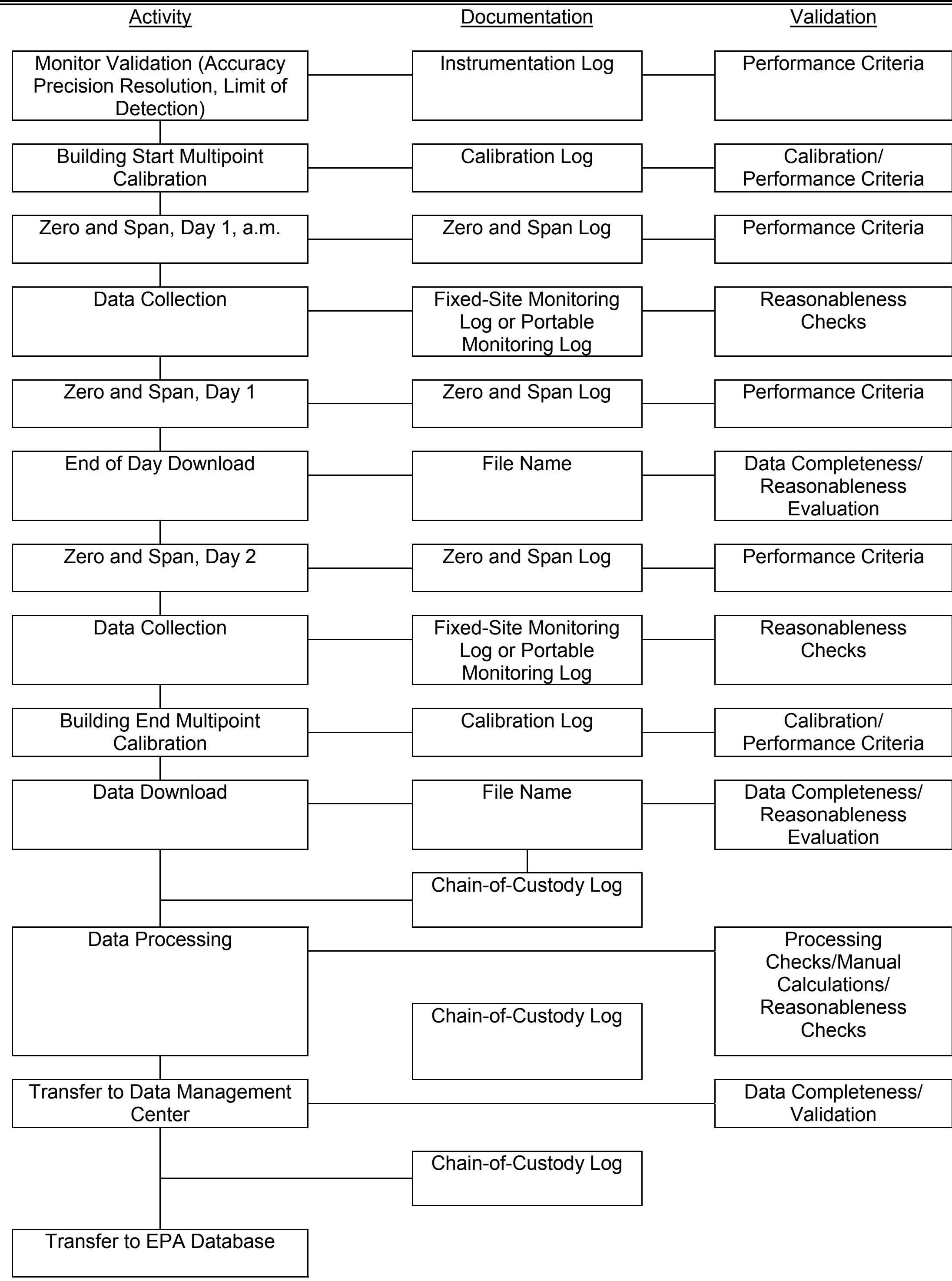
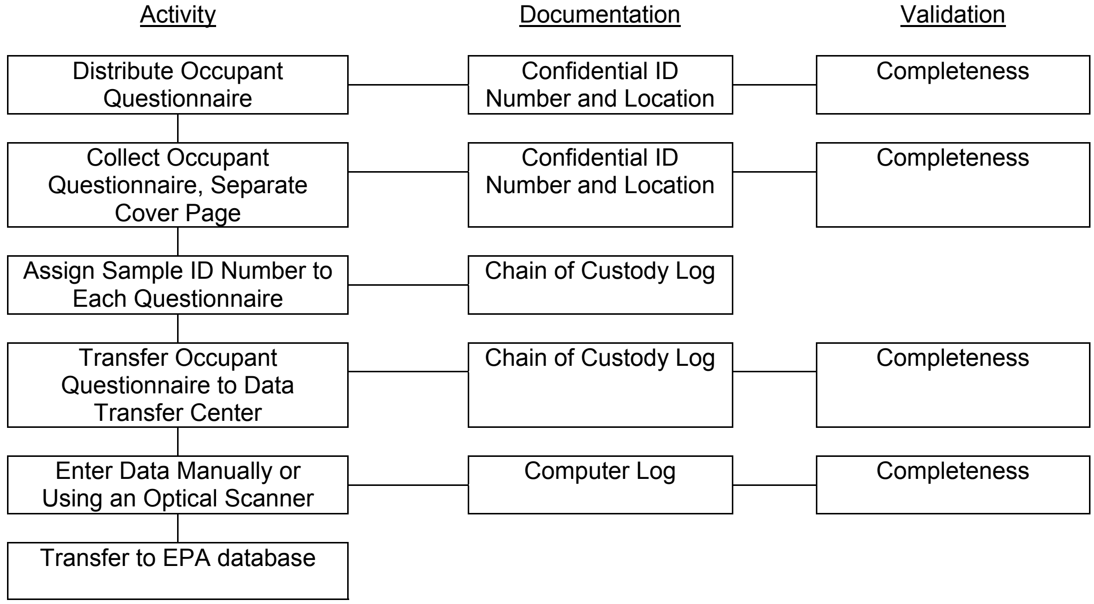


Figure 7-4 Management of Occupant Questionnaire Data



All sampling materials and supplies will be transported to and from the field under the direction of the field team leader. The field team leader or designated sample custodian will be responsible for the proper storage and shipment of samples while in the field. Samples will be stored and shipped according to the procedures outlined in the specific sampling protocols. These procedures include:

- For inhalable particles, hand-carry the filters, if possible; overnight shipment otherwise. Filters are stored in a temperature- and humidity-controlled environment and allowed to condition for at least 24 hours before tare and gross weighing.

- For formaldehyde and acetaldehyde, exposed cartridges are resealed in culture tubes, placed inside sealed, uncoated paint cans, then shipped overnight to the laboratory in cushioned, hard-sided shipping containers. The cartridges are stored in a "clean" freezer at 4 degrees Celsius for no more than four weeks before analysis.

- For VOCs, SUMMA® canisters are separated from their flow controllers, inlets are capped, and the cans are re-packed in their shipping box. For multisorbent tubes, exposed cartridges are capped with swage locks and placed in glass vials. Upon packing with bubble wrap, samplers are packaged with ice packs and secured in hard-sided shipment coolers.

- For bioaerosols, the samples are stored in well-insulated boxes. They must be received at the laboratory within 24 hours following collection. Sample incubation begins as soon as possible after receipt at the laboratory. Slides used for collecting fungal spores are secured in slide containers prior to overnight delivery.

- For radon, overnight Thursday shipment is required.

Samples will be sent directly to the analyzing laboratory from the field. A Chain-of-Custody/Sample Tracking List will be included with each shipment. Receipt of the samples will require visual inspection of each sample for damage and appropriate notations made on the Chain-of-Custody/Sample Tracking List followed by proper storage.

7.1.2 Management of Real-Time Monitoring Data

Real-time sample data will consist of electronic computer files generated by downloading recorded data from dataloggers. Real-time samples will be collected at fixed-site locations with stationary monitors. A unique alphanumeric identification code will be assigned to each sample collected. These identification codes will indicate the type of sample (CO, CO_2, etc.), the building being sampled, the sampling location, and sample type (mobile, fixed, duplicate, and monitoring time). A Fixed Site Monitoring Log and a Portable Monitoring Log will be used to record pertinent information. The Fixed Site Monitoring Log will document sampling locations, start and stop times, monitor IDs, and data filenames for stored data. The Portable Monitoring Log will document the locations sampled and the time of sampling at each location. This information will be used in conjunction with the datalogger information to assign location identifications to the concentrations recorded by the datalogger. This log will also document the monitor IDs and data filenames.

At the end of the monitoring period, the dataloggers will be downloaded to a portable computer using the appropriate interfacing hardware and program software. The datalogger software will prompt the necessary entry information. In general, the datalogger start time, monitor ID, input channel, monitoring location, sample ID, and operator ID will be entered. The data will be viewed on the computer screen to verify successful downloading. Once verified, a unique filename will be assigned and the data saved under that filename. The filename will be recorded on the appropriate monitoring log. Verification of the file's existence will be checked by viewing the file listing. Backup files will be copied to diskettes to protect against loss of data due to computer failure. The dataloggers will not be turned off until all data have been successfully retrieved, saved, backed up, and reviewed by the field team leader to check for completeness and reasonableness. Diskettes will be labeled and delivered to the field team leader. Data that does not appear reasonable will be flagged by the field team leader using the Fixed Site Monitoring Log so that further review can be conducted during the data validation process (Section 7.3). No data will be deleted from the downloaded file during the sampling week.

7.1.3 HVAC Measurement Data

HVAC measurement data will be entered onto appropriate logsheets and subsequently entered to an electronic file using a portable computer. All logsheets will be maintained in the building logbook. Within each file, the date of the test, the time of day, and the measurement location (e.g., air handler number, exhaust fan, diffuser) will be entered into the file. Each data file will be assigned a unique alphanumeric identification code. The identification code will indicate the measurement parameters (e.g., supply airflow rate), the building being sampled, and the sampling date and time (e.g., a.m. or p.m. for supply airflow rate). At the end of the day, the field team leader will review the files for reasonableness of the entries and for completeness. A backup file will be copied to a diskette to protect against the loss of data due to computer failure. Back-up diskettes will be labeled, as appropriate, and stored separately from the computer.

7.1.4 Building, Study Area(s), and HVAC Description Checklists

The information collected on the building and study area description and source information checklists and the HVAC system description checklists will be entered onto appropriate logsheets and subsequently entered into an electronic file using a portable computer. All logsheets will be maintained in the building logbook. Each data file will be assigned a unique alphanumeric identification code. The identification code will indicate the building, date and time, and the checklist. Prior to completion of activities at the building, the field team leader will review the file to check for reasonableness of entries and completeness. A backup file will be copied to a diskette.

7.1.5 Occupant Questionnaire

The on-site survey administrator will retrieve and process all occupant questionnaires on Thursday or Friday morning. Questionnaires will be turned in and compared to the distribution list. The survey administrator will attempt to retrieve all the questionnaires that were distributed, consistent with the rights of participants to refuse to complete the document.

Once questionnaires are retrieved, the survey administrator will verify that the questionnaires and informed consent documents have been separated and there is nothing that can link a participant's name with a questionnaire. Questionnaires will then be assigned an ID number. A chain-of-custody list with all questionnaire ID numbers will then be generated.

The questionnaires and original chain-of-custody list will be returned to the study team's data processing center using a commercial overnight delivery service. A copy of the chain-of-custody list should be sent separately. Documentation of chain-of-custody will be maintained throughout the shipping and processing of the questionnaires.

7.2 DATA REDUCTION

Data reduction procedures for each of the measurement parameters are given in Table 7-1. For real-time measurements, instrumental output is used directly. For integrated samples, results are generated from the calibration curve for the analytical instrument used to make the measurement. Measurement corrections are not made for zero offset, calibration drift, contamination of field blanks, or recovery on field controls.

For real-time measurements, data output will be reduced to five-minute averages for fixed site monitors. Integrated sample concentrations will be calculated by dividing measured mass by sample air volume. Quantitative results will be reported for measurements below the minimum quantitation level with a designation of -98. Measurements detected below the limit of detection will be designated as -97. Other coding designations shall be -99 (exceeding calibration standard), -96 (not applicable or incalculable), and -95 (sample voided by field team or analytical laboratory).

Table 7-1 Data Reduction Procedures

Parameter	Procedure
Air Temperature	Direct instrumental readout – 5-min. averages generated at four heights[a]
Relative Humidity	Direct instrumental readout – 5-min. averages generated[a]
CO_2	Direct instrumental readout – 5-min. averages generated[a]
CO	Direct instrumental readout – 5-min. averages generated[a]
Sound	Direct instrumental readout – 5-min. averages generated[a]
Illuminance	Direct instrumental readout – 5-min. averages generated[a]
Inhalable Particles	Filter weight after sampling minus filter weight before sampling divided by sample volume
VOCs	Measured mass on cartridges calculated using chromatographic peak areas and relative response factors generated during calibration. Sample concentration determined by dividing measured mass by sample volume
Aldehydes (formaldehyde and acetaldehyde)	Measured mass on cartridge calculated using chromatographic peak area and calibration curve for area vs. mass. Sample concentration determined by dividing measured mass by sample volume

CO2 carbon dioxide
CO carbon monoxide
VOC volatile organic compound

[a] For fixed site monitors, data will be recorded with the datalogger as 5-minute averages. For mobile monitoring sites, a single data point is recorded on log sheets after allowing sufficient time for instrument stabilization.

7.3 DATA VALIDATION

Data validation will begin in the field (at the building) and will continue in the laboratory and data center after the integrated samples have been analyzed. Data validation activities include actions completed: before the team leaves a building; by the supporting laboratories before shipping the data to the research organization; by the research organization quality assurance officer evaluating the entire building investigation data set; and by the EPA Project Officer.

7.3.1 Validation Required Before Leaving a Building

The field team leader will be responsible for the validation of the building data. In the field, various aspects of the monitoring and sample collection will be evaluated to assess the validity of the measurements. This evaluation consists of an assessment of the reasonableness of the data, determination of data completeness, and comparison to criteria defined for specific parameters, such as pump flow rates and real-time monitor calibrations. If data do not appear to be valid or do not meet validation criteria, they will be flagged and verified. Information and data completeness will be verified by the field team leader by reviewing the documentation collected and stored in the building logbook. Any information not collected should be collected prior to leaving the building. Reasonableness checks and evaluation criteria are summarized in Table 7-2. Note that some reasonableness criteria cannot be verified until results are received from the analytical laboratories.

Table 7-2 Reasonableness Checks and Criteria for Validating Data

Parameter	Collocated	Hourly Readings	Reasonable Data	Evaluation Criteria
Temperature	±2 °C	±5 °C	Indoor temperature range of 18 – 27 °C (65 – 80 °F) rarely exceeded	Verify calibration if temperature of meter differs from reference device by greater than ±2 °C; verify indoor environmental readings of <60 °F or >85 °F
Relative humidity	±5% RH	±10% RH	Varies by season and geographical region; rarely <20% or >80% indoors	Verify calibration if RH of meter differs from reference device by greater than ±10%; verify indoor environmental readings of <20% or >80%
Carbon dioxide	±50 ppm	±100 ppm	Ambient concentration is approximately 350 ppm; indoors concentrations of 350 to 900 ppm common; rarely above 1500 ppm	Verify calibration if meter reading differs from known concentration at any level by greater than ±150 ppm on final calibration or during zero and span checks; verify environmental readings if outdoors < indoors > 350 ppm
Carbon monoxide	±2 ppm	±3 ppm	National Ambient Air Quality Standard (NAAQS, 8-hour) of 9 ppm may occasionally be exceeded; early a.m. and late p.m. levels may be elevated	Verify calibration if meter reading differs from known concentration at any level by greater than ±2 ppm at final calibration or during zero and span checks; verify environmental readings if >15 ppm
Sound level	±5 dB	±10 dB	Expected levels in range of 30 to 100 dB in offices	Verify environmental readings of <30 dB or >100 dB
Illuminance	±20 lux	±50 lux	Expected levels in range of 20 to 2000 lux in offices	Verify environmental readings of <20 lux or >2000 lux.
$PM_{2.5}$	±10%	±15%	NAAQS for $PM_{2.5}$ (24-hour) is 65 µg/m^3	Verify samples >30 µg/m^3 $PM_{2.5}$ < PM_{10}
PM_{10}	±10%	±15%	NAAQS for PM_{10} (24-hour) is 150 µg/m^3	Verify samples >30 µg/m^3 $PM_{2.5}$ < PM_{10}
VOCs	individual ± 20%sum ± 20%	individual ± 100%sum ± 50%	Concentrations of individual VOCs rarely exceed 50 µg/m^3 indoors; sum of VOC generally less than 5 mg/m^3 indoors	Verify data for individual VOCs >100 µg/m^3 or sum of VOC >5 mg/m^3
Formaldehyde	±20%	±100%	Concentrations of 100 ppb generally not exceeded except in new or recently remodeled building areas	Verify samples >100 ppb HCHO
Bioaerosols Fungi/ Mesophilic Bacteria/ Thermophilic Bacteria	individual species ± 25% CFU	individual species ± 50%CFU	In the absence of indoor sources, the same species are usually identified indoors and out. Indoor concentrations are usually less than outdoor concentrations. Total CFU concentrations do not generally exceed 1,000 CFU/m^3	Verify samples where In>Out. Verify samples where total concentration exceed 1,000 CFU/m^3

Table 7-2 Continued

Parameter	Collocated	Hourly Readings	Reasonableness Data	Evaluation Criteria
Formaldehyde	± 20%	± 100%	Concentrations of 100 ppb generally not exceeded except in new or recently remodeled building areas	Verify samples >100 ppb HCHO
Bioaerosols Fungi/ Mesophilic Bacteria/ Thermophilic Bacteria	individual species ± 25% CFU	individual species ± 50%CFU	In the absence of indoor sources, the same species are usually identified indoors and out. Indoor concentrations are usually less than outdoor concentrations. Total CFU concentrations do not generally exceed 1,000 CFU/m^3	Verify samples where In>Out. Verify samples where total concentration exceed 1,000 CFU/m^3
Radon			U.S. EPA guideline is 4 pCi/L. Concentrations may exceed 20 pCi/L in selected geographic regions. Concentrations on upper floors should generally be lower than on the ground contact floor.	Verify samples >4 pCi/L
Pump airflow rates				Verify if airflow rates at end of day differ by greater than ±10% from starting flow rates
Duct airflow rates			Compare to design specifications	Verify environmental data if measurement differs from specification by greater than ±30%
Supply air temperature			Compare to design specifications	Verify calibration if temperature of meter differs from reference device by greater than ±2 °C; verify indoor environmental readings of <60 °F or >85 °F
Supply air relative humidity			Related to outdoor air RH, indoor air RH, percent outdoor air supply, and percent recirculation	Verify calibration if RH of meter differs from reference device by greater than ±10%; verify indoor environmental readings of <20% or >80%
Exhaust fan airflow rate			Compare to design specifications	Verify environmental data if measurement differs from design specification by greater than ±30%
Diffuser supply airflow rate			Compare to design specifications	Verify environmental data if measurement differs from design specification by greater than ±30%

Table 7-2 Continued

°C	degrees Celsius
°F	degrees Fahrenheit
RH	relative humidity
ppm	parts per million
dB	decibels
$PM_{2.5}$	inhalable particles with an aerodynamic diameter less than or equal to 2.5 microns
PM_{10}	inhalable particles with an aerodynamic diameter less than or equal to 10 microns
$\mu g/m^3$	micrograms per cubic meter
mg/m^3	milligrams per cubic meter
VOC	volatile organic compound
ppb	parts per billion
HCHO	formaldehyde
CFU	colony forming units
CFU/m^3	colony forming units per cubic meter
pCi/L	picocuries per liter

On Thursday, the Field Team Leader will conduct an inventory of the building study data to ensure completeness of data collection. The continuous monitor data will also be reviewed to ensure that the data fall within the reasonableness checks reflected in Table 7-2. Data completeness and data review should be conducted on Thursday night so that any questionable or missing data can be reviewed and updated as appropriate to include narrative statements supporting the out-of-expected-range values.

In-field data validation for integrated samples will also include the following checks on data quality:

- Within-control analytical conditions will be verified and data generated under conditions judged to be out-of-control will be noted.

- The mechanism used to transmit raw data from the analyst to the individual responsible for their quantitation, compilation, and batching will be reviewed.

- The concentration calculations of a random subset (10%) of the raw data will be re-calculated. This will consist of re-entering the input data on computer programs used originally for this purpose.

Prior to transmitting data to the research organization study team leader, the field team leader shall review all of the entered field and analytical data to assess the reasonableness of the data being reported. The cause for missing data will be investigated and reported quantitation limits will be verified. After data entry, all of the keyed material will be summarized on a control file printout. This will provide information regarding the completeness of the file and will indicate samples that were scheduled for collection, but for which there are no data.

7.3.2 Validation Required By the Supporting Laboratories

The analysis team leader will be responsible for the validation of the results of environmental analysis. These checks include ensuring appropriate chain-of-custody documentation, acceptable calibration and control sample analysis, and other procedures employed by the research organization to ensure high quality data are reported. The analysis team leader will also ensure that the results of analysis are submitted to the study team leader in the appropriate electronic and hardcopy formats. The required templates for each type of sample are provided in Tables 7-3 through 7-12.

7.3.3 Validation Required by the Research Organization Quality Assurance Officer and Study Team Leader

The research organization quality assurance officer and study team leader will review all of the building study data following the field and laboratory validation steps. They will ensure the validity, completeness, reasonableness, and appropriate formatting of the entire data set. This validation process should ensure that all of the data fall within the expected ranges reflected in Table 7-2 or that explanations are provided when the data fall outside these expected ranges.

As shown in Table 7-2, the reasonableness of measurements with real-time monitors for temperature, relative humidity, CO, and CO_2 can be evaluated on a continuing basis by comparison to expected readings. For example, the National Ambient Air Quality Standard (eight-hour) for CO of 9 parts per million (ppm) may be exceeded in some areas of the country, but both indoor and outdoor concentrations are usually below 9 ppm. Data for CO can also be evaluated by comparing indoor and outdoor levels, which are usually similar unless there is a significant source (e.g., an attached parking garage) contributing to indoor levels. For CO_2, guidelines for reasonableness of data are also presented in Table 7-2. If elevated levels of CO or CO_2 are detected indoors, the reasonableness of the readings can be verified by comparison to other monitors indoors and/or outdoors.

For temperature, relative humidity, CO, CO_2, light, and sound level, Table 7-2 also presents evaluation criteria for monitor performance that will be used to verify data. The criteria apply to both daily zero and span checks for CO and CO_2 and to the calibration checks performed at the end of the two days of monitoring. If the criteria for CO and CO_2 are not met during a zero and span check, the meter reading should be checked at different concentration levels to determine if the problem is related to the monitor or the calibration gas.

Concentrations of VOCs, formaldehyde, $PM_{2.5}$, PM_{10}, and radon should be compared to reasonable levels expected in office building environments. As indicated in Table 7-2, when extremely high values that may be outliers are measured, acceptable performance for the measurement system should be verified immediately and documented. The reason for the elevated levels should be investigated.

7.3.4 Submitting Data to the EPA Project Officer

Data will be delivered to the EPA Project Officer after it has been fully evaluated and verified by the research group. The validated data (including field data, results data, building characteristic data, questionnaire responses, etc.) will be processed and saved in the database system specifically developed for the study. The data set should not include voided data, unvalidated data, flow checks or spans, or other unexplained data variables. Results of data that have been voided shall be removed and replaced with the appropriate code used for this purpose. The submittal of data to EPA will be based on the submittal requirements of the EPA Project Officer. This may be on a building-by-building basis, or on a study season basis if multiple building are studied consecutively.

7.3.5 Validation by the EPA Project Officer

One the dataset is received by EPA, the EPA Project Officer conduct a final validation and verification check on the data. The EPA Project Officer will validate the acceptability of the electronically transferred data and report findings to the research group.

Table 7-3 Format for the Submission of Particle Samples (PM_{10}, $PM_{2.5}$)

BUILDING EVENT CODE	*XXXXXX*	Date					
# SAMPLES IN THIS SET	*XX*	Initials					
-95 – SAMPLE VOIDED BY LAB							
-96 – SAMPLE NOT ANALYZED							
-97 – < MINIMUM DETECTION LIMIT							
-98 – < MINIMUM QUANTITATION LIMIT							
-99 – > HIGHEST CALIBRATION STANDARD							
LAB QUANT LMTS (THIS SAMPLE SET)		DET LMT (µg)					
		XXXX					
SPECIES							
PARTICULATES							
SAMPLE ID #	**LAB ID #**	**VOLUME (m^3)**	**TARE WEIGHT (mg)**	**FINAL WEIGHT (mg)**	**NET WEIGHT (µg)**	**EPA STD CONC (µg/m^3)**	**COMMENTS**
XXPPMXXXX							
XXPPMXXXX							

Table 7-4 Format for the Submission of Radon Samples			
BUILDING EVENT CODE	*XXXXXX*	Date	
# SAMPLES IN THIS SET	*XX*	Initials	
-95 – SAMPLE VOIDED BY LAB			
-96 – SAMPLE NOT ANALYZED			
-97 – < MINIMUM DETECTION LIMIT			
-98 – < MINIMUM QUANTITATION LIMIT			
-99 – > HIGHEST CALIBRATION STANDARD			
LAB QUANT LMTS (THIS SAMPLE SET)		DET LMT (pCi/L)	
		XXXX	
SPECIES			
Radon			
SAMPLE ID #	**LAB ID #**	**Radon Activity (pCi/L)**	**COMMENTS**
XXRADXXXX			
XXRADXXXX			

Table 7-5 Format for the Submission of Aldehyde Samples

BUILDING EVENT CODE	*XXXXXX*	Date			
# SAMPLES IN THIS SET	*XX*	Initials			
-95 – SAMPLE VOIDED BY LAB					
-96 – SAMPLE NOT ANALYZED					
-97 – < MINIMUM DETECTION LIMIT					
-98 – < MINIMUM QUANTITATION LIMIT					
-99 – > HIGHEST CALIBRATION STANDARD					
LAB QUANT LMTS (THIS SAMPLE SET)					
GC/MS Target Compound	**CAS NO**	**DET LMT (µg)**	**QUANT LMT (µg)**		
FORMALDEHYDE	50-00-0	*XXX.XX*	*XXX.XX*		
ACETALDEHYDE	75-07-0	*XXX.XX*	*XXX.XX*		
SAMPLE ID NUMBER	*XXALDXXXX*				
LABORATORY ID NUMBER	*XXXXXXXXXXX*				
TOTAL VOLUME (CUBIC METERS)					
GC/MS Target Compound	**CAS NO**	**MASS (µg)**	**EPA STD CONC (µg/m^3)**	**EPA STD CONC (ppb)**	**COMMENTS**
FORMALDEHYDE	50-00-0	*XXX.XX*	*XXX.XX*	*XXX.XX*	
ACETALDEHYDE	75-07-0	*XXX.XX*	*XXX.XX*	*XXX.XX*	

Table 7-6 Format for the Submission of Volatile Organic Compound Samples*

BUILDING EVENT CODE								
SAMPLE ID NUMBER *XXCANXXXX*								
LAB ID NUMBER								
TOTAL STP VOLUME (m3)								
GC/MS Target Compounds	**Net (ng/sample)**	**Sample Concentration ($\mu g/m^3$)**	**LOQ** ($\mu g/m^3$)**	**LOD*** ($\mu g/m^3$)**	**Sample Concentration (ppb)**	**LOQ (ppb)**	**LOD (ppb)**	**Comments**
Dichlorodifluoromethane								
Chloromethane								
Vinyl chloride								
Bromomethane								
Chloroethane								
Acetone								
Trichlorofluoromethane								
Methylene chloride								
Trichlorotrifluoroethane								
Carbon disulfide								
t-butyl methyl ether								
2-butanone (Methyl-ethyl-ketone (MEK))								
3-methyl pentane								
Ethyl acetate								
Chloroform								
1,2-dichloroethane								
1,1,1-trichloroethane								
Benzene								
Carbon tetrachloride								
Trichloroethene								
4-methyl-2-pentanone								
Dimethyl disulfide								
Toluene								
Butyl acetate								

Table 7-6 Continued

GC/MS Target Compounds	Net (ng/sample)	Sample Concentration ($\mu g/m^3$)	LOQ** ($\mu g/m^3$)	LOD*** ($\mu g/m^3$)	Sample Concentration (ppb)	LOQ (ppb)	LOD (ppb)	Comments
n-octane								
1,2-dibromoethane								
Tetrachloroethene								
Chlorobenzene								
Ethylbenzene								
m & p-xylenes								
Styrene								
Nonane								
o-xylene								
4-ethyltoluene								
a-pinene								
1,3,5-trimethylbenzene								
n-decane								
1,2,4-trimethylbenzene								
1,4-dichlorobenzene								
d-limonene								
1,2-dichlorobenzene								
n-undecane								
n-dodecane								
Naphthalene								
TVOC (other)								
1-butanol								
Pentanal								
Hexanal								
2-butoxyethanol								
2-ethyl-1-hexanol								

Table 7-6 Continued

GC/MS Target Compounds	Net (ng/sample)	Sample Concentration ($\mu g/m^3$)	LOQ** ($\mu g/m^3$)	LOD*** ($\mu g/m^3$)	Sample Concentration (ppb)	LOQ (ppb)	LOD (ppb)	Comments
n-nonanal								
Phenol								
4-phenylcyclohexene								
2,2,4-trimethyl-1,3-pentanediol monoisobutyrate								
Butylated hydroxytoluene								
2,2,4-trimethyl-1,3-pentanediol diisobutyrate								
n-hexane								

* This table includes the most recent VOC compound list used for EPAs BASE Study. Some modifications were made to this list throughout the course of the study. Other compounds analyzed for during the study include the following:

Dichlorotetrafluoroethane, 1,3-butadiene, 2-propanol, Ethanol, n-heptanal, 2-methyl-1-propanol, Hexachlorobutadiene, Benzyl chloride, 1,3-dichlorobenzene, 1,2,4-trichlorobenzene, Trans-1,3-dichloropropene, 1,1,2-trichloroethane, Cis-1,3-dichloropropene, 1,2-dichloropropane, 1,1-dichloroethane, Cis-1,2-dichloroethene, 1,1-dichloroethene (Vinylidene chloride)

** Limit of quantitation for the compound

*** Limit of detection for the compound

Table 7-7 Format for the Submission of Airborne Fungi Samples

BUILDING EVENT CODE		
SAMPLE ID NUMBER *XXFUNXXXX*		
LAB ID NUMBER		
SAMPLE VOLUME Volume (m^3)		
DETECTION LIMIT (2 minute sample)		
DETECTION LIMIT (5 minute sample)		
TOTAL CFU/PLATE *XXX*		
Organisms	**Total CFU/m^3**	**Comments**
ACREMONIUM		
ALTERNARIA		
ARTHROSPORES		
ASPERGILLUS OTHER		
ASPERGILLUS FLAVUS		
ASPERGILLUS FUMIGATUS		
ASPERGILLUS GLAUCUS		
ASPERGILLUS NIGER		
ASPERGILLUS OCHRACEUS		
ASPERGILLUS VERSICOLOR		
AUREOBASIDIUM		
BOTRYTIS		
CLADOSPORIUM		
COELOMYCETES		
CUNNINGHAMELLA		
CURVULARIA		
DRECHSLERA		
EPICOCCUM		
FUSARIUM		
NON-SPORULATING		
PAECILOMYCES		
PENICILLIUM		
PERICONIA		
PESTALOTIA		
PITHOMYCES		
RHINOCLADIELLA-LIKE		
TOTAL		
TRICHODERMA		
ULOCLADIUM		
UNKNOWN		
WALLEMIA		
YEAST		
ZYGOMYCETES		

Table 7-8 Format for the Submission of Airborne Bacteria Samples

BUILDING EVENT CODE		
SAMPLE ID NUMBER *XXFUNXXXX*		
INCUBATION TEMPERATURE (C)		
LAB ID NUMBER		
SAMPLE VOLUME Volume (m^3)		
DETECTION LIMIT (2 minute sample)		
DETECTION LIMIT (5 minute sample)		
TOTAL CFU/PLATE *XXX*		
Organisms	**Total CFU/m^3**	**Comments**
Gm+ cocci		
Gm- cocci		
Gm+ rods		
Gm- rods		
Bacillium*		
Actinius*		
Unknown*		

* Thermophilic organisms reported

Table 7-9 Format for the Submission of Bulk Fungi Samples

BUILDING EVENT CODE		
SAMPLE ID NUMBER *XXBULXXXX*		
LAB ID NUMBER		
SAMPLE WEIGHT (g)		
DILUENT VOLUME (mL)		
DILUENT FACTOR		
DETECTION LIMIT (CFU/g)		
TOTAL CFU/PLATE *XXX*		
Organisms	**Total CFU/g**	**Comments**
ACREMONIUM		
ALTERNARIA		
ARTHROSPORES		
ASPERGILLUS OTHER		
ASPERGILLUS FLAVUS		
ASPERGILLUS FUMIGATUS		
ASPERGILLUS GLAUCUS		
ASPERGILLUS NIGER		
ASPERGILLUS OCHRACEUS		
ASPERGILLUS VERSICOLOR		
AUREOBASIDIUM		
BOTRYTIS		
CLADOSPORIUM		
COELOMYCETES		
CUNNINGHAMELLA		
CURVULARIA		
DRECHSLERA		
EPICOCCUM		
FUSARIUM		
NON-SPORULATING		
PAECILOMYCES		
PENICILLIUM		
PERICONIA		
PESTALOTIA		
PITHOMYCES		
RHINOCLADIELLA-LIKE		
TOTAL		
TRICHODERMA		
ULOCLADIUM		
UNKNOWN		
WALLEMIA		
YEAST		
ZYGOMYCETES		

Table 7-10 Format for the Submission of Bulk Bacteria Samples		
BUILDING EVENT CODE		
SAMPLE ID NUMBER *XXFUNXXXX*		
INCUBATION TEMPERATURE (C)		
LAB ID NUMBER		
SAMPLE WEIGHT (g)		
DILUENT VOLUME (mL)		
DILUENT FACTOR		
DETECTION LIMIT (CFU/g)		
TOTAL CFU/PLATE *XXX*		
Organisms	**Total CFU/m^3**	**Comments**
Gm+ cocci		
Gm- cocci		
Gm+ rods		
Gm- rods		
Bacillium*		
Actinius*		
Unknown*		
* Thermophilic organisms reported		

Table 7-11 Format for the Submission of Antigen Samples

BUILDING EVENT CODE	*XXXXXX*	Date				
# SAMPLES IN THIS SET	*XX*	Initials				
-95 - SAMPLE VOIDED BY LAB						
-96 - SAMPLE NOT ANALYZED						
-97 - < MINIMUM DETECTION LIMIT						
-98 - < MINIMUM QUANTITATION LIMIT						
-99 - > HIGHEST CALIBRATION STANDARD						
LAB QUANT LMTS (THIS SAMPLE SET)		Dermatoph-agoides Farinae (µg/g)	Dermatoph-agoides Pteronyssinus (µg/g)	Feline Domesticus (µg/g)		
		XXXX	*XXXX*	*XXXX*		
SPECIES						
Antigens						
SAMPLE ID #	**LAB ID #**	**WEIGHT (g)**	**Dermatoph-agoides Farinae (µg/g)**	**Dermatoph-agoides Pteron-yssinus (µg/g)**	**Feline Domesticus (µg/g)**	**COMMENTS**
XXBULXXXX						
XXDUSXXXX						

Table 7-12 Format for the Submission of Airborne Spore Samples

BUILDING EVENT CODE		
SAMPLE ID NUMBER *XXBURXXXX*		
LAB ID NUMBER		
SAMPLE VOLUME Volume (m^3)		
DETECTION LIMIT (4 minute sample)		
TOTAL RAW SPORE COUNT *XXX*		
BACKGROUND DEBRIS		
Organisms	**Total Spores/m^3**	**Comments**
Alternaria		
Arthrinium		
Ascospores		
Aureobasidium pullulans		
Basidiospores		
Botrytis		
Chaetomium		
Cladosporium		
Curvularia		
Drechslera / Bipolaris group		
Epicoccum		
Fusarium		
Myrothecium		
Nigrospora		
Other colorless		
Penicillium / Aspergillus types		
Pithomyces		
Rusts		
Smuts, Periconia, Myxomycetes		
Stachybotrys		
Stemphyllium		
Torula herbarum		
Total		
Ulocladium		
Unknown		
Zygomycetes		

APPENDIX A

CHECKLISTS FOR CHARACTERIZATION OF THE WHOLE BUILDING, THE STUDY AREA(S), AND THE STUDY AREAS(S) HVAC SYSTEM

The checklists presented in the table below are used for collecting data on the whole building and on the building test space. The data collected using these checklists are entered into the Indoor Air Data Collection System (IADCS) software. Instructions for completing each individual checklist are provided in Appendix A at the beginning of each respective checklist.

Form	Title
Form A Instructions	Checklist Instructions: Whole Building Description
Checklist A-1	Building Description Checklist
Checklist A-2	Source Information Checklist
Form B Instructions	Checklist Instructions: Test Space Description
Checklist B-1	Test Space Description Checklist
Checklist B-2	Test Space Source Information Checklist
Form C Instructions	Checklist Instructions: Test Space HVAC System Description
Checklist C-1	Central Air Handling and Distribution System
Checklist C-2	Perimeter Zone Units
Checklist C-3	Unitary Systems
Checklist C-4	Evaporative Cooling Systems
Checklist C-5	Outdoor Air Intake Control
Checklist C-6	Natural Ventilation Systems
Checklist C-7A	Air Handler Specifications
Checklist C-7B	Exhaust Fan Specifications
Checklist C-8	Filtration and Air Cleaning Systems
Checklist C-9	Air Washers
Checklist C-10	Humidification Systems
Checklist C-11	Maintenance
Checklist C-12	Inspection

CHECKLIST INSTRUCTIONS: WHOLE BUILDING DESCRIPTION

The whole building description employs the following two forms:

- Form A-1, BUILDING DESCRIPTION
- Form A-2, SOURCE INFORMATION

One copy of each form must be filled out for each building.

FORM A-1 BUILDING DESCRIPTION

Form A-1 is used to obtain information on the whole building, including space use, occupancy, climate and site, building equipment, and the building envelope. This information is acquired by examining the building plans, conducting a building walk-through and speaking with the building owner, manager, and operator. This information can generally be collected during the building preliminary visit, and can be verified by the field team during the study week. The entries on the form are to be completed as follows:

1. **Building Age:** Enter the year that the building construction was completed. If there is a question as to when construction was complete, enter the year that the building was first occupied. If the building was constructed in phases, enter the year in which the first phase was completed. This value should be obtained from the building owner or manager.

2. **Latest Building Addition:** Enter the year in which the last major renovation or addition occurred. A major renovation might include the addition of a new wing or new floors on an existing structure.

3. **Gross Floor Area:** Enter the total floor area of the building, including the space on all floors enclosed by the exterior walls. This value is comprised of the total area within the building footprint, including all parking areas integral to building structure. Do not correct for the building core, interior walls or columns. This value can be estimated from the building plans or obtained from the building owner or manager.

4. **Occupied Floor Area:** Enter the occupied floor area of the building. *Occupied floor area* includes only that space which is currently occupied. This value should exclude mechanical rooms, utility closets, stairwells, elevator shafts, janitorial closets, common hallways, atriums, restrooms, currently vacant office space, etc. This value can be estimated from the building plans or obtained from the building owner or manager.

5. **Number of Floors Below Grade:** Enter the number of building floors that are below grade.

6. **Number of Floors Above Grade:** Enter the number of building floors that are above grade.

Space Usage

7. **Activity Category:** Enter the primary and secondary activity category for each floor within the building using the activity categories described below.

• Office	This category includes open and private office space and other spaces associated with general office activities, including conference rooms.
• Foyer/Reception	
• Retail	This category includes commercial establishments, such as retail stores and restaurants.
• Vacant	This category includes vacant space. This category need not be limited to vacant office space.
• Assembly	This category includes large meeting rooms and auditoriums.
• Multi-use	
• Laboratory	
• Storage	
• Food Services	This category includes kitchens and cafeterias, excluding food preparation areas used by employees.
• Mechanical	
• Packing/Shipping	
• Parking	This category includes indoor parking areas.
• Other	

Building Occupancy

8. **Number of Occupants:** Enter the number of people (including visitors) that normally occupy the building. This value should be obtained from the building owner or manager.

9. **Days per Week Building is Occupied:** Enter the number of days per week that the building is substantially occupied. This value should not include days that the building has only minimal (less than 25%) occupancy and should be obtained from the building owner or manager.

10. **Hours per Day Building is Occupied (WEEKDAYS):** Enter the number of hours that the building is at 25% or more of full occupancy on weekdays. This value should be obtained from the building owner or manager.

11. **Hours per Day Building is Occupied (WEEKEND DAYS):** Enter the number of hours that the building is at 25% or more of full occupancy on weekends. This value should be obtained from the building owner or manager.

Climate and Site

12. **Heating Degree Days:** Enter the average number of heating degree days for the building location. This value can be obtained from the nearest station of the National Weather Service and a variety of references including meteorological manuals. Designate the units, either C-Days or F-Days.

13. **Cooling Degree Days:** Enter the average number of cooling degree days for the building location. This value can be obtained from the nearest station of the National Weather Service and a variety of references including meteorological manuals. Designate the units, either C-Days or F-Days.

14. **Winter Design Dry-bulb Temperature (99%):** Enter the 99% value of the winter design dry-bulb temperature for the building location. This value can be obtained from the American Society of Heating, Refrigerating, and Air-Conditioning Engineers,

Inc. (ASHRAE) Handbook of Fundamentals (Chapter on Weather Data). Designate the units, either C or F.

15. **Summer Design Dry-bulb Temperature (1%):** Enter the 1% value of the summer design dry-bulb temperature for the building location. This value can be obtained from the ASHRAE Handbook of Fundamentals (Chapter on Weather Data). Designate the units, either C or F.

16. **Summer Design Wet-bulb Temperature (1%):** Enter the 1% value of the summer design wet-bulb temperature for the building location. This value can be obtained from the ASHRAE Handbook of Fundamentals (Chapter on Weather Data). Designate the units, either C or F.

17. **Site Characterization**: Check the category that best characterizes the building site. The distinction between urban, suburban, and rural is straightforward, with urban referring to the core of the city, not simply to the incorporated area. Within the categories of urban and suburban, the three subcategories describe the dominant influence within a 1 kilometer (km) radius of the site and are defined as follows:

    - Industrial: Product-oriented establishments, such as manufacturing and utilities.
    - Commercial: Service-oriented establishments, such as retail establishments, restaurants, and shopping centers.
    - Residential: Because most areas include some residential use, this category is used in the absence of a dominating industrial or commercial influence.

    Within the category of rural, the four subcategories describe the dominant influence within a 1 km radius of the site and are defined as follows:

    - Near Urban: Essentially a rural area that is close enough to a major urban center as to be affected by the urban area.
    - Agricultural: Including orchards, crop raising, and livestock grazing.
    - Industrial: Product-oriented establishments, such as manufacturing and utilities.
    - Commercial: Service-oriented establishments, such as retail establishments, restaurants, and shopping centers.

Building Equipment

18. **Building Ventilation (Natural or Mechanical):** Enter whether the building is ventilated naturally or mechanically. Natural ventilation includes any un-powered ventilation system including operable windows, ventilation shafts, intentional ventilation openings in walls and envelope leakage. The existence of isolated mechanical exhaust fans does not disqualify such a building from the natural ventilation category. A mechanically ventilated building employs a powered system to bring outdoor air into the building, even if it also contains some natural ventilation elements as well.

19. **Cooling Systems:** Enter “yes” if the building is air-conditioned and “no” if it is not. For each equipment type listed, enter whether this system is primary, secondary, or other. Note that more than one of the equipment categories may exist in the building.

20. **Heating System:** Enter “yes” if the building is equipped with heating systems and “no” if it is not. For each equipment type listed, enter whether this system is primary, secondary, or other. Note that more than one of the equipment categories may exist in the building.

Operating Schedule

21. **Space Conditioning Days per WEEKDAY:** Enter the number of days per week (on weekdays) that the building space-conditioning equipment is operated. This value should be obtained from the building owner, manager, or operator.

22. **Space Conditioning Hours per WEEKDAY:** Enter the number of hours per day (on weekdays) that the building space-conditioning equipment is operated. This value should be obtained from the building owner, manager, or operator.

23. **Space Conditioning Days per WEEKEND DAY:** Enter the number of days per week (on weekend days) that the building space-conditioning equipment is operated. This value should be obtained from the building owner, manager, or operator.

24. **Space Conditioning Hours per WEEKEND DAY:** Enter the number of hours per week (on weekend days) that the building space-conditioning equipment is operated. This value should be obtained from the building owner, manager, or operator.

25. **Ventilation System Operation Days per WEEKDAY:** Enter the number of days per week (on weekdays) that the building ventilation equipment is operated. This value should be obtained from the building owner, manager, or operator.

26. **Ventilation System Operation Hours per WEEKDAY:** Enter the number of hours per day (on weekdays) that the building ventilation equipment is operated. This value should be obtained from the building owner, manager, or operator.

27. **Ventilation System Operation Days per WEEKEND DAY:** Enter the number of days per week (on weekend days) that the building ventilation equipment is operated. This value should be obtained from the building owner, manager, or operator.

28. **Ventilation System Operation Hours per WEEKDAY:** Enter the number of hours per week (on weekend days) that the building ventilation equipment is operated. This value should be obtained from the building owner, manager, or operator.

Building Envelope

29. **Exterior Wall Construction:** Enter the construction of the exterior walls of the building, selecting from the following options:

    - Glass and metal curtain wall
    - Masonry
    - Precast concrete panels
    - Stone panels
    - Exterior insulation finish system
    - Siding on frame construction
    - Metal building system
    - Other

Indicate whether the construction selected is primary, secondary, or other. More than one of the wall construction categories may apply in the building. If the wall construction is not listed, it can be described in the constriction category named “OTHER."

30. **Roof Construction:** Enter the construction of the roof of the building, selecting from the following options:

    - Built-up roof
    - Single ply membrane
    - Inverted membrane
    - Shingles
    - Metal
    - Other

    Indicate whether the construction selected is primary, secondary, or other. More than one of the roof construction category may apply in the building. If the roof construction is not listed, it can be described in the construction category named “OTHER."

31. **Glazing Elements:** Enter whether the windows are single, double, or triple pane.

32. **Operable Windows:** Enter “yes” or “no,” as to whether the building has operable windows.

33. **Percentage of Operable Windows:** Enter the percentage of operable windows.

34. **Shading Elements:** Enter “yes” or “no,” to whether the windows are equipped with shading elements.

35. **Percentage of Windows with Shading Elements:** Enter the percentage of windows equipped with shading elements, such as overhangs, window treatments, or shades.

HVAC Control Systems

36. **HVAC Control Implementation:** For heating, ventilating, and air-conditioning (HVAC) controls, select the control system types that best describe the building control system, pneumatic, low-voltage analog electric, or direct-digital. Select whether these systems are Primary (P), Secondary (S), or Other (O).

37. **HVAC Control Response Strategy:** Enter the response strategy for the building control system, two-position, proportional, floating point, proportional-integral, and proportional-integral derivative. Select whether these strategies are Primary (P), Secondary (S), or Other (O).

FORM A-2 BUILDING SOURCE INFORMATION

This form is used to obtain information related to sources of indoor and outdoor pollutants that may impact the building. This information is acquired through a combination of a building walk-through and discussions with the building owner, manager and operator. This information can generally be collected during the building preliminary visit, and can be verified by the field team during the study week. The entries on the form are to be completed as follows:

Outdoor Contaminant Sources

Note whether each of the following sources exist in the immediate vicinity of the building. The source need not be proximate to the outdoor air intake.

1. **Garbage Dumpsters**

2. **Power Plants:** A positive response indicates the existence of a power plant including electricity or steam generation.

3. **Heavy Motor Vehicle Traffic:** A positive response indicates the existence of heavy traffic during at least part of the day. It need not be heavy all day long.

4. **Construction Activities:** A positive response indicates the existence of building construction on nearby building sites, including new construction, renovation, and demolition.

5. **Emergency Generators:** A positive response indicates the existence of emergency electricity generators, even if they are generally inactive.

6. **Industrial Stacks:** A positive response indicates the existence of industrial stacks from industrial facilities.

Smoking Policies

Information on smoking policies can be obtained by the building owner or manager.

7. **Smoking Permitted in Building:** Enter “yes” if smoking is permitted anywhere in the building and “no” if smoking is not allowed.

8. **Smoking permitted in entire building:** Enter “yes” if smoking is permitted throughout the entire building and “no” if smoking is permitted only in specific locations.

9. **Restricted to Private Offices:** Enter “yes” if smoking is restricted within the building except for private offices and “no” if smoking is not allowed in private offices.

10. **Restricted to Indoor Smoking Areas:** Enter “yes” if smoking is restricted within the building except for designated smoking areas (including designated restrooms). Enter “no” if indoor smoking areas do not exist.

11. **Restricted to Outdoor Smoking Areas:** Enter “yes” if smoking is allowed outside the building.

Water Damage

Information on water damage can be obtained from the building owner or manager.

12. **Past Occurrences:** Enter “yes” if there has been past water damage in the building.

13. **Location of Past Water Damage:** If water damage occurred in the past, enter the location from the list where water damage has occurred, i.e., basement, roof, mechanical, or occupied space. If the water damage occurred in the occupied space, enter the floor where damage occurred.

14. **Current Water Damage:** Enter “yes” if there is currently water leakage or visible water damage within the building.

15. **Location of Current Water Damage:** If current water damage or water leaks are present, enter the location from the list where this is occurring, i.e., basement, roof, mechanical, or occupied space. If it is occurring in the occupied space, enter the floor where it is occurring.

Fire Damage

Information on fire damage can be obtained from the building owner or manager.

16. **Past Occurrences:** Enter “yes” if there has been fire damage within the building.

17. **Date of Fire Damage:** If “yes,” enter the date that the damage occurred.

18. **Extent of Damage:** Enter whether the fire damage was building wide or whether the damage occurred in limited areas or floors of the building.

Building Renovations

This section describes the renovations, if any, that have occurred in the building during the past year. This information can be obtained from a building walk-through and from the building owner or manager.

Painting

19. **Painting:** Enter “yes” if there has been painting within the building within the last year.

20. **Continuous:** If the building has a continuous painting cycle (i.e., some part of the building is always undergoing painting), enter “continuous.” If painting is not implemented continuously, enter the both the location and date of each painting renovation.

Carpeting

21. **Carpeting:** Enter “yes” if there has been carpeting installed within the building within the last year.

22. **Continuous:** If the building has a continuous re-carpeting cycle (i.e., some part of the building is always undergoing re-carpeting), enter “continuous.” If re-carpeting is not implemented continuously, enter the both the location and date of each carpeting renovation.

Roofing

23. **Roofing:** Enter “yes” if there has been re-roofing implemented within the building within the last year.

24. **Continuous:** If the building has a continuous re-roofing cycle (i.e., some part of the building is always undergoing re-roofing), select “continuous.” If re-roofing is not implemented continuously, enter the both the location and date of each re-roofing renovation.

Furniture

25. **Furniture:** Enter “yes” if there has been new furniture installed within the building within the last year.

26. **Continuous:** If the building has a continuous new furniture installation cycle select "continuous." If new furniture is not installed continuously, enter the both the location and date of each new furniture installation.

Partition and Interior Wall Systems

27. Enter "yes" if there has been movement of partitions or interior walls within the building within the last year.

28. **Continuous:** If the building has a continuous partition or interior wall movement cycle, select "continuous." If partition or interior wall movement projects are not implemented continuously, enter the both the location and date of each project.

Cleaning Schedules

Information pertaining to cleaning schedules can be obtained from the building owner, manager, or operator.

29. **Office Cleaning:** Enter the frequency at which office cleaning is done. Note whether this cleaning is done during occupied hours, evenings, or weekends.

30. **Dry Mopping:** Enter the frequency at which dry mopping is done. Note whether dry mopping is done during occupied hours, evenings, or weekends.

31. **Wet Mopping:** Enter the frequency at which wet mopping is done. Note whether wet mopping is done during occupied hours, evenings, or weekends.

32. **Vacuuming:** Enter the frequency at which vacuuming is done. Note whether vacuuming is done during occupied hours, evenings, or weekends.

33. **Type of Vacuum Used:** If vacuuming is conducted, enter the type of vacuum used. These include standard vacuums and vacuums equipped with high efficiency particle air (HEPA) filtration.

Indoor Trash Storage

34. **Trash Storage:** Enter the locations within the building where trash is stored, other than temporarily during collection. Collect information of building floor and the location on each floor (i.e., occupied space, stairwell, freight elevator lobby, or loading dock).

Cleaning Materials

35. **Materials Used:** Select each cleaning material used in the building from the list. General descriptors include window cleaner, furniture cleaner, floor wax, bathroom cleaners, bleach, soap, and carpet cleaners.

36. **Inventory of Cleaning Materials:** Collect an inventory of all cleaning materials used in the building. This information should be collected by taking an inventory of each storage room within the building.

37. **Storage Location:** Enter the locations within the building where cleaning materials are stored. Appropriate information includes the building floor and where on the building floor cleaning materials are located, such as janitors closet or storage room.

Pest Control

Pest control information should be obtained from the building owner, manager, or facilities engineer.

38. **Exterior Application:** Enter the frequency of exterior pesticide application. Appropriate frequencies include weekly, monthly, semi-annually, etc.

39. **Date of Last Exterior Application Frequency:** Enter the date of the last exterior pesticide application.

40. **Interior Application**: Enter the frequency of interior pesticide application. Appropriate frequencies include weekly, monthly, semi-annually, etc.

41. **Date of Last Interior Application Frequency:** Enter the date of the last interior pesticide application.

42. **Interior Pesticide Application Location:** Enter the floors and locations within the building where pesticides are applied. Appropriate information includes the building floor and location such as occupied space, storage areas, and mechanical spaces.

43. **Pesticides Used:** Enter the name of the pesticides used both for interior and exterior applications.

44. **Pesticide Storage:** Enter whether pesticides are stored on-site within the building or whether pesticides are stored off-site.

45. **Storage Locations:** If pesticides are stored on-site, enter the floors and locations where pesticides are stored. Appropriate information includes the building floor and location such as occupied space, janitorial closet, or storage room.

Special Use Spaces (46 through 57)

Information regarding special use spaces should be obtained from the building owner, manager, or facilities engineer. For each of the categories, (smoking lounges through conference rooms) provide the following information:

Existence: Enter “yes” if the space use category exists in the building.

Floor and Space Ventilation: Enter the floor within the building where this space exists. Enter whether this special use space is equipped with its own dedicated ventilation system and dedicated exhaust system.

FORM A-1 BUILDING DESCRIPTION

One copy of Form A-l is completed for each building.

GENERAL BUILDING CHARACTERISTICS

1 Building Age (construction) ____________________

2 Latest Building Addition ____________________

3 Gross Floor Area ____________________ m^2 or ft^2

4 Occupied Floor Area ____________________ m^2 or ft^2

5 Number of Floors Below Grade ____________________

6 Number of Floors Below Grade ____________________

SPACE USE

7 **Activity Category**: Define as office, foyer/reception, retail, vacant, assembly, multi-use, laboratory, storage, food services, mechanical, parking, or other.

Floor Designation	Primary Activity Category	Secondary Activity Category	Comments

OCCUPANCY INFORMATION

8 Number of Occupants ____________________

9 Days Per Week Building is Occupied ____________________

10 Hours Per Day Building is Occupied (WEEKDAYS) ____________________

11 Hours Per Day Building is Occupied (WEEKEND DAYS) ____________________

CLIMATE INFORMATION

12 Heating Degree Days ____ (C-Day or F-day)

13 Cooling Degree Days ____ (C-Day or F-day)

14 Winter Design Drybulb Temperature (99%): ____ (C-Day or F-day)

15 Summer Design Drybulb Temperature (1%): ____ (C-Day or F-day)

16 Summer Design Wetbulb Temperature (1%): ____ (C-Day or F-day)

SITE INFORMATION

17 Site Characterization (check most representative)

Urban/Industrial		Suburban/Industrial	
Urban/Residential		Suburban/Residential	
Urban/Commercial		Suburban/Commercial	
Rural/Near Urban		Rural/Commercial	
Rural/Agricultural		Rural/Industrial	

BUILDING EQUIPMENT INFORMATION

18 Building Ventilation (natural or mechanical) ____

19 Building Equipped with Cooling System (yes/no) ____

For the mechanical systems listed below, indicate whether the system is "primary"(P), "secondary" (S), or "other"(O)

P/S/O	**Cooling Equipment**	**Comments**
_______	Chillers	________________________
_______	Packaged Air Conditioning Units	________________________
_______	Heat Pump	________________________
_______	Ducted Air Distribution	________________________
_______	Fan Coil Units	________________________
_______	Individual Room Air Conditioners	________________________
_______	Central System with Cooling Coils	________________________
_______	Split Air Conditioning Units	________________________
_______	Make-up Air Units	________________________

BUILDING EQUIPMENT INFORMATION (CONTINUED)

20 Building Equipped with Heating System (yes/no) ____________________

For the mechanical systems listed below, indicate whether the system is "primary"(P), "secondary" (S), or "other"(O)

P/S/O	Heating Equipment	Comments
_______	Steam or Hot Water Boiler	____________________
_______	Central System with Heating Coils	____________________
_______	Reheat Coils in Air Distribution System	____________________
_______	Packaged Units	____________________
_______	Forced Air Furnace	____________________
_______	Heat Pump	____________________
_______	Ducted Air Distribution	____________________
_______	Fan Coil Units	____________________
_______	Individual Space Heaters	____________________
_______	Fin Tube Radiators	____________________
_______	Electric Baseboard	____________________
_______	Make-up Air Units	____________________

BUILDING OPERATING SCHEDULE

21 Space Conditioning Days Per Day (WEEKDAY) ____________________

22 Space Conditioning Hours Per Day (WEEKDAY) ____________________

23 Space Conditioning Days Per Week (WEEKEND DAY) ____________________

24 Space Conditioning Hours Per Day (WEEKEND DAY) ____________________

25 Ventilation System Operation Days Per Week (WEEKDAY) ____________________

26 Ventilation System Operation Hours Per Day (WEEKDAY) ____________________

27 Ventilation System Operation Days Per Week (WEEKEND DAY) ____________________

28 Ventilation System Operation Hours Per Day (WEEKEND DAY) ____________________

BUILDING ENVELOPE CHARACTERIZATION

29 Exterior Wall Construction

For the wall constructions listed below, indicate whether the construction is "primary"(P), "secondary" (S), or "other"(O)

P/S/O	Exterior Wall Construction	Comments
_______	Glass or Metal Curtain Wall	____________________
_______	Masonry	____________________
_______	Pre-cast Concrete Panels	____________________
_______	Stone Panels	____________________
_______	Exterior Insulation Finish System	____________________
_______	Siding on Frame Construction	____________________
_______	Metal Building System	____________________
_______	Other	____________________

30 Roof construction

For the roof constructions listed below, indicate whether the construction is "primary"(P), "secondary" (S), or "other"(O)

P/S/O	Roof Construction	Comments
_______	Built-up Roof	____________________
_______	Single-ply Membrane	____________________
_______	Inverted Membrane	____________________
_______	Shingles	____________________
_______	Metal	____________________
_______	Other	____________________

31 Glazing Elements ____________________(Single, Double, or Triple)

32 Operable Windows (yes/no) ____________________

33 Percentage of Operable Windows ____________________

34 Shading Elements (yes/no) ____________________

35 Percentage of Windows with Shading Elements (overhangs, window treatments, or shades) ____________________

BUILDING HVAC CONTROL SYSTEMS

36 HVAC Control Implementation

For the control methods listed below, indicate whether the method is "primary"(P), "secondary" (S), or "other"(O)

P/S/O	Control Implementation	Comments
_______	Pneumatic	____________________
_______	Low Voltage Analog Electric	____________________
_______	Direct Digital	____________________

BUILDING HVAC CONTROL SYSTEMS (CONTINUED)

37 HVAC Control Response Strategy

For the control response strategy listed below, indicate whether the strategy is "primary"(P), "secondary" (S), or "other"(O)

P/S/O	Control Response Strategy	Comments
______	Two-position	______
______	Proportional	______
______	Floating Point	______
______	Proportional-integral	______
______	Proportional-integral-derivative	______

FORM A-2 BUILDING SOURCE INFORMATION

One copy of Form A-2 is completed for each building.

OUTDOOR CONTAMINANT SOURCES

1	Garbage Dumpsters	______________
2	Power Plants	______________
3	Heavy Motor Vehicle Traffic	______________
4	Construction Activities	______________
5	Emergency Generators	______________
6	Industrial Stacks	______________

SMOKING POLICIES

7	Smoking Permitted in Building? (yes/no)	______________
8	Is Smoking Permitted in Entire Building? (yes/no)	______________
9	Is Smoking Restricted to Private Offices? (yes/no)	______________
10	Is Smoking Restricted to Indoor Smoking Areas? (yes/no)	______________
11	Is Smoking Restricted to Outdoor Smoking Areas? (yes/no)	______________

WATER DAMAGE

12	Past Occurrences of Water Damage (yes/no)	______________
13	If Yes, Location of Past Water Damage	
	Basement	______________
	Roof	______________
	Mechanical Space	______________
	Occupied Space	______________
	Floors Damaged	______________
		______________

WATER DAMAGE (CONTINUED)

14 Current Water Leakage or Damage (yes/no) ____________

15 If Yes, Location of Current Water Damage

Basement ____________

Roof ____________

Mechanical Space ____________

Occupied Space ____________

Floors Damaged ____________

____

FIRE DAMAGE

16 Past Occurrences of Fire Damage (yes/no) ____________

17 If Yes, Date When Fire Occurred ____________

18 Extend of Fire Damage

Building Wide ____________

Limited Paces ____________

Floors Damaged ____________

____

BUILDING RENOVATIONS

Painting

19 Have Painting Renovations Occurred in the Last Year? (yes/no) ____________

20 Are Painting Projects Implemented Continuously Throughout the Building ____________

If Not Continuous, Enter Location and Date of Painting Renovations

Location	Date (mm/yy)

BUILDING RENOVATIONS (CONTINUED)

Carpeting

21 Have New Carpet Renovations Occurred in the Last Year? ______________________

22 Is New Carpeting Installed Continuously Throughout the Building? ______________________

If not continuous, enter floor and date of new carpet installations

Location	Date (mm/yy)

Roofing

23 Has Re-roofing Occurred in the Last Year? ______________________

24 Is Re-roofing Implemented Continuously Throughout the Building? ______________________

If not continuous, enter floor and date where re-roofing occurred

Location	Date (mm/yy)

Furniture

25 Has New Furniture Been Installed in the Last Year? ______________________

26 Is New Furniture Installation Implemented Continuously Throughout the Building? ______________________

If not continuous, enter floor and date where new furniture was installed

Location	Date (mm/yy)

BUILDING RENOVATIONS (CONTINUED)

Partition and Interior Wall Systems

27 Has the Movement of Partitions or Interior Walls Been Implemented in the Last Year? ____________________

28 Are Partition or Interior Wall Movement Projects Implemented Continuously Throughout the Building? ____________________

If not continuous, enter floor and date where partition or interior wall movement occurred

Location	Date (mm/yy)

CLEANING SCHEDULES

		Frequency	Occupied Hours	Evenings	Weekends
29	Office Cleaning				
30	Dry Mopping				
31	Wet Mopping				
32	Vacuuming				
33	Type of Vacuum Used				

INDOOR TRASH STORAGE

34 Location of Indoor Trash Storage (describe floor and storage area)

Floor	Occupied Space	Stairwell	Freight Elevator Lobby	Loading Dock

CLEANING MATERIALS USED

35 Cleaning Materials Used in Building (check all that apply)

Window Cleaner	____________
Furniture Cleaner	____________
Floor Wax	____________
Bathroom Cleaner	____________
Bleach	____________
Liquid Soap	____________
Carpet Cleaner	____________
Other (describe)	________________________

36 Cleaning Materials Inventory (document all cleaning materials used in the building by name and manufacturer)

CLEANING MATERIALS STORAGE

37 Location of Indoor Trash Storage (describe floor and storage area)

Floor	Occupied Space	Janitorial Closet	Storage Room

PEST CONTROL

38 Frequency of Exterior Pesticide Application ________________________

39 Date of Last Exterior Pesticide Application ________________________

40 Frequency of Interior Pesticide Application ________________________

41 Date of Last Interior Pesticide Application ________________________

42 Location of Interior Pesticide Application (describe floor and area of application)

Floor	Occupied Space	Storage Area	Mechanical Room

PEST CONTROL (CONTINUED)

43 Pesticides Used

Interior	Exterior

44 Pesticide Storage (on-site or off-site) ______________________

45 Pesticide Storage Location

Floor	Occupied Space	Janitorial Closet	Storage Room

SPECIAL USE SPACES

Smoking Areas

46 Does the Building Have Any Designated Smoking Areas? ______________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Kitchenettes

47 Does the Building Have Any Kitchenettes? ______________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

SPECIAL USE SPACES (CONTINUED)

Vending Areas

48 Does the Building Have Any Vending Areas? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Laboratory Areas

49 Does the Building Have Any Laboratory Areas? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Print Shops

50 Does the Building Have Any Print Shops? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

SPECIAL USE SPACES (CONTINUED)

Graphic Art Areas

51 Does the Building Have Any Graphic Art Areas? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Commercial Kitchens

52 Does the Building Have Any Commercial Kitchens? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Loading Docks

53 Does the Building Have Any Loading Docks? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

SPECIAL USE SPACES (CONTINUED)

Parking Garages

54 Does the Building Have Any Parking Garages? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Restrooms

55 Does the Building Have Any Restrooms? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Computer Rooms

56 Does the Building Have Any Computer Rooms? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

Conference Rooms

57 Does the Building Have Any Conference Rooms? ____________________
If yes, enter the following information

Floor	Dedicated Ventilation System	Dedicated Exhaust System

CHECKLIST INSTRUCTIONS: TEST SPACE DESCRIPTION

The test space description employs the following two forms:

- Form B-1, TEST SPACE DESCRIPTION
- Form B-2, TEST SPACE SOURCE INFORMATION

One copy of each form is completed for each building.

FORM B-1 TEST SPACE DESCRIPTION

This form is used to obtain information related to sources of indoor and outdoor pollutants that may impact the test space. This information is acquired through a combination of a test space walk-through and discussions with the building owner, manager, and operator. The entries on the form are to be completed as follows:

Test Space Description

1. **Test Space Identification:** Enter the location of the test space area.

2. **Gross Floor Area:** Enter the total floor area enclosed by the boundaries of the test space. Test space gross floor area should exclude mechanical rooms, utility closets, stairwells, elevator shafts, any currently unoccupied vacant office space, and any other areas deemed inappropriate for inclusion in the study area. Included in this value should be currently occupied tenant office space, bathrooms, janitor’s closet, common hallways, etc. This value should be obtained through measurements of the existing mechanical or architectural plans.

3. **Occupied Floor Area:** Enter the occupied floor area of the test space. Occupied floor area excludes common hallways, bathrooms, janitor’s closet, cafeterias, etc.

4. **Ceiling Height:** Enter the distance from the floor to the ceiling in the test space. If the space has a suspended ceiling, the distance to the suspended ceiling should be entered. If the test space has more than one ceiling height, enter the height that is predominant.

5. **Suspended Ceiling:** Enter “yes” if the test space has a suspended ceiling and “no” if it does not.

6. **Plenum Height:** Enter the distance from the suspended ceiling to the floor above. If the space does not have a suspended ceiling, leave this entry blank.

7. **Space Use Change:** Enter “yes” if the space use has changed since the original design of the building, such as from storage to office use. Enter “no” if the space is still being used for the purpose for which it was originally designed.

8. **Ventilation System Modification:** Enter “yes” if the test space ventilation system was redesigned based on the space use change, including modifications of the air handler, the ductwork, and the diffusers. Enter “no” if it was not. Leave blank if there was no space use change.

9. **Air Handling Units Serving Test Space:** Enter AHU designation and percentage of total test space air from referenced AHU.

10. **Private Office Workstations:** Enter the number of workstations located in private offices. Private offices are offices with no more than three workstations enclosed by permanent walls with an operable door. A single workstation is one used as a primary workstation at least 20 hours per week.

11. **Partitioned Office Workstations:** Enter the number of workstations located in partitioned offices. Partitioned offices are offices that are separated by partitions that do not extend to the ceiling. A single workstation is one used as a primary workstation at least 20 hours per week. Also, enter the height of the partitions as measured from the floor to the top of the partition. If more than one partition height is used, enter the value that is predominant.

12. **Partition Height:** Enter the height of the partitions located throughout the test space.

13. **Open Office Workstations:** Enter the number of workstations located in open offices. Open offices are those offices in which the workstations are not separated by

any walls or partitions. A single workstation is one used as a primary workstation at least 20 hours per week.

14. **Windows in Test Space:** Enter the total number of windows in the test space.

15. **Operable Windows in Test Space:** Of the total number of windows, enter the number of windows that are operable.

16. **Design Floor Area per Workstation:** Enter the design floor area per workstation. Note that this value does not indicate the floor area at the time of building design. Rather, this value represents the floor area per occupant calculated during the study week. Design floor area per occupant is calculated by taking the test space occupied floor area (2), divided by the total number of test space workstations (9 + 10 + 11).

Test Space Furniture

17. **Systems Furniture:** Enter the number of workstations comprised of systems furniture. Systems furniture is fixed to the floor or wall and cannot be moved without detaching the furniture from its installation hardware. Also, enter the systems furniture materials used within the test space. These include wood, wood veneer, textiles, metal, formica, or other. For each material used in systems furniture in the test space, select primary, secondary, or other.

18. **Movable Furniture:** Enter the number of workstations comprised of movable furniture. Movable furniture is not attached to the floor or wall and can be moved without requiring detachment from installation hardware. Also, enter the movable furniture materials used within the test space. These include wood, wood veneer, textiles, metal, formica, or other. For each material used in movable furniture in the test space, select primary, secondary, or other.

Test Space Interior Finishes

19. **Wall Finish:** Enter the types of wall finish in the test space. These include painted wallboard, fabric, metal, wallpaper, wood paneling, or other. For each material used, select primary, secondary, or other.

20. **Partition Finish:** Enter the types of partition finish in the test space. These include cloth, wood veneer, metal, plastic, wood, or other. For each material used, select primary, secondary, or other.

21. **Ceiling Finish:** Enter the types of ceiling finish in the test space. These include suspended, fabric, metal, painted wallboard, wood paneling, or other. For each material used, select primary, secondary, or other.

22. **Floor Finish:** Enter the types of floor finish in the test space. These include carpet, wood, tile, concrete, or other. For each material used, select primary, secondary, or other.

Test Space Lighting

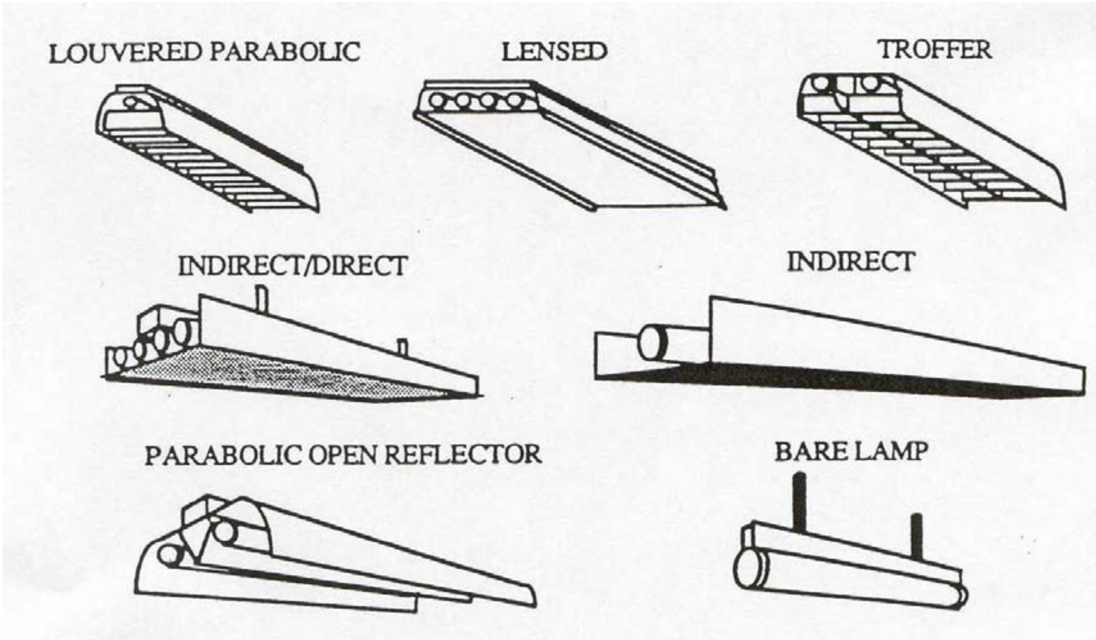
23. **Incandescent Lamps:** Enter the number of incandescent lamps permanently fixed to walls or ceilings in the test space.

24. **Incandescent Lamps Wattage:** Enter the typical wattage of these lamps.

25. **Fluorescent Lamps:** Enter the number of fluorescent lamps permanently fixed to walls or ceilings in the test space.

26. **Fluorescent Lamp Type:** Enter the lamp type. When describing the lamp type, include the typical bulb wattage.

27. **Fluorescent Lamp Luminaire:** Enter the typical luminaire type of the lamps. Luminaire types include parabolic, lensed, troffer, indirect/direct, indirect, and bare. An example of each type is shown below. Note that a single fixture may contain multiple lamps.



28. **Task Lights:** Enter the number of task lights found in the test space. Task lights are lights built into system furniture.

29. **Desk Lamps:** Enter the number of desk lamps found in the test space. Desk lamps include all lights found on workstations that are detachable from the furniture.

Test Space Ventilation Fixtures

30. **Supply Vent:** Enter the total number of supply air vents in the test space.

31. **Supply Vent Type:** Enter the type of supply vent used in the test space, including the discharge direction, horizontal or vertical. Select from the following options. If more than one type is used, include them all. For each type, select primary, secondary, or other.

- Linear ceiling diffusers
- Sidewall diffusers
- High sidewall grilles
- Floor registers
- Slots around ceiling luminaires
- Perforated ceiling panels
- Square or round ceiling diffusers
- Floor or near-floor diffusers
- Low sidewall grilles
- Fan coil units or unit ventilators
- Other (describe the vent in as few words as possible)

32. **Return Vents:** Enter the total number of return vents in the test space.

33. **Return Vent Type:** Enter the type of return vents used in the test space. Select from the following options. If more than one type is used, include them all. For each type, select primary, secondary, or other. Also, enter the total number of return air vents in the test space.

- Ceiling grilles
- Ceiling slots
- Low sidewall or floor grilles
- Slots around ceiling luminaires
- High sidewall grilles
- Other (describe the vent in as few words as possible)

34. **Additional Space Equipment:** Enter the types of additional space conditioning equipment found in the test space. Select from the following list. For each equipment type, enter the total number found and the number found operating

- Air cleaners
- Humidifiers
- Desk fans
- Space heaters
- Dehumidifiers

FORM B-2 TEST SPACE SOURCE INFORMATION

This form is used to obtain information related to sources of indoor and outdoor pollutants that may impact the test space. This information is acquired through a combination of a test space walk-through and discussions with the building owner, manager, and operator. The entries on the form are to be completed as follows:

Test Space Smoking

1. **Smoking Permitted:** Enter “yes” if smoking is permitted anywhere in the test space and “no” if smoking is not allowed.

2. **Smoking Permitted in Entire Test Space:** Enter “yes” if smoking is permitted throughout the entire test space and “no” if smoking is permitted only in specific locations.

3. **Restricted to Private Offices:** Enter “yes” if smoking is restricted within the test space except for private offices and “no” if smoking is not allowed in private offices.

4. **Restricted to Indoor Smoking Areas:** Enter “yes” if smoking is restricted within the test space except for designated smoking areas (including designated restrooms). Enter “no” if indoor smoking areas do not exist.

5. **Restricted to Outdoor Smoking Areas:** Enter “yes” if smoking is allowed outside the test space.

Test Space Water Damage

6. **Past Occurrences**: Enter “yes” if there has been past water damage in the test space.

7. **Location of Past Water Damage:** If water damage occurred in the past, enter the location from the list where water damage has occurred, basement, roof, mechanical space, or occupied space. If the water damage occurred in the occupied space, enter the floor where damage occurred.

8. **Current Water Damage:** Enter “yes” if there is currently water leakage or visible water damage within the test space.

9. **Location of Current Water Damage:** If current water damage or water leaks are present, enter the location from the list where this is occurring, basement, roof, mechanical space, or occupied space. If it is occurring in the occupied space, enter the floor where it is occurring.

Test Space Fire Damage

10. **Test Space Damage:** Enter “yes” if there has been fire damage within the test space.

11. **Month/Year:** If “yes,” enter the month and year that the damage occurred.

Test Space Renovations

This section describes the renovations that have occurred in the test space during the past year. This information can be obtained from a building walk-through and from the building owner or manager.

Painting

12. **Painting:** Enter “yes” if there has been painting within the test space within the last year.

13. **Month:** If “yes,” enter the month and year that painting occurred.

Carpeting

14. **Carpet:** Enter “yes” if there has been new carpeting installed within the test space within the building within the last year.

15. **Month:** If “yes,” enter the month and year that carpeting was installed.

Furniture

16. **Furniture:** Enter “yes” if there has been new furniture installed within the test space within the building within the last year.

17. **Month:** If “yes,” enter the month and year that new furniture was installed.

Partition and Interior Wall Systems

18. **Partitions:** Enter “yes” if there has been partition replacement or interior wall movement within the test space within the building within the last year.

19. **Month:** If “yes,” enter the month and year that partition replacement or interior wall movement occurred.

Test Space Cleaning

This section describes cleaning that may occur in the test space. Information recorded on this form may differ from that for whole building cleaning such as cleaning schedules, when cleaning is performed and materials used. This information can be obtained from a building walk-through and from the building owner or manager.

Cleaning Schedules

20. **Office Cleaning:** Enter the frequency at which test spaced office cleaning is done. Note whether this cleaning is done during occupied hours, evenings, or weekends.

21. **Dry Mopping:** Enter the frequency at which test space dry mopping is done. Note whether dry mopping is done during occupied hours, evenings, or weekends.

22. **Wet Mopping:** Enter the frequency at which test space wet mopping is done. Note whether wet mopping is done during occupied hours, evenings, or weekends.

23. **Vacuuming:** Enter the frequency at which test space vacuuming is done. Note whether vacuuming is done during occupied hours, evenings, or weekends.

24. **Vacuum Type:** If vacuuming is conducted, enter the type of vacuum used. These include standard vacuums, and vacuums equipped with HEPA filtration.

Cleaning Materials

25. **Storage Location:** Enter “yes” if cleaning materials are stored in the test space and “no” if they are not.

26. **Materials Used:** Select from the list each cleaning material used in the test space. General descriptors include window cleaner, furniture cleaner, floor wax, bathroom cleaners, bleach, soap, and carpet cleaners.

27. **Inventory of Cleaning Materials:** Collect an inventory of all cleaning materials used in the test space. This information should be collected by taking an inventory of each storage room within the test space.

Test Space Trash Storage

28. **Trash Storage:** Enter “yes” if trash is stored in the test space and no if it is not. Enter “no” if trash is stored only temporarily during trash collection.

Special Use Spaces (29 through 61)

Information regarding special use spaces should be obtained from the building owner, manager, or facilities engineer and verified by a walkthrough. For each of the categories, (smoking lounges through conference rooms) provide the following information:

Existence: Enter “yes” if the space use category exists in the building. Also, enter whether this special use space is equipped with its own dedicated ventilation system and dedicated exhaust system.

FORM B-1 TEST SPACE DESCRIPTION

One copy of Form B-I is completed for each building.

GENERAL TEST SPACE CHARACTERISTICS

1	Test Space Identification	______________________	
2	Gross Floor Area (see description for exclusions)	______________________	m^2 or ft^2
3	Occupied Floor Area (see description for exclusions)	______________________	m^2 or ft^2
4	Ceiling Height (see description for exclusions)	______________________	m or ft
5	Suspended Ceiling	______________________	
6	Plenum Height	______________________	m or ft
7	Space Use Change	______________________	
8	Ventilation System Modification	______________________	

9 Test Space Air Handling Units

AHU Designation	Percentage of Total Test Space Air From Referenced AHU
____________	____________
____________	____________
____________	____________
____________	____________

Enter Number of Each

10	Workstations in Private Offices	______________________
11	Workstations in Partitioned Offices (see description)	______________________
12	Partition Height	______________________
13	Workstations in Open Office Space (see description)	______________________
14	Windows in Test Space	______________________
15	Operable Windows in Test Space	______________________
16	Design Floor Area Per Work Station	______________________

Furniture

17 Systems Furniture: Number of Workstations ______________________________

Systems Furniture Materials: *Indicate whether material is "primary", "secondary", or "other*

P/S/O	Materials	Comments
_______	Wood	______________________________
_______	Wood Veneer	______________________________
_______	Textiles	______________________________
_______	Metal	______________________________
_______	Plastic Laminate or Composite Wood (formica)	______________________________
_______	Other	______________________________

18 Movable Furniture: Number of Workstations ______________________________

Movable Furniture Materials: *Indicate whether material is "primary", "secondary", or "other*

P/S/O	Materials	Comments
_______	Wood	______________________________
_______	Wood Veneer	______________________________
_______	Textiles	______________________________
_______	Metal	______________________________
_______	Plastic Laminate or Composite Wood (formica)	______________________________
_______	Other	______________________________

Interior Finishes

19 Wall Finish: *Indicate whether finish is "primary", "secondary", or "other*

P/S/O	Wall Finish	Comments
_______	Painted Wallboard	______________________________
_______	Fabric Wall Covering	______________________________
_______	Metal	______________________________
_______	Wallpaper	______________________________
_______	Wood Paneling	______________________________
_______	Other	______________________________

20 Partition Finish: *Indicate whether finish is "primary", "secondary", or "other*

P/S/O	Partition Finish	Comments
_______	Cloth	______________________________
_______	Wood Veneer	______________________________
_______	Metal	______________________________
_______	Plastic	______________________________
_______	Wood	______________________________
_______	Other	______________________________

21 Ceiling Finish: *Indicate whether finish is “primary”, “secondary”, or “other*

P/S/O	Ceiling Finish	Comments
_______	Suspended Ceiling	________________________
_______	Fabric	________________________
_______	Metal	________________________
_______	Painted Wallboard	________________________
_______	Wood Paneling	________________________
_______	Other	________________________

22 Floor finish: *Indicate whether finish is “primary”, “secondary”, or “other*

P/S/O	Floor Finish	Comments
_______	Carpet	________________________
_______	Wood	________________________
_______	Plastic Tile or Sheet	________________________
_______	Concrete	________________________
_______	Other	________________________

Lighting

23 Number of Fixed Incandescent Lamps ________________________

24 Typical Wattage of Fixed Incandescent Lamps ________________________

25 Number of Fluorescent Lamps ________________________

26 Fluorescent Lamp Type ________________________

27 Fluorescent Luminaire Type ________________________

28 Number of Task Lights ________________________

29 Number of Desk Lamps ________________________

Ventilation Fixtures

30 Total Number of Supply Vents ________________________

31 Supply Air Vent Type: *Indicate whether type is “primary”, “secondary”, or “other*

P/S/O	Materials	Comments
_______	Linear Ceiling Diffusers	________________________
_______	Sidewall Diffusers	________________________
_______	High Sidewall Grilles	________________________
_______	Floor Registers	________________________
_______	Perforated Ceiling Panels	________________________
_______	Square or Round Ceiling Diffusers	________________________
_______	Floor or Near-floor Diffusers	________________________
_______	Low Sidewall Grilles	________________________
_______	Fan Coil Units or Unit Ventilators	________________________
_______	Slots Around Ceiling Luminaires	________________________
_______	Other	________________________

32 Total Number of Return Vents ______________________________

33 Return Air Vent Type: *Indicate whether type is “primary”, “secondary”, or “other*

P/S/O	**Materials**	**Comments**
_______	Ceiling Grilles	______________________________
_______	Ceiling Slots	______________________________
_______	Low Sidewall or Floor Grilles	______________________________
_______	Slots Around Ceiling Luminaires	______________________________
_______	High Sidewall Grilles	______________________________
_______	Other	______________________________

Additional Space Conditioning Equipment

34	Number of Air Cleaners Observed in Test Space	______________________________
	Number of Operating Air Cleaners	______________________________
	Number of Space Heaters Observed in Test Space	______________________________
	Number of Operating Space Heaters	______________________________
	Number of Humidifiers Observed in Test Space	______________________________
	Number of Operating Humidifiers	______________________________
	Number of Dehumidifiers Observed in Test Space	______________________________
	Number of Operating Dehumidifiers	______________________________
	Number of Desk Fans Observed in Test Space	______________________________
	Number of Operating Desk Fans	______________________________

FORM B-2 TEST SPACE DESCRIPTION

One copy of Form B-2 is completed for each building.

SMOKING POLICIES

1	Smoking Permitted in Test Space? (yes/no)	________________
2	Is Smoking Permitted in Entire Test Space?	________________
3	Is Smoking Restricted to Private Offices?	________________
4	Is Smoking Restricted to Indoor Smoking Areas?	________________
5	Is Smoking Restricted to Outdoor Smoking Areas?	________________

WATER DAMAGE

6	Past Occurrences of Water Damage (yes/no)	________________
7	If Yes, Location of Past Water Damage	
	Basement	________________
	Roof	________________
	Mechanical Space	________________
	Occupied Space	________________
		________________
8	Current Water Leakage or Damage	
9	If Yes, Location of Current Water Leakage or Damage	
	Basement	
	Roof	
	Mechanical Space	
	Occupied Space	

FIRE DAMAGE

10	Past Occurrences of Test Space Fire Damage (yes/no)	________________
11	If Yes, Month/Year When Fire Occurred	________________

TEST SPACE RENOVATIONS

Painting

12	Have Painting Renovations Occurred in the Last Year? (yes/no)	________________
13	If Yes, Enter Month and Year	________________

New Carpet

14	Has New Carpet Been Installed in the Last Year? (yes/no)	________________
15	If Yes, Enter Month and Year	________________

New Furniture

16	Has New Furniture Been Installed in the Last Year? (yes/no)	________________
17	If Yes, Enter Month and Year	________________

Partition Replacement

18	Has Partition Replacement or Interior Wall Movement Occurred in the Last Year? (yes/no)	________________
19	If Yes, Enter Month and Year	________________

TEST SPACE CLEANING

		Frequency	**Occupied Hours**	**Evenings**	**Weekends**
20	Office Cleaning	______	______	______	______
21	Dry Mopping	______	______	______	______
22	Wet Mopping	______	______	______	______
23	Vacuuming	______	______	______	______
24	Type of Vacuum Used	________________			

25 Are Cleaning Materials Stored in Test Space? ________________

26 Cleaning Materials Used in Building (check all that apply)

Window Cleaner	________
Furniture Cleaner	________
Floor Wax	________
Bathroom Cleaner	________
Bleach	________
Liquid Soap	________
Carpet Cleaner	________
Other (describe)	________________

27 Cleaning Materials Inventory (document all cleaning materials used in the test space by name and manufacturer)

Test Space Trash Storage

28 Is Trash Stored in the Test Space? ____________________

SPECIAL USE SPACES

Smoking Areas

29 Does the Test Space Have Any Smoking Areas? ____________________

30 If Yes, is the Space Served by a Dedicated Ventilation System? ____________________

31 If Yes, is the Space Served by a Dedicated Exhaust System? ____________________

Kitchenettes

32 Does the Test Space Have Any Kitchenettes? ____________________

33 If Yes, is the Space Served by a Dedicated Ventilation System? ____________________

34 If Yes, is the Space Served by a Dedicated Exhaust System? ____________________

Vending Areas

35 Does the Test Space Have Any Vending Areas? ____________________

36 If Yes, is the Space Served by a Dedicated Ventilation System? ____________________

37 If Yes, is the Space Served by a Dedicated Exhaust System? ____________________

Laboratory Areas

38 Does the Test Space Have Any Laboratory Areas? ____________________

39 If Yes, is the Space Served by a Dedicated Ventilation System? ____________________

40 If Yes, is the Space Served by a Dedicated Exhaust System? ____________________

Print Shop

41 Does the Test Space Have a Print Shop? ____________________

42 If Yes, is the Space Served by a Dedicated Ventilation System? ____________________

43 If Yes, is the Space Served by a Dedicated Exhaust System? ____________________

Graphic Arts

44	Does the Test Space Have a Graphic Arts Area?	______________
45	If Yes, is the Space Served by a Dedicated Ventilation System?	______________
46	If Yes, is the Space Served by a Dedicated Exhaust System?	______________

Commercial Kitchen

47	Does the Test Space Have a Commercial Kitchen?	______________
48	If Yes, is the Space Served by a Dedicated Ventilation System?	______________
49	If Yes, is the Space Served by a Dedicated Exhaust System?	______________

Loading Dock

50	Does the Test Space Have a Loading Dock?	______________
51	If Yes, is the Space Served by a Dedicated Ventilation System?	______________
52	If Yes, is the Space Served by a Dedicated Exhaust System?	______________

Parking Garage

53	Does the Test Space Have a Parking Garage?	______________
54	If Yes, is the Space Served by a Dedicated Ventilation System?	______________
55	If Yes, is the Space Served by a Dedicated Exhaust System?	______________

Computer Room

56	Does the Test Space Have a Computer Room?	______________
57	If Yes, is the Space Served by a Dedicated Ventilation System?	______________
58	If Yes, is the Space Served by a Dedicated Exhaust System?	______________

Conference Room

59	Does the Test Space Have a Conference Room?	______________
60	If Yes, is the Space Served by a Dedicated Ventilation System?	______________
61	If Yes, is the Space Served by a Dedicated Exhaust System?	______________

CHECKLIST INSTRUCTIONS: TEST SPACE HVAC SYSTEM DESCRIPTION

The description of the HVAC system serving the test space employs a series of forms, with the specific forms used and their number depending on the system. The use of Forms C-1 through C-10 depends on the components of the HVAC system. Forms C-11 and C-12 will be used in all buildings. The forms for HVAC descriptions and inspections are as follows:

C1	AIR HANDLING AND DISTRIBUTION SYSTEM
C2	PERIMETER ZONE UNITS
C3	UNITARY SYSTEMS
C4	EVAPORATIVE COOLING SYSTEMS
C5	OUTDOOR AIR INTAKE CONTROL
C6	NATURAL VENTILATION SYSTEMS
C7A	AIR HANDLER SPECIFICATIONS
C7B	EXHAUST FAN SPECIFICATIONS
C8	FILTRATION AND AIR CLEANING SYSTEMS
C9	AIR WASHERS
C10	HUMIDIFICATION SYSTEMS
C11	MAINTENANCE
C12	INSPECTION

FORM C-1 AIR HANDLING AND DISTRIBUTION SYSTEMS

Central air handling systems, sometimes also referred to as "all-air," provide space conditioning by supplying conditioned air and ventilation by supplying outdoor air. A test space air handling unit may be defined as an air handling unit that supplies outdoor air to the test space. This form is used to describe the air handling and distribution systems serving the test space. One form should be completed for each system serving the test space.

Air Handling Unit Description

1. **Identification:** Enter the air handler identification using floor numbers and either room numbers or a description of the location on that floor.

2. **System Type Code:** Select the system type from one of the following options. The system type should be determined by review of equipment specifications and documentation, and system inspection. Additional information should be obtained from the building operator.

A Single Duct, Constant Volume, Single Zone

The air handler supplies a constant volume of supply air to a single zone with minimum heating and cooling load variations. The load within the space is controlled by varying the temperature of the supply air. The supply air temperature is controlled by varying the quantity and/or temperature of the heating or cooling source, by varying the relative proportions of outdoor air intake and recirculation air, by modulating the position of face and bypass dampers within the air handler, or a combination of these approaches.

B Single Duct, Constant Volume, Multiple Zone Reheat

The air handler supplies a constant volume of supply air to multiple zones with unequal loads. The load within each zone is controlled by varying the temperature of the supply air delivered to the zone. The supply air temperature is controlled by varying the amount of heating or cooling at the air handler, the relative proportions of outdoor air intake and recirculation, the position of face and bypass dampers within the air handler, or a combination of these approaches. Further temperature control in individual zones is provided by reheat coils in the ducts in each individual zone.

C Single Duct, Constant Volume, Multiple Zone Bypass

The air handler supplies a constant volume of supply air to multiple zones with unequal loads. The load within each zone is controlled by varying the temperature of the supply air delivered to the zone and the amount of supply air that is actually delivered to the zone. The supply air temperature is controlled by varying the amount of heating or cooling at the air handler, the relative proportions of outdoor air intake and recirculation, the position of face and bypass dampers within the air handler, or a combination of these approaches. Further temperature control in individual zones is provided through the use of a bypass box in the zone which dumps some of the supply air into the return air plenum or duct.

D Single Duct, Variable Air Volume

The air handler supplies air at a constant temperature of approximately 13 degrees Celsius (55 degrees Fahrenheit) through a duct system to variable air volume (VAV) units located in the ceiling plenum. In each zone, the VAV unit controls the quantity of supply air delivered to meet the cooling load requirements within that zone. The total quantity of supply air delivered by the air handler therefore varies in response to variations in the building space load. A true VAV system provides cooling only, with perimeter zones heated by some other system.

E Single Duct, Variable Air Volume, Reheat

This system is a modification of a true VAV system capable of providing both heating and cooling. Heat is provided in or near the terminal units after the supply airflow rate has been reduced to a predetermined minimum.

F Single Duct, Variable Air Volume, Induction

A VAV air handler provides primary air to unpowered VAV terminal units that induce plenum or room air into the supply airstream. The combination of primary and induced air provides a constant airflow. Variations in space load are met by varying the relative proportions of the primary and induced air. Reheat coils or some other form of auxiliary heat are required when heat gain in the room and ceiling is less than the sum of the transmission losses and the cooling loads associated with the primary air.

G Single Duct, Variable Air Volume, Fan Powered, Constant Fan

A VAV air handler supplies primary air to fan-powered VAV induction units that are installed in series with the primary supply airflow. The fan-powered units run continuously and operate at a relatively constant volume. In each zone, the unit mixes primary supply air with induced return air from the plenum to meet the space loads. Terminal units in exterior zones have heating coils for winter heating requirements. The heating coil is not activated until the primary air volume is sensed.

H Single Duct, Variable Air Volume, Fan Powered, Intermittent Fan

A VAV air handler supplies primary air to fan-powered VAV induction units that are installed in parallel with the primary supply airflow. The unit modulates the primary supply air in response to the cooling loads of the zone and operates the fan-powered unit when induced air is needed to meet the heating requirements. The primary air and the induced air mix within a common plenum within the fan-powered unit.

I Single Duct, Variable Air Volume, Dual Conduit

This system has two airstreams, one system used to meet year round cooling loads and a second system to offset transmission losses. The first system is a conventional central VAV system that provides year-round cooling to meet space cooling loads. The second system operates at constant volume, with the air temperature varied to meet transmission losses, and conditions return air from the ceiling plenum or the room. In some systems, this second system operates only during peak loads.

J Dual Duct, Constant Volume

The air handler supplies a constant volume of supply air to multiple zones; with the supply fan blowing through cooling coil and bypass sections connected to cold and hot decks respectively. These two decks run through the building to unpowered mixing boxes in the ceiling plenum, which mix the warm and cold air to meet the loads in the zone.

K Dual Duct, Constant Volume, Reheat

The air handler supplies a constant volume of supply air to multiple zones, with the supply airstream being split into two flows, one blowing through cooling coils and the other blowing through heating coils. The hot and cold air decks run through the building to unpowered mixing boxes in the ceiling plenum, which mix the hot and cold air to meet the loads in the zone. Interior zones mixing boxes may only be connected to the cold deck.

L Dual Duct, Variable Air Volume, Single Fan

A single VAV air handler supplies air to multiple zones, with the supply fan blowing through cooling and heating coil sections connected to cold and hot decks respectively. These two decks run through the building to VAV mixing boxes in the ceiling plenum, which mix the hot and cold air to meet the loads in the zone. The dampers in the mixing boxes are controlled by zone thermostats. Interior zone boxes may be connected to only the cold duct, while exterior zones will be connected to both the hot and cold decks.

M Dual Duct, Variable Air Volume, Dual Fan

In this system, separate supply fans serve the cold and hot decks. The two decks run through the building to VAV mixing boxes in the ceiling plenum, which mix the hot and cold air to meet the loads in the zone. Interior zone boxes may be connected to only the cold duct while exterior zones will be connected to both the hot and cold ducts.

N Multizone, Constant Volume

A constant volume air handler serves multiple zones, with the supply fan blowing through a cooling or heating coil, or both. Each zone's space load is met with a mixture of the hot and cold airstreams carried by a single duct to the zone. The mixing of the two airstreams for each zone takes place at the unit, with dampers in the hot and cold decks.

The airflow rate to each zone is fairly constant depending on the pressure drop through each coil and the position of the mixing dampers.

O Constant Volume, Blow-through Bypass

A constant volume air handler serves multiple zones, with the supply fan blowing air through the cooling coil section or through a bypass section around the cooling coil. The two supply ducts, cold and bypass, split off such that there is a cold duct and bypass air duct for each zone. These two supply airflows are brought together within the mechanical room, with the damper in the bypass air duct and a heating coil downstream of where the two flows merge. A constant quantity of air is supplied to each zone through this single duct and the supply air temperature to each zone is varied to meet space load by modulating the bypass damper and the use of the heating coil. The heating coil is activated only when all of the zone's supply air is bypass air. Interior zones may not have the heating coil in their ducts.

P Texas Multizone, or Three-deck Multizone

The air handler supplies a constant volume of supply air to multiple zones, with the supply fan blowing through a cooling coil, a bypass section or a heating coil. The space load of each zone is met through a mixture of the cold, bypass, and hot airstreams that is carried by a single duct to the zone. The mixing of the three airstreams for each zone takes place at the unit, employing dampers in the three decks. Interior zones are generally not connected to the hot deck. The heating coils are activated only if the bypass air can not meet the loads. The total air quantity to each zone is more or less constant depending on the pressure drop through each coil and the position of the mixing dampers.

3. **Zones Served:** Enter the thermostatically controlled zones served by the air handling unit. This value can be obtained by a review of building design drawings. Note that this count should include both zones inside and outside of the test space.

4. **Return Air Fan:** Enter “yes” if the air handling unit is equipped with a return air fan and “no” if it is not.

5. **Variable Temperature Setpoint:** If the system is VAV and the supply air temperature is varied by the control system in response to conditions, choose “Yes” in response to variable supply air temperature setpoint. Choose “No” if the system is VAV, but does have a variable supply air temperature. If the system is not VAV, leave this question blank.

6. **Test Space Served by Air Handler:** For each test space served by this air handler, enter the two digit code used to identify the test space and the approximate percentage of total air handler capacity going to that test space.

Air Handling Unit Ductwork

7. **Supply Ducting:** Enter the type of supply ductwork used by the air handling unit, galvanized, flexible fiber board, no ducting used, or other. When multiple types of ducting are used, select each type as primary, secondary, or other.

8. **Return Ducting:** Enter the type of return ductwork used by the air handling unit, galvanized, flexible fiber board, no ducting used, or other. When multiple types of ducting are used, select each type as primary, secondary, or other.

FORM C-2 PERIMETER ZONE UNITS

This form is used to describe systems that provide space conditioning to perimeter zones. In many cases, the systems within the section on central systems will also serve perimeter zones, but the systems described on this form are intended solely for perimeter applications. Only one form is required for the test space. One copy of Form C-2 should be completed for each test space.

1. **Air Water Induction Units:** Enter “yes” if air water induction units are used in the test space and “no” if they are not. Also, if “yes,” enter whether these systems are equipped with condensate drain pans and air filters.

2. **Fan Coil Units:** Enter “yes” if fan coil units are used in the test space and “no” if they are not. Also, if “yes,” enter whether these systems are equipped with condensate drain pans and air filters.

3. **Unit Ventilators:** Enter “yes” if unit ventilators are used in the test space and “no” if they are not. Also, if “yes,” enter whether these systems are equipped with condensate drain pans and air filters and whether the units are provided with ventilation air.

4. **Fin-tube Radiation:** Enter “yes” if fin-tube radiation is used in the test space and “no” if they are not.

5. **Electric Baseboard:** Enter “yes” if electric baseboard is used in the test space and “no” if they are not.

FORM C-3 UNITARY SYSTEMS

This form is used to describe unitary air-conditioning equipment, which includes a range of systems consisting of factory-assembled components providing heating, cooling, and outdoor air. Generally, each zone is served by a separate unit, unless the zone is very large. One copy of Form C-3 should be completed for each test space.

1. **Rooftop Units:** Enter “yes” if the test space is conditioned by rooftop units. These units are single package units consisting of unitary equipment, a ducted air distribution system, and a temperature control system. They may serve single or multiple zones, and may be constant and variable air volume. Also, enter the number of rooftop systems serving the test space, the type of zoning, and whether the systems are constant air volume (CAV) or VAV.

2. **Packaged Room AC Systems:** Enter “yes” if the test space is conditioned by individual room packaged air-conditioning (AC) units. Individual room packaged AC units are small capacity direct expansion (DX) refrigeration cycle air-conditioning package units that do not introduce outside air. Also, if “yes,” enter whether these systems are equipped with condensate drain pans and air filters.

3. **Heat Pump Systems:** Enter “yes” if the test space is conditioned by heat pump systems. Heat pump systems are factory-assembled units with the capacity to heat and cool. A single system can be used to condition an entire building or individual

zones. Heat pump types include air-to-air, water-to-air, air-to-water, and water-to-water. Ventilation air may be supplied by a central system to the individual units through a system of ductwork or the individual units may provide ventilation. If the test space is served by these systems, enter the number of systems serving the space and whether ventilation air is provided.

4. **Other:** If some other type of unitary system is being used, enter “yes” and describe the system.

FORM C-4 EVAPORATIVE COOLING SYSTEMS

Evaporative cooling systems are non-refrigerant systems that cool air by exchanging sensible heat for latent heat, thereby reducing temperatures, but raising humidity levels. This form is used to describe evaporative cooling systems that may be used to condition the test space. One copy of Form C-4 should be completed for each test space.

1. **Direct Evaporative Air Coolers:** Enter “yes” if the test space is served by a direct evaporative cooling system. If “yes,” also enter the type of system being used. These include the following:

   Wetted-media: A fan pulls air through wetted pads and delivers the cooled air to the space. A pump lifts water from a reservoir allowing it to flow down the media back to the sump.

   Rigid-media: A fan moves air horizontally through wet sheets of rigid corrugated material. A pump lifts water from a reservoir allowing it to flow down the media back to the sump.

   Slinger packaged: A fan draws outdoor air through a water spray, an evaporative filter pad, and an entrained-moisture eliminator pad. The spray is created by a motor-driven disk that is partially emersed in a water reservoir.

   Packaged rotary: A fan pulls air through a pad that rotates through a water reservoir.

2. **Indirect Evaporative Air Coolers:** Enter "yes" if the test space is served by an indirect evaporative cooling system. In an indirect evaporative air cooler, a fan forces an air stream across one side of a heat exchanger. On the other side of the heat exchanger, the conditioned air being supplied to the space is sensibly cooled by contact with the heat exchanger surfaces. An indirect evaporative cooler may either be self-contained or a part of a packaged air handling system.

FORM C-5 OUTDOOR AIR INTAKE CONTROL

This form is used to describe the means of outdoor air intake control employed in the mechanical ventilation system serving the test space. The information on this form can be determined from the mechanical equipment specifications and verified by inspection and discussion with the building operator. One copy of Form C-5 should be completed for each test space.

1. **Intake Strategy:** Enter the intake strategy for the air handling units serving the test space from the list provided below:

   Conditioned positive: A separate fan is used to bring in the required amount of outdoor air. This air is filtered and possibly dehumidified and heated or cooled prior to being delivered to the air handler

   Unconditioned positive: A separate fan is used to bring in the required amount of outdoor air, but this air is not treated prior to being delivered to the air handler.

   Unconditioned suction: Outdoor air is brought into the building through a separate duct by the suction induced by the supply fan. This air is not treated prior to being delivered to the air handler.

   Unconditioned suction with no duct: Untreated outdoor air intake is induced by the supply fan suction, directly into the air handling unit.

2. **Control Strategy:** Enter the outdoor air control strategy for the air handling units serving the test space from the list provided below.

100% outdoor air intake: The air handler provides 100 percent outdoor air at all times, with no recirculation of return air.

Fixed minimum outdoor air intake: The rate of outdoor air intake is constant whenever the air handler is operating. The supply air consists of constant proportions of outdoor air and recirculated return air.

Economizer cycle: If the outdoor air temperature is above a low temperature setpoint, the return, relief, and outdoor air intake dampers modulate to maintain the mixed air temperature at its setpoint. When the outdoor air temperature is below this setpoint, the outdoor air intake is at a minimum. When the outdoor air temperature is above a high temperature limit, the outdoor air intake is reduced to a minimum level.

Enthalpy economizer cycle: If the outdoor air enthalpy is above a low enthalpy setpoint, the return, relief, and outdoor air intake dampers modulate to maintain the mixed air temperature at its setpoint. When the outdoor air enthalpy is below this setpoint, the outdoor air intake is at a minimum. When the outdoor air enthalpy is above a high enthalpy limit, the outdoor air intake is reduced to a minimum level.

3. **Means of Maintaining Minimum:** From the list provided, enter the method used by the air handling unit in maintaining a minimum outdoor air setpoint.

   Fixed damper position: The intake and recirculation dampers are fixed and the pressure in the mixed air plenum determines the outdoor air intake rate.

   Supply/return fan tracking: Based on the difference between the supply and return fan airflow rates, the outdoor air intake dampers position is modulated to provide a constant outdoor air intake rate.

   Intake airflow monitoring: The outdoor air intake rate is monitored with an airflow station and the control system modulates the outdoor air intake dampers based on the measured airflow rate as compared to a set point.

Additional Outdoor Air Control

4. **Morning Warm-up Cycle:** Enter “yes” if the air handling units operate with a morning warm-up cycle and “no” if they do not. With morning warm-up, the system operates with no outdoor air to warm up the building prior to occupancy. This mode is used during unoccupied hours.

5. **Morning Purge Cycle:** Enter “yes” if the air handling units operate with a morning purge cycle and “no” if they do not. With morning purge, the system operates at a high level of outdoor air to purge the building of any contaminants that may have built up over the night. This mode occurs prior to occupancy.

6. **Night Cool-down Cycle**: Enter “yes” if the air handling units operate with a night cool-down cycle and “no” if they do not. With night cool-down, the system is run at 100% outdoor air intake in order to cool the building prior to occupancy. This mode is operated under certain outdoor air temperature and humidity conditions.

FORM C-6 NATURAL VENTILATION SYSTEMS

This form is used to describe the ventilation strategy employed in naturally ventilated buildings. Natural ventilation systems operate without external power, employing pressure differences caused by wind and temperature differences to induce airflow through the building. A building with a natural ventilation system may still have powered exhaust systems serving toilets and other areas. Information on the natural ventilation system can be determined from the mechanical equipment specifications, and verified by inspection and discussion with the building operator. One copy of Form C-6 should be completed for each building.

1. **Through-the-exterior Wall Vents:** Enter “yes” if the building is ventilated by airflow through openings in the exterior wall and “no” if it is not. If “yes,” enter the number and size of the vents. Note that if the building is not naturally ventilated this question is left blank.

2. **Central Shaft:** For naturally ventilated buildings, enter “yes” if the building is ventilated through central shaft that connects to the floors and carries air to the roof

of the building. Note that if the building is not naturally ventilated this question is left blank.

3. **Mechanical Exhaust System:** For naturally ventilated buildings, enter “yes” if the building is ventilated only by a mechanical exhaust system. The exhaust system should not include those used for bathrooms and/or special use spaces. Note that if the building is not naturally ventilated this question is left blank.

FORM C-7A AIR HANDLING UNIT SPECIFICATIONS

This form is used to record the design specifications of the air handler(s) serving the test space. Information on the air handler is generally found in the mechanical equipment specifications. The accuracy of these specifications should be verified by discussions with the building operator. One copy of Form C-7A should be completed for each air handling unit serving the test space.

1. **Supply Capacity:** Enter the design supply airflow rate capacity for the air handling unit. Also, enter the source where this value was obtained.

2. **Minimum Outdoor Air Rate:** Enter the design minimum outdoor air intake rate for the air handling unit. Also, enter the source where this value was obtained.

3. **Space Served by Supply Air:** Enter the space served by the air handling unit supply air system. Include the floor number and description of the space.

4. **Floor Area Served by Supply:** Enter the floor area served by the air handling unit supply air system. Also, enter the source where this value was obtained.

5. **Occupants Served:** Enter the total number of occupants served by the air handling unit supply air system. This information can be obtained through the building operator or through a walkthrough of the air handling unit zones. Also, enter the source where this value was obtained.

6. **Design Cooling Load:** Enter the design-cooling load for the air handling unit. This value is obtained from the schedule page of the buildings mechanical design drawings and is calculated by dividing the cooling coil capacity by the floor area served by the air handling unit. Also, enter the source where this value was obtained.

7. **Return Fan:** Enter "yes" if the air handling unit is equipped with a dedicated return fan and "no" if it is not.

8. **Return Capacity:** Enter the design return airflow rate capacity for the air handling unit. Also, enter the source where this value was obtained.

9. **Space Served by Return Air**: Enter the space served by the air handling unit return air system. Include the floor number and description of the space. Note that this question is still valid even if the air handling unit is not equipped with a dedicated return air fan.

10. **Floor Area Served by Return:** Enter the floor area served by the air handling unit return air system. Also, enter the source where this value was obtained. Note that this question is still valid even if the air handling unit is not equipped with a dedicated return air fan.

FORM C-7B EXHAUST FAN SPECIFICATIONS

This form is used to record the design specifications for the exhaust fan(s) serving the test space. Information on the exhaust fans is generally found in the mechanical equipment specifications. The accuracy of these specifications should be verified by discussions with the building operator. One copy of Form C-7B should be completed for each exhaust fan serving the test space.

1. **Identification:** Enter the exhaust fan identification using floor numbers and either room numbers or a description of the location on that floor.

2. **Exhaust Capacity:** Enter the design exhaust airflow rate capacity for the exhaust fan. Also, enter the source where this value was obtained.

3. **Space Served by Exhaust Fan:** Enter the space served by the exhaust fan. Include the floor number and description of the space.

4. **Floor Area Served by Exhaust Fan:** Enter the floor area served by the exhaust fan. Also, enter the source where this value was obtained.

5. **Fan Controls:** Enter, from the list below, the type of control used to operate the exhaust fan.

   - Manual: Enter “yes” if the exhaust fan operation is controlled manually with an on/off switch.
   - Time of Day: Enter “yes” if the exhaust fan operation is controlled automatically based on the time of day.
   - Temperature: Enter “yes” if the exhaust fan operation is controlled automatically based on temperature.
   - Equipment Operation: Enter “yes” if the exhaust fan operation is controlled automatically based on the operation of a piece of equipment.
   - Pressure: Enter “yes” if the exhaust fan operation is controlled by means of a building pressure.

FORM C-8 FILTRATION AND AIR CLEANING SYSTEMS

This form is used to record information regarding filtration and air cleaning systems used in the air handling units serving the test space. Information on these systems is generally found in the mechanical equipment specifications. The accuracy of these specifications should be verified by inspection of the systems and discussion with the building operator. One copy of Form C-8 should be completed for each filtration and air cleaning system. Therefore, more than one copy of the form may be needed for a given air handler, for example if the air handler has a pre-filter and a HEPA filter.

1. **Air Handler Number:** Enter the air handling unit number where the filtration or air-cleaning device is installed. This number should correspond to an air handling number defined in Form C-1.

2. **Location within Air Handler:** Enter the location within the air handling unit where the filtration or air-cleaning device is installed. Appropriate terms include recirculation air, outdoor air, mixed air upstream of coils, mixed air downstream of coils, and supply air downstream of fan.

3. **Air Cleaner Type:** Enter the type of filtration or air cleaning device installed in the air handling unit. These include filter, electronic, or gaseous.

For an air cleaner type designated as an “air filter” complete the following questions

4. **Manufacturer:** Enter the filtration system or air cleaning device manufacturer, Also enter the manufacturer’s model number.

5. **Filter system type:** Enter whether the filter is a panel filter of a roll filter.

6. **Panel filter type:** If the filter is a panel filter type, enter whether the filter is a dry filter or a viscous impingement filter. Viscous filters consist of a coarse media of high porosity that is treated with a viscous substance such as oil to which particles adhere when they impinge on the filter. Dry filters are made of random filter mats or blankets. If the system employs a dry filter, enter the dry filter type: flat panel, pleated, bag or HEPA.

7. **Roll Filter Type:** Enter whether the roll filter is a viscous impingement filter or a dry filter. Also, enter whether the mechanism to introduce new media into the airstream is manual or automatic.

8. **Size:** Enter the total face area of the filter bank.

9. **Media:** Enter the type of filter media employed in the filter.

10. **Rating:** Enter the rating of the filter as determined from the manufacturer's specifications. Specify the rating as the synthetic dust weight arrestance, the atmospheric dust spot efficiency or the dust holding capacity as determined

according to ASHRAE Standard 52-76, or the DOP efficiency of HEPA filters as determined according to U.S. Military Standard, MJL-STD-282.

For an air cleaner type designated as an “electronic” filter, complete the following questions:

11. **Size:** Enter the total face area of the filter bank.

12. **Auto Wash System:** Enter “yes” if the air cleaner has an automatic wash system and no if it does not.

For an air cleaner type designated as a “gaseous” filter, complete the following questions:

13. **Size:** Enter the total face area of the filter bank.

14. **Depth:** Enter the depth of the media bed.

15. **Absorbent Media:** Enter the media utilized in the air cleaning.

FORM C-9 AIR WASHERS

This form is used to record information on air washer systems used in the air handling units serving the test space. Information on these systems is generally found in the mechanical equipment specifications. The accuracy of these specifications should be verified by inspection of the systems and discussion with the building operator. One copy of Form C-9 should be completed for each air handler serving the test space.

1. **Air Washer System:** Enter “yes” if the air handling unit is equipped with an air washer system and “no” if it is not. For systems so equipped, enter the type of air washer system from the list provided. These include:

   High-velocity spray: In a high-velocity spray, water is pumped to a series of spray nozzles that discharge a finely atomized spray of water into the airstream

Cell Type: In cell type systems, air is passed through a tiered arrangement of cells packed with glass, metal or fiber screens. Water is pumped to the top of this tier and flows down over the cells, providing contact between the water and air.

FORM C-10 HUMIDIFICATION SYSTEMS

This form is used to record information on humidification systems used in the air handlers serving the test space. Information on these systems is generally found in the mechanical equipment specifications. The accuracy of these specifications should be verified by inspection of the systems and discussion with the building operator. One copy of Form C-10 should be completed each air handler serving the test space.

1. **Humidification System:** Enter “yes” if the air handling unit is equipped with a humidification system. If “yes,” enter the system type from those provided below.

   A Heated Pan: A heated pan of water is exposed to the air duct, and water evaporates directly into the airstream.

   B Steam Type. Enclosed Steam Grid: A steam pipe passes through an enclosure within the air duct and releases steam into this enclosure. Condensate is drained from the enclosure, and dry steam is released into the airstream.

   C Steam Type. Cup or Pot-Type: Steam is led into a cup attached under an air duct. Condensate drains from the cup and steam is released into the airstream.

   D Steam Type. Jacketed Dry-steam: Steam is supplied to a perforated tube after passing through a condensate separator This perforated discharge tube is located within a jacket fed by the steam before it passes through thc separator. The perforations face into the airstream.

   E Steam Type. Self-contained. Tap water is converted into steam by electrical energy, and the steam is injected directly into the airstream.

F Wetted element: Air is circulated over or through a wetted element, and water evaporates into the airstream.

G Atomizing: A high-speed disk slings water through a fine comb to create a mist that is introduced directly into the airstream, where it evaporates.

2. **Water Softening:** Enter “yes” if a water softening system is used to reduce scaling of system components and “no” if it is not.

3. **Demineralizer:** Enter “yes” if a water demineralizing system is used to reduce hardness and remove dissolved solids from the makeup water and “no” if it is not.

FORM C-11 MAINTENANCE

This form is used to record information regarding HVAC system maintenance procedures and schedules. This information should be obtained through discussion with the building manager and operator. One copy of Form C-11 is required for the building.

Air Handler Inspections

1. **Regularly Scheduled:** Enter “yes” if there are regularly scheduled inspections of the air handling systems, including the air intakes, dampers, damper controls, filters, fans, fan belts, and fan housings. Enter “no” if this equipment is not regularly inspected.

2. **Frequency:** Enter the frequency of these inspections. The frequency should be entered in times per year or months between inspections. If there are no regularly scheduled inspections, leave this entry blank.

Particulate Filtration Systems

PANEL FILTER REPLACEMENT

3. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for filter replacement, and enter “no” if not.

4. **Frequency:** Enter the frequency of panel filter replacement. The frequency should be entered in times per year or months between replacement. If there is no regular schedule for filter replacement, leave this entry blank.

Manual Roll Filter Advancement

5. **Regularly Scheduled:** Enter "yes" if there is a regular schedule for roll filter advancement, and enter "no" if not.

6. **Frequency:** Enter the frequency of filter advancement. The frequency should be entered in times per year of months between advancements. If there is no regular schedule for filter advancement, leave this entry blank.

Automatic Roll Filter Inspection

7. **Regularly Scheduled:** Enter "yes" if there is a regular schedule for inspection of the advancement mechanism for automatic roll filters, and enter "no" if not.

8. **Frequency:** Enter the frequency of advancement mechanism inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

Electronic Air Cleaners

INSPECTION

9. **Regularly Scheduled:** Enter "yes" if there is a regular schedule for inspection of the electronic air cleaners, and enter "no" if not.

10. **Frequency:** Enter the frequency of air cleaner inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

CLEANING

11. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for cleaning the electronic air cleaners, and enter “no” if not.

12. **Frequency:** Enter the frequency of air cleaner cleaning. The frequency should be entered in times per year or months between cleanings. If there is no regular schedule for cleaning, leave this entry blank.

Heating and Cooling Coils

INSPECTION

13. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of the heating and cooling coils, and enter “no” if not.

14. **Frequency:** Enter the frequency of coil inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

CLEANING

15. **Regularly Scheduled:** Enter “yes” if there is regular schedule for cleaning the heating and cooling coils, and enter “no” if not.

16. **Frequency:** Enter the frequency of coil cleaning. The frequency should be entered in times per year or months between cleanings. If there is no regular schedule for cleaning, leave this entry blank.

Drain Pans

INSPECTION

17. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of the drain pans in the air handlers, and enter “no” if not.

18. **Frequency:** Enter the frequency of drain pan inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

CLEANING

19. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for cleaning the drain pans in the air handlers, and enter “no” if not.

20. **Frequency:** Enter the frequency of drain pan cleaning. The frequency should be entered in times per year or months between cleanings. If there is no regular schedule for cleaning, leave this entry blank.

Air Distribution Ductwork

INSPECTION

21. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of the air distribution ductwork, and enter “no” if not.

22. **Frequency:** Enter the frequency of ductwork inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

CLEANING

23. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for cleaning the air distribution ductwork, and enter “no” if not.

24. **Frequency:** Enter the frequency of ductwork cleaning. The frequency should be entered in times per year or months between cleanings. If there is no regular schedule for cleaning, leave this entry blank.

Humidifiers

INSPECTION

25. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of humidifier in the air handlers, and enter “no” if not.

26. **Frequency:** Enter the frequency of humidifier inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

CLEANING

27. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for cleaning the humidifiers in the air handlers, and enter “no” if not.

28. **Frequency:** Enter the frequency of humidifier cleaning. The frequency should be entered in times per year or months between cleanings. If there is no regular schedule for cleaning, leave this entry blank.

29. **Purge or Blowdown:** Enter “yes” if there is a regular schedule for purging or blowing down the humidifiers. Enter “no” if not.

30. **Purge Frequency:** Enter the frequency of purging the humidifiers. The frequency should be entered in times per year or months between purgings. If there is no regularly scheduled purging, leave this entry blank.

31. **Purge Duration:** Enter the length of time of the purge cycle in hours.

32. **Purge Control:** Enter automatic if the purge cycle is done automatically or manual if it is initiated manually.

Evaporative Coolers

INSPECTION

33. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of evaporative coolers, and enter “no” if not.

34. **Frequency:** Enter the frequency of evaporative cooler inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

CLEANING

35. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for cleaning the evaporative coolers, and enter “no” if not.

36. **Frequency:** Enter the frequency of evaporative cooler cleaning. The frequency should be entered in times per year or months between cleanings. If there is no regular schedule for cleaning, leave this entry blank.

37. **System Bleeding Frequency:** Enter the frequency of bleeding of the system to minimize scale accumulation. The frequency should be entered in times per year or months between bleedings. If there are no regularly system bleeding, leave this entry blank.

38. **Water Treatment:** Enter “yes” if the water in the system is treated to keep dissolved solids in suspension. Enter “no” if not.

39. **Water Treatment Frequency:** Enter the frequency of application of water treatment to the system. The frequency should be entered in times per year or months between treatments. If there is no regular water treatment, leave this entry blank.

40. **Water Treatment Compound:** Enter the compound used in the water treatment.

41. **Biocide Treatment:** Enter “yes” if the water in the system is treated to control biological growth. Enter “no” if not.

42. **Biocide Treatment Frequency:** Enter the frequency of application of biocide to the system. The frequency should be entered in times per year or months between treatments. If there is no biocide treatment, leave this entry blank.

43. **Biocide Treatment Compound:** Enter the compound used in the biocide treatment.

Air Washers

INSPECTION

44. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of air washers, and enter “no” if not.

45. **Frequency:** Enter the frequency of air washer inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

CLEANING

46. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for cleaning the air washers, and enter “no” if not.

47. **Frequency:** Enter the frequency of air washer cleaning. The frequency should be entered in times per year or months between cleaning. If there is no regular schedule for cleaning, leave this entry blank.

48. **Tank Maintenance Frequency:** Enter the frequency of draining and cleaning the air washer tanks. The frequency should be entered in times per year or months between drainings and cleanings. If there are no regularly scheduled cleaning, leave this entry blank.

49. **Eliminator Repainting Frequency:** Enter the frequency of repainting of the eliminators and baffles to prevent corrosion. The frequency should be entered in times per year or months between painting. If there is no regularly scheduled repainting, leave this entry blank.

50. **Glass Media Cleaning Frequency:** Enter the frequency of cleaning of the glass media. The frequency should be entered in times per year or months between cleanings. If there is no regularly scheduled cleaning, leave this entry blank.

51. **System Bleeding Frequency:** Enter the frequency of bleeding of the system to minimize scale accumulation. The frequency should be entered in times per year or months between bleedings. If there is no regularly scheduled system bleeding, leave this entry blank.

52. **Water Treatment:** Enter “yes” if the water in the air washer system is treated to keep dissolved solids in suspension. Enter “no” if not.

53. **Water Treatment Frequency:** Enter the frequency of application of water treatment to the system. The frequency should be entered in times per year or months between treatments. If there is no regular water treatment, leave this entry blank.

54. **Water Treatment Compound:** Enter the compound used in the water treatment.

55. **Biocide Treatment:** Enter “yes” if the water in the air washer system is treated to control biological growth. Enter “no” if not.

56. **Biocide Treatment Frequency:** Enter the frequency of application of biocide to the system. The frequency should be entered in times per year or months between treatments. If there is no biocide treatment, leave this entry blank.

57. **Biocide Treatment Compound:** Enter the compound used in the biocide treatment.

Control System

INSPECTION

58. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of the control system components, and enter “no” if not.

59. **Frequency:** Enter the frequency of control system inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

SENSOR RECALIBRATION

60. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for recalibrating the control system sensors, and enter “no” if not.

61. **Frequency:** Enter the frequency of recalibration. The frequency should be entered in times per year or months between cleanings. If there is no regular schedule for recalibration, leave this entry blank.

Testing and Balancing

62. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for testing and balancing the HVAC system, and enter “no” if not.

63. **Frequency:** Enter the frequency of testing and balancing. The frequency should be entered in times per year or months between testing and balancing efforts. If there is no regular schedule, leave this entry blank.

Cooling towers

INSPECTION

64. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of the cooling towers, and enter “no” if not.

65. **Frequency:** Enter the frequency of cooling tower inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

66. **Surface Cleaning Frequency:** Enter the frequency at which the system is drained and the wetted surface cleaned. The frequency should be entered in times per year or months between cleanings. If there is no regularly scheduled cleaning, leave this entry blank.

67. **Scale Control Treatment:** Enter "yes" if the scale control treatment is used in the cooling tower system, either blowdown or chemical treatment. Enter "no" if not.

68. **Blowdown or Chemical Treatment:** Enter blowdown if blowdown is used to control scaling or chemical if a chemical treatment is used.

69. **Blowdown Frequency:** Enter the frequency of system blowdown or chemical treatment. The frequency should be entered in times per year or months between blowdowns. If there is no regular schedule, leave this entry blank.

70. **Scale Control Treatment Compound:** Enter the compound used in the scale control treatment.

71. **Corrosion Treatment:** Enter "yes" if the water in the cooling tower system is treated to control corrosion. Enter "no" if not.

72. **Corrosion Treatment Frequency:** Enter the frequency of application of the corrosion treatment to the system. The frequency should be entered in times per year or months between treatments. If there is no corrosion treatment, leave this entry blank.

73. **Corrosion Treatment Compound:** Enter the compound used in the corrosion treatment.

74. **Biocide Treatment:** Enter “yes” if the water in the cooling tower system is treated to control biological growth. Enter “no” if not.

75. **Biocide Treatment Frequency:** Enter the frequency of application of biocide to the system. The frequency should be entered in times per year or months between treatments. If there is no biocide treatment, leave this entry blank.

76. **Biocide Treatment Compound:** Enter the compound used in the biocide treatment.

77. **Silt Treatment:** Enter “yes” if the water in the cooling tower system is treated to control silt. Enter “no” if not.

78. **Silt Treatment Frequency:** Enter the frequency of application of biocide to the system. The frequency should be entered in times per year of months between treatments. If there is no silt treatment, leave this entry blank.

79. **Silt Treatment Compound:** Enter the compound used in the silt treatment.

Fan coil units

INSPECTION

80. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of the fan coil units in the building, including the condensate drainage, valves, fans and coils. Enter “no” if not.

81. **Frequency:** Enter the frequency of fan coil unit inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

Filter Replacement

82. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for replacing the filters in the fan coil units, and enter “no” if not.

83. **Frequency:** Enter the frequency of filter replacement. The frequency should be entered in times per year or months between replacement. If there is no regular schedule for replacement, leave this entry blank.

Terminal units

INSPECTION

84. **Regularly Scheduled:** Enter “yes” if there is a regular schedule for inspection of the terminal units in the building, and enter “no” if not.

85. **Frequency:** Enter the frequency of terminal unit inspection. The frequency should be entered in times per year or months between inspections. If there is no regular schedule for inspection, leave this entry blank.

FORM C-12 INSPECTION

This form is used to record information obtained during the inspection of the HVAC system and its major components. Some of this information will be dependent on when the inspection is conducted and how the system is being operated at this time. One copy of Form C-12 is required for the building.

Mechanical Room: These entries are intended to provide information on the state of the mechanical room containing the air handling equipment.

1. **General condition:** Enter 1, 2, or 3 based on the following descriptions.

   1 Clean, no sign of water leakage
   2 Fairly dusty, some evidence of water on floor
   3 Very dirty, standing water on floor

2. **Part of Return System:** Enter “yes” if unducted return airflows through the mechanical room before being recirculated through the air handler. Enter “no” if not.

3. **Used for Storage:** Enter “yes” if the mechanical room is used for storage of chemicals or refuse. Enter “no” if not.

System Check-Out: These entries are intended to provide information on the operation of the air handling system.

Supply Fans

4. **Operating:** Enter “yes” if the supply fans serving the test space were operating at the time of the inspection. Enter “no” if not, and identify the fans that were not operating.

5. **Correct Direction of Fan Rotation:** Enter “yes” if the supply fans were rotating in the correct direction at the time of the inspection. Enter “no” if not, and identify the fans that were not rotating the correct direction.

6. **Correct Airflow Direction:** Enter “yes” if air was flowing through the supply fans in the correct direction at the time of the inspection. Enter “no” if not, and identify the fans through which air was flowing in the wrong direction.

Return Fans

7. **Operating:** Enter “yes” if the return fans serving the test space were operating at the time of the inspection. Enter “no” if not, and identify the fans that were not operating.

8. **Correct Direction of Fan Rotation:** Enter “yes” if the return fan was rotating in the correct direction at the time of the inspection. Enter “no” if not, and identify the fans that were not rotating in the correct direction.

9. **Correct Airflow Direction:** Enter “yes” if air was flowing through the return fans in the correct direction at the time of the inspection. Enter “no” if not, and identify the fans through which air was flowing in the wrong direction.

Exhaust Fans

10. **Operating:** Enter “yes” if the exhaust fans serving the test space were operating at the time of the inspection. Enter “no” if not, and identify the fans that were not operating.

11. **Correct Direction of Fan Rotation:** Enter “yes” if the exhaust fans were rotating in the correct direction at the time of the inspection. Enter “no” if not, and identify the fans that were not rotating in the correct direction.

12. **Correct Airflow Direction:** Enter “yes” if air was flowing through the exhaust fans in the correct direction at the time of the inspection. Enter “no” if not, and identify the fans through which air was flowing in the wrong direction.

13. **Correct Airflow Direction:** Enter “yes” if outdoor air was flowing into the building through the air intake at the time of the inspection. Enter “no” if air was flowing out of the building through the intake.

14. **Height:** Enter the height above the ground of the outdoor air intake serving the test space. If the intake is on the roof, enter the height of the intake above the roof.

Proximity to Pollutant Sources: For the following entries, enter “yes” if the source is located within 7.5 m (25ft) of the outdoor air intake serving the test space.

15. **Standing Water**

16. **Exhaust Vents**

17. **Sanitary Vents**

18. **Cooling Tower**

19. **Loading Dock**

20. **Parking Garage**

21. **Vehicle Traffic**

22. **Trash Dumpster**

Air Handler Housing

23. **General condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Clean, metal panels securely in place
2 Fairly dusty, some gaps at seams
3 Very dirty, many gaps at seams, metal panels loose

24. **Sound liner:** Enter 1, 2, or 3 based on the following descriptions.

1 Clean, dry, securely in place
2 Moist in places, loose in some spots
3 Very dirty, moist and separating from panels at many locations

Air Handler Components

25. **General condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Clean and dry, components in place and operational
2 Some dust and moisture, some components not securely in place
3 Very dirty, significant moisture, some components out of position or not operational

26. **Intakes:** Enter 1, 2, or 3 based on the following descriptions.

1 Clean insect screen, no debris inside plenum, linkages in good condition, minimum dampers open
2 Insect screen needs cleaning, some debris inside plenum, linkages need maintenance

3 Insect screen partially blocked, much debris inside plenum, linkages broken or in very bad condition, minimum dampers closed

27. **Dampers:** Enter 1, 2, or 3 based on the following descriptions.

1 Linkages in good condition, dampers in correct positions, closed dampers fully closed and not excessively leaky, open dampers properly positioned
2 Linkages need maintenance, small deviations from correct positions, closed dampers leaking
3 Linkages broken or in very bad condition, dampers not in correct positions

28. **Coils:** Enter 1, 2, or 3 based on the following descriptions.

1 Coils clean
2 Coils dirty
3 Coils very dirty

29. **Drain pans:** Enter 1, 2, or 3 based on the following descriptions.

1 Drain pans clean and draining well
2 Some residue in pans but still draining
3 Drain pans very dirty, poor drainage from pans

30. **Fan belts:** Enter 1, 2, or 3 based on the following descriptions.

1 Belts in good condition
2 Belts somewhat worn, will need replacement soon
3 Belts fraying or broken, need immediate replacement

Air Distribution Ductwork: The inspection should include examination of the exterior of the ductwork within the mechanical room as well as of the interior ductwork that is accessible from all access panels.

31. Enter 1, 2, or 3 based on the following descriptions.

1 Clean and dry, securely in place, well labeled
2 Some dust and moisture, some ducts not securely in place
3 Very dirty, significant moisture, some ducts poorly secured

32. **Leakage at seams:** Enter 1, 2, or 3 based on the following descriptions.

1 No or only minimal leakage
2 Small leaks at only some of the locations
3 Large leaks at many locations

33. **Liners:** Enter 1, 2, or 3 based on the following descriptions.

1 Clean, dry, securely in place
2 Moist in places, loose in some spots
3 Very dirty, moist and very loose at many locations

Exhaust Fans: The following items concern the condition of all the exhaust fans serving the test space. These fans may be located in the mechanical room and elsewhere.

34. **General condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Clean and dry, operational
2 Some dust and moisture, some ducts not securely in place
3 Very dirty, significant moisture, some ducts poorly secured

35. **Fan belts:** Enter 1, 2, or 3 based on the following descriptions.

1 Belts in good condition
2 Belts somewhat worn, will need replacement soon
3 Belts fraying or broken, need immediate replacement

Particulate Filtration Systems: The following items concern the particulate filtration systems within the air handler, as opposed to desktop air cleaners within the occupied space.

36. **General condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Filters and frames in good physical condition, securely in position
2 Filters somewhat old, some filters not securely in place
3 Filters very old and deteriorating, some filters out of position, frames in very bad shape

37. **Accessibility:** Enter 1, 2, or 3 based on the following descriptions.

1 Large access doors providing access to both sides of filters, adequate space for inspecting and changing filters
2 Small access doors, very limited space for inspecting and changing filters
3 No access doors, no means of inspecting or changing filters

38. **Filter Fit into Frames:** Enter 1, 2, or 3 based on the following descriptions.

1 Filters fit very well into frames, minimal leakage around filters
2 Filters fit marginally well into frames, some bypass around filters
3 Filters fit poorly into frames, large amounts of bypass around filters

39. **Condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Filters in very good physical condition, recently changed or no need to change anytime soon
2 Filters somewhat old, will need to be changed soon
3 Filters very dirty, need to be changed immediately

40. **Evenness of Loading:** Enter 1, 2, or 3 based on the following descriptions.

1 Filter loading very even across the face
2 Some unevenness in loading
3 Filter loading very uneven, some areas heavily loaded while others are like new

41. **Indicator of Resistance:** Enter “yes” if the system contains an indicator for the resistance across the filter bank, generally a differential pressure gauge.

42. **Time to Change Label:** Enter “yes” if the resistance indicator shows when the filter should be changed.

43. **Pressure Indicator Reading:** If the system contains a differential pressure indicator across the filter bank, enter the reading of the pressure gauge.

Humidifiers: The following items concern any humidification systems within the air handler, as opposed to any local devices within the occupied space.

44. **General Condition:** Enter 1, 2, or 3 based on the following descriptions. Inspect water lines and any pumps, pump filters and fans.

    1 Components clean and in good physical condition, no corrosion
    2 Components somewhat dirty, some corrosion, some water leakage
    3 Components very dirty, heavily corrosion, large water leaks, some components not held securely in position

45. **Drain Pans:** Enter 1, 2, or 3 based on the following descriptions.

    1 Drain pans clean and draining well
    2 Some residue in pans but still draining
    3 Drain pans very dirty, poor drainage from pans

Evaporative Coolers

46. **General Condition:** Enter 1, 2, or 3 based on the following descriptions. Inspect water lines, pumps, pump filters and fans.

    1 Components clean and in good physical condition
    2 Components somewhat dirty, some water leakage

3 Components very dirty, large water leaks, some components not held securely in position

47. **Water Pans:** Enter 1, 2, or 3 based on the following descriptions.

1 Pans very clean
2 Some residue in pans
3 Drain pans very dirty, no evidence of ever having been cleaned

48. **Water Clarity:** Enter 1, 2, or 3 based on the following descriptions.

1 Water very clear
2 Water somewhat dirty, can see bottom of pan
3 Water very dirty, can't see bottom of pan

Air Washers

49. **General Condition:** Enter 1, 2, or 3 based on the following descriptions. Inspect water lines, pumps, nozzles, pump filters and fans.

1 Components clean and in good physical condition, all nozzles working, uniform coil coverage
2 Components somewhat dirty, some water leakage, moderately uniform coil coverage
3 Components very dirty, large water leaks, some components not held securely in position, many nozzles clogged, coil coverage very nonuniform

50. **Water Pans**: Enter 1, 2, or 3 based on the following descriptions.

1 Pans very clean
2 Some residue in pans
3 Drain pans very dirty, no evidence of ever having been cleaned

51. **Water Clarity:** Enter 1, 2, or 3 based on the following descriptions.

1 Water very clear
2 Water somewhat dirty, can see bottom of pan
3 Water very dirty, can't see bottom of pan

52. **Eliminators and Baffles**: Enter 1, 2, or 3 based on the following descriptions.

1 Very clean, no corrosion
2 Somewhat dirty, some corrosion
3 Very dirty, heavily corroded, some out of position or loose

Control System

53. **General Condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Components clean and in good physical condition
2 Components somewhat dirty, some electrical and/or pneumatic connections loose
3 Components very dirty, some electrical and/or pneumatic connections disconnected.

54. **Sensors:** Enter 1, 2, or 3 based on the following descriptions.

1 Sensors clean and securely in place
2 Sensors somewhat dirty, some sensor connections loose
3 Sensors very dirty, some sensors out of position

Cooling Tower

55. **General condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Components clean and in good physical condition
2 Components somewhat dirty, some deterioration evident
3 Components very dirty, some components seriously deteriorated

56. **Surfaces:** Enter 1, 2, or 3 based on the following descriptions.

1 Surfaces clean and in good physical condition, free of scaling
2 Surfaces somewhat dirty, some deterioration evident
3 Surfaces very dirty, heavy scaling, serious deterioration evident

57. **Water Condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Water very clear
2 Water somewhat dirty
3 Water very dirty

Fan Coil Units: The following items concern fan coil units located within the occupied space. All of the fan coil units within the test space should be inspected.

58. **General condition:** Enter 1, 2, or 3 based on the following descriptions.

1 Components clean and in good physical condition
2 Components somewhat dirty, some deterioration evident
3 Components very dirty, some components seriously deteriorated

59. **Valves:** Enter 1, 2, or 3 based on the following descriptions.

1 Valves clean and in good working order
2 Valves somewhat dirty, some deterioration evident
3 Valves very dirty, seriously deterioration evident

60. **Fans:** Enter 1, 2, or 3 based on the following descriptions.

1 Fans clean and in good working order
2 Fans somewhat dirty, some rust or other deterioration evident
3 Fans very dirty, rust and other serious deterioration evident

61. **Coils:** Enter 1, 2, or 3 based on the following descriptions.

1 Coils clean and in good physical condition

2 Coils somewhat dirty, some deterioration evident
3 Coils very dirty, serious deterioration evident

62. **Drain Pans**: Enter 1, 2, or 3 based on the following descriptions.

1 Drain pans clean and draining well
2 Some residue in pans but still draining
3 Drain pans very dirty, poor or no drainage from pans

63. **Air Filters:** Enter 1, 2, or 3 based on the following descriptions.

1 Filters clean or recently changed, securely in position
2 Filters somewhat dirty, will need changing soon
3 Filters very dirty, need to be changed immediately, some filters out of position

Terminal Units: The following items concern terminal boxes located within the occupied space. All of the terminal boxes within the test space should be inspected.

64. **General Condition**: Enter 1, 2, or 3 based on the following descriptions.

1 Components clean and in good physical condition
2 Components somewhat dirty, some deterioration evident
3 Components very dirty, some components seriously deteriorated

65. **Dampers:** Enter 1, 2, or 3 based on the following descriptions.

1 Dampers clean, linkages in good condition
2 Dampers somewhat dirty, some deterioration of linkages evident
3 Dampers very dirty, linkages seriously deteriorated, dampers unable to modulate

FORM C-1 AIR HANDLING UNIT DISTRIBUTION SYSTEMS

One copy of Form C-1 is completed for each test space air handling unit

1 Air Handling Unit Identifier ______________________

2 Air Handling Unit System Type (A-P)* ______________________

3 Number of Zones Served ______________________

4 Equipped with Return Air Fan (yes/no) ______________________

5 Variable Supply Air Temperature Setpoint? (for VAV systems only) ______________________

6 Test Spaces Served by Air Handling Unit

Test Space Number (i.e. "01", "02", "03")	Percent of AHU Capacity Serving Test Space
________	________
________	________
________	________

Supply Airflow Ductwork Type: *Indicate whether type is "primary", "secondary", or "other*

P/S/O	Materials	Comments
______	Galvanized	______________________
______	Flexible	______________________
______	Fiber Board	______________________
______	No Ducting Used	______________________
______	Other	______________________

17 Return Airflow Ductwork Type: *Indicate whether type is "primary", "secondary", or "other*

P/S/O	Materials	Comments
______	Galvanized	______________________
______	Flexible	______________________
______	Fiber Board	______________________
______	No Ducting Used	______________________
______	Other	______________________

* Air Handling Unit System Type Codes

A	Single Duct, Constant Volume, Single Zone
B	Single Duct, Constant Volume, Multiple Zone Reheat
C	Single Duct, Constant Volume, Multiple Zone Bypass
D	Single Duct, Variable Air Volume
E	Single Duct, Variable Air Volume, Reheat
F	Single Duct, Variable Air Volume, Induction
G	Single Duct, Variable Air Volume, Fan Powered, Constant Fan
H	Single Duct, Variable Air Volume, Fan Powered, Intermittent Fan
I	Single Duct, Variable Air Volume, Dual Conduit
J	Dual Duct, Constant Volume
K	Dual Duct, Constant Volume, Reheat
L	Dual Duct, Variable Air Volume, Single Fan
M	Dual Duct, Variable Air Volume, Dual Fan
N	Multizone, Constant Volume
O	Constant Volume, Blow- Through Bypass
P	Texas Multizone, or Three-Deck Multizone

FORM C-2 PERIMETER ZONE UNITS

This form is used to describe the systems that provide space conditioning to perimeter zones. One copy of Form C-2 is completed for each test space

1	Air Water Induction Units (yes/no)	______________
	If yes, are these equipped with condensate drain pans?	______________
	If yes, are these equipped with air filters?	______________
2	Fan Coil Units (yes/no)	______________
	If yes, are these equipped with condensate drain pans?	______________
	If yes, are these equipped with air filters?	______________
3	Unit Ventilators(yes/no)	______________
	If yes, do these supply ventilation air?	______________
	Source of ventilation air	______________
	If yes, are these equipped with condensate drain pans?	______________
	If yes, are these equipped with air filters?	______________
4	Fin Tube Radiation (yes/no)	______________
5	Electric Baseboard (yes/no)	______________

FORM C-3 UNITARY SYSTEMS

This form is used to describe unitary air conditioning equipment that serves the test space. One copy of Form C-3 is completed for each test space

1 Roof-top units (yes/no) ______________________

If yes, enter the number of roof-top units ______________________

System zoning (single/multiple) ______________________

System air volume (CAV/VAV) ______________________

2 Individual Packaged AC Units (yes/no) ______________________

If yes, are these equipped with condensate drain pans? ______________________

If yes, are these equipped with air filters? ______________________

3 Heat Pump Systems (yes/no) ______________________

If yes, enter the number of heat pump systems ______________________

Supplied ventilation air (yes/no) ______________________

Source of ventilation air ______________________

4 Other Unitary System Types (yes/no) ______________________

If yes, describe types ______________________

____

____

____

____

FORM C-4 EVAPORATIVE COOLING SYSTEMS

This form is used to describe evaporative cooling systems used to condition the test space. One copy of Form C-4 is completed for each test space

1 Direct Evaporative Cooler (yes/no) ______________________________
If yes, enter the direct system type*

2 Indirect Evaporative Cooler (yes/no) ______________________________

***Direct evaporative cooler system types**

Wetted-media

Rigid-media

Slinger packaged

Packaged rotary

FORM C-5 OUTDOOR AIR INTAKE

This form is used to describe the outdoor air intake strategy employed by the mechanical ventilation systems serving the test space. One copy of Form C-5 is completed for each test space

1 Outdoor Air Intake Strategy (select one of the following)

Conditioned positive	______________________
Unconditioned positive	______________________
Unconditioned suction	______________________
Unconditioned suction, no duct	______________________

2 Control Strategy (select one of the following)

100% outdoor air	______________________
Fixed minimum outdoor air intake	______________________
Economizer cycle	______________________
Enthalpy economizer cycle	______________________

3 Means of Maintaining Minimum Outdoor Air (select one of the following)

Fixed damper position	______________________
Supply/return fan tracking	______________________
Intake airflow monitoring	______________________

4	Morning Warm-up Cycle (yes/no)	______________________
5	Morning purge cycle (yes/no)	______________________
6	Night cool-down cycle (yes/no)	______________________

FORM C-6 NATURAL VENTILATION SYSTEM

This form is used to describe the ventilation strategy employed in naturally ventilated buildings. One copy of Form C-6 is completed for each building

1	Ventilation Via the Wall Exterior Vents (yes/no)	______________________
2	Ventilation Via a Central Shaft (yes/no)	______________________
3	Ventilation Via Mechanical Exhaust Systems (yes/no)	______________________

FORM C-7A AIR HANDLING UNIT SPECIFICATIONS

This form is used to describe the specifications of the air handling units serving the test space. One copy of Form C-7A is completed for each test space air handling unit.

1 Air Handling Unit Supply Airflow Rate ________________________(ft^3/min or m^3/min)
Source of value _______________________________________

2 Air Handling Unit Minimum Outdoor Airflow Rate ________________________(ft^3/min or m^3/min)
Source of value _______________________________________

3 Space Served by Air Handling Unit Supply Air System

Floor	**Description of area served**
_____	____
_____	____
_____	____
_____	____
_____	____

4 Floor Area Served by Air Handling Unit Supply Air System ______________________________(ft^2 or m^3)
Source of value _______________________________________

5 Number of Occupants Served by Air Handling Unit Supply Air System _______________________________________
Source of value _______________________________________

6 Design Air Handling Unit Cooling Load ______________________(BTU/ft^2 or Watts/m^2)
Source of value _______________________________________

7 Is Air Handling Unit Equipped with a Return Fan (yes/no) _______________________________________

8 Air Handling Unit Return Airflow Rate ________________________(ft^3/min or m^3/min)
Source of value _______________________________________

9 Space Served by Air Handling Unit Return Air System

Floor	**Description of area served**
______	______________________________
______	______________________________
______	______________________________
______	______________________________
______	______________________________

10 Floor Area Served by Air Handling Unit Return Air System ______________________________(ft^2 or m^3)

Source of value ______________________________

FORM C-7B EXHAUST FAN SPECIFICATIONS

This form is used to describe the specifications of the exhaust fans serving the test space. One copy of Form C-7B is completed for each test space exhaust fan.

1 Exhaust Fan Identifier ______________________________

2 Exhaust Fan Airflow Rate ____________________(ft^3/min or m^3/min)
Source of value ______________________________

3 Space Served by Exhaust Fan

Floor	Description of Area Served
_____	______________________________
_____	______________________________
_____	______________________________
_____	______________________________
_____	______________________________

4 Floor Area Served by Exhaust Fan ________________________(ft^2 or m^3)
Source of value ______________________________

5 Exhaust Fan Operated through Manual Control (yes/no) ______________________________

6 Exhaust Fan Operated through Time of Day Control (yes/no) ______________________________

7 Exhaust Fan Operated through Temperature Control (yes/no) ______________________________

8 Exhaust Fan Operated Based on Other Equipment Operation (yes/no) ______________________________

9 Exhaust Fan Operated Based on Building Pressure (yes/no) ______________________________

FORM C-8 FILTRATION AND AIR CLEANING SYSTEMS

This form is used to describe filtration and air cleaning systems used in the air handling units serving the test space. One copy of Form C-8 is completed for each filtration or air-cleaning device.

1	Air Handling Unit Number	______________________
2	Location of Filter within Air Handling Unit	______________________
3	Air Cleaner Type: (Filter, Electronic, or Gaseous)	______________________

Air Filtration Systems

4	Filter Manufacturer	______________________
	Filter Model Number	______________________
5	Filter Type (panel or roll filter)	______________________
6	Panel Filter Type (Dry or viscous impingement)	______________________
	If Dry, Enter the Dry Filter Type (flat panel, pleated, bag or HEPA.)	______________________
7	Roll Filter Type (Dry or viscous impingement)	______________________
	Filter Advance (manual or automatic)	______________________
8	Size (filter bank)	______________________(ft^2 or m^2)
9	Filter Media	______________________
10	Filter Rating	______________________

Electronic Air Cleaner

11	Size (filter bank)	______________________(ft^2 or m^2)
12	Equipped with Auto Wash Down (yes/no)	______________________

Gaseous Air Cleaner

13	Size (filter bank)	______________________(ft^2 or m^2)
14	Filter Depth	______________________ (ft or m)
15	Absorbent Media	______________________

FORM C-9 AIR WASHERS

This form is used to describe air washer systems within the air handling units serving the test space. One copy of Form C-9 is completed for each test space air handling unit.

1 Air Washer System (yes/no) ______________________________

If yes, enter system type* ______________________________

***Air Washer System Types**

High-velocity spray

Cell Type

FORM C-10 HUMIDIFICATION SYSTEMS

This form is used to describe humidification systems within the air handling units serving the test space. One copy of Form C-10 is completed for each test space air handling unit.

1	Humidification System (yes/no)	____________________
	If yes, enter system type code*	____________________
2	Water Softening (yes/no)	____________________
3	Demineralizer yes/no)	____________________

***Humidification System Types**

A	Heated Pan
B	Steam Type
C	Steam Type. Cup or Pot- Type
D	Steam Type. Jacketed Dry-steam
E	Steam Type. Self-contained
F	Wetted element
G	Atomizing

FORM C-11 MAINTENANCE

This form is used to describe the HVAC system maintenance procedures and schedules. One copy of Form C-11 is completed for the building

Air Handling Unit Inspections

1	Scheduled Inspections (yes/no)	______________
2	Inspection Frequency*	______________

Particulate Filtration Systems

3	Scheduled Filter Replacements (yes/no)	______________
4	Frequency of Panel Filters Replacement	______________
5	Scheduled Manual Roll Filter Advancement (yes/no)	______________
6	Frequency of Manual Roll Filters Advancement	______________
7	Scheduled Automatic Roll Filter Inspection (yes/no)	______________
8	Frequency of Automatic Roll Filters Inspection	______________

Electronic Air Cleaners

9	Scheduled Inspections (yes/no)	______________
10	Frequency of Inspection	______________
11	Scheduled Cleaning (yes/no)	______________
12	Frequency of Cleaning	______________

Heating and Cooling Coils

13	Scheduled Inspections (yes/no)	______________
14	Frequency of Inspection	______________
15	Scheduled Cleaning (yes/no)	______________
16	Frequency of Cleaning	______________

Condensate Drain Pans

17	Scheduled Inspections (yes/no)	______________
18	Frequency of Inspection	______________
19	Scheduled Cleanings (yes/no)	______________
20	Frequency of Cleaning	______________

Air Distribution Ductwork

21	Scheduled Inspections (yes/no)	______
22	Frequency of Inspection	______
23	Scheduled Cleaning (yes/no)	______
24	Frequency of Cleaning	______

Humidifiers

25	Scheduled Inspections (yes/no)	______
26	Frequency of Inspection	______
27	Scheduled Cleaning (yes/no)	______
28	Frequency of Cleaning	______
29	Regularly Scheduled Purge or Blowdown (yes/no)	______
30	Frequency of Purge or Blowdown	______
31	Duration of Purge or Blowdown	______hours
32	Control of Purge or Blowdown	______

Evaporative Coolers

33	Scheduled Inspections (yes/no)	______
34	Frequency of Inspection	______
35	Scheduled Cleanings (yes/no)	______
36	Frequency of Cleaning	______
37	Frequency of System Bleeding	______
38	Water Treatment (yes/no)	______
39	Water Treatment Frequency	______
40	Water Treatment Compound Used	______
41	Biocide Treatment (yes/no)	______
42	Biocide Treatment Frequency	______
43	Biocide Treatment Compound Used	______

Air Washers

44	Scheduled Inspections (yes/no)	______
45	Frequency of Inspection	______
46	Scheduled Cleaning (yes/no)	______
47	Frequency of Cleaning	______
48	Frequency of Tank Maintenance	______
49	Frequency of Eliminator Repainting	______
50	Frequency of Glass Media Cleaning	______
51	Frequency of System Bleeding	______
52	Water Treatment (yes/no)	______
53	Water Treatment Frequency	______
54	Water Treatment Compound Used	______
55	Biocide Treatment (yes/no)	______
56	Biocide Treatment Frequency	______
57	Biocide Treatment Compound Used	______

Control System

58 Scheduled Inspections (yes/no) ____________________
59 Frequency of Inspection ____________________

Sensor Calibration

60 Scheduled Inspections (yes/no) ____________________
61 Frequency of Inspection ____________________

Testing and Balancing

62 Scheduled Inspections (yes/no) ____________________
63 Frequency of Inspection ____________________

Cooling Towers

64 Scheduled Inspections (yes/no) ____________________
65 Frequency of Inspection ____________________
66 Frequency of Surface Cleaning ____________________

67 Scale Treatment (yes/no) ____________________
68 If Yes, Type of Scale Treatment (blowdown or chemical) ____________________
69 Frequency of Blowdown/Chemical Treatment ____________________
70 Scale Treatment Compound Used ____________________

71 Corrosion Treatment (yes/no) ____________________
72 Corrosion Treatment Frequency ____________________
73 Corrosion Treatment Compound Used ____________________

74 Biocide Treatment (yes/no) ____________________
75 Biocide Treatment Frequency ____________________
76 Biocide Treatment Compound Used ____________________
77 Silt Treatment (yes/no) ____________________
78 Silt Treatment Frequency ____________________
79 Silt Treatment Compound Used ____________________

Fan Coil Units

80 Scheduled Inspections (yes/no) ____________________
81 Frequency of Inspection ____________________
82 Scheduled Filter Change (yes/no) ____________________
83 Frequency of Filter Changing ____________________

Terminal Units

84 Scheduled Inspections (yes/no) ____________________
85 Frequency of Inspection ____________________

FORM C-12 INSPECTIONS

This form is used to record information obtained during the inspection of the HVAC system and its major components. One copy of Form C-12 is completed for each test space AHU.

Mechanical Room

1	General Condition*	________________
2	Part of Return Air System (yes/no)	________________
3	Used for Storage (yes/no)	________________

Air Handling Unit System Check-out - Supply Fans

4	Supply Fan Operating (yes/no)	________________
5	Supply Fan Correct Direction Fan Rotation	________________
6	Supply Fan Correct Airflow Direction (yes/no)	________________

Air Handling Unit System Check-out - Return Fans

7	Exhaust Fan Operating (yes/no)	________________
8	Exhaust Fan Correct Airflow Direction (yes/no)	________________
9	Return Correct Airflow Direction (yes/no)	________________

Exhaust Fans

10	Exhaust Fan Operating (yes/no)	________________
11	Exhaust Fan Correct Direction Fan Rotation	________________
12	Exhaust Fan Correct Airflow Direction (yes/no)	________________
13	Outdoor Air Flowing into Building through Air Intake (yes/no)	________________
14	Intake Height from Ground or Roof Level	________________

Outdoor Air Intakes

Pollutant sources within 250 feet from intake (check all that apply)

___ 15. Standing Water ______________________________
___ 16. Exhaust Vents ______________________________
___ 17. Sanitary Vents ______________________________
___ 18. Cooling Tower ______________________________
___ 19. Loading Dock ______________________________
___ 20. Parking Garage ______________________________
___ 21. Vehicle Traffic ______________________________
___ 22. Trash Dumpsters ______________________________

Air Handling Unit Housing

23. General Condition ______________________________

24. Sound Liner Condition ______________________________

Air Handling Unit Components

25. General Condition ______________________________

26. Outdoor Air Intake Condition ______________________________

27. Air Damper Condition ______________________________

28. Heating and Cooling Coil Condition ______________________________

29. Condensate Drain Pan Condition ______________________________

30. Fan Belt Condition ______________________________

Air Distribution Ductwork

31. General Condition ______________________________

32. Leakage at Seams ______________________________

33. Duct Liner Condition ______________________________

Exhaust Fans

34. General Condition ______________________________

35. Fan Belts ______________________________

Particulate Filtration Systems

36. General Condition ____________________
37. Accessibility ____________________
38. Filter Fit into Frames ____________________
39. Filter Condition ____________________
40. Evenness of Filter Loading ____________________
41. Indicator of Resistance (yes/no) ____________________
42. Filter Change Label (yes/no) ____________________
43. Pressure Indicator Reading ____________________(in H_2O)

Humidifiers

44. General Condition ____________________
45. Drain Pans ____________________

Evaporate Coolers

46. General Condition ____________________
47. Water Pans ____________________
48. Water Clarity ____________________

Air Washers

49. General Condition ____________________
50. Water Clarity ____________________
51. Water Pans ____________________
52. Eliminators and Baffles ____________________

Control Systems

53. General Condition ____________________
54. Sensors ____________________

Cooling Towers

55. General Condition ______________________
56. Water Condition ______________________
57. Surface Condition ______________________

Fan Coil Units

58. General Condition ______________________
59. Valve Condition ______________________
60. Fan Condition ______________________
61. Coil Condition ______________________
62. Drain Pan Condition ______________________
63. Air Filter Condition ______________________

Terminal Units

64. General Condition ______________________
65. Damper Condition ______________________

*** Condition Ratings**

1 System or component is in good condition
2 System or component is in fair condition
3 System or component is in poor condition

APPENDIX B

AUGMENTATION PARAMETERS

AUGMENTATION PARAMETERS

This appendix describes augmentation parameters that may be considered for some buildings. Augmentation parameters are additional parameters that were measured at some of the buildings in the program. Measurements of augmentation parameters were considered for inclusion at selected buildings based on considerations of the research objectives, historical data, potential for integration of the measurement results with other studies, and other factors as deemed appropriate by the EPA Program Manager. Table B.1 lists potential augmentation parameters and methods that may be considered for inclusion.

Table B.1 Potential Augmentation Parameters and Methods

Parameter	Method Description	Suggested Protocol
Nicotine	Ambient air passes through XAD-4 sorbent tube. Nicotine extract with solvent. Extract analyzed by gas chromatography with nitrogen specific detector	Table B2, Appendix B
Air Handling Unit Continuous Airstream CO_2 Monitoring	Continuous CO_2 concentration measurements may also be made simultaneously in the AHU supply and return air stream and at the AHU outdoor air intake.	Table B3, Appendix B
Acetaldehyde	Ambient air passes through DNPH coated silica gel cartridge. DNPA-aldehyde deviate eluded. Eluant analyzed by reverse phase HPLC with UV detection (360 nm)	Table C10, Appendix C
Biologicals in Dust	Dust samples will be collected from exposed surfaces. Sample analyzed for microbiological organism (bacteria and fungi).	Table C12, Appendix C
Air Infiltration Rate	The building envelope infiltration rate in mechanically ventilated buildings may be estimated by post-occupancy carbon dioxide decay tests or other tracer gas methods.	Appendix B, Section B.1

Table B2 Protocol for Measurement of Nicotine

MEASUREMENT PARAMETER	Nicotine concentration ($\mu g/m^3$)
METHOD DESCRIPTION	Ambient air passes through a sorbent tube containing XAD-4. Nicotine extract from the XAD-4 with ethyl acetate containing 0.01% Triethylamine. The extract analyzed by gas chromatography using nitrogen specific detector (GC/NDD). Specific protocols to be proposed by research team
RELEVANT PROTOCOLS	Indoor Air Compendium Method IP-2A
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 15% RSD
Accuracy	± 25%
Method Quantifiable Limit (MLQ)	0.07 $\mu g/m^3$ for 8 hour sample
Range (Quantifiable Limit)	0.07 to 400 $\mu g/m^3$
Interferences	Absorption of nicotine onto glassware surfaces
FIELD INSTRUMENTATION	
Requirements	
Pump Flow Rate	1.5 L/min
Pump Flow Stability	± 0.05 L/min
Operational Temperature Range	0 –40° C
Operational Relative Humidity Range	1 –100%
Sampling Duration	8 hour continuous
Warm-up Time	5 minute (pump)
Size	Portable
Power	Battery/115 VAC adapter
Noise	Use low noise pump
Available Instrumentation	Dupont Alpha-2 Dupont Company Kennet Square, PA SKC Model 222-4 Eighty Four, PA Gilian LFS113 Wayne NJ
PUMP CALIBRATION REQUIREMENTS	
Method description	Pump flowrate is measured from the outlet of the pump with a soap film bubblemeter
Frequency	Flow rate measurements at the beginning and at the end of each monitoring period
Time required to calibrate	10 minutes
Calibration equipment	Soap film bubble flow meter
MONITORING FREQUENCY AND DURATION	
Frequency	Collect at fixed site sampling locations on one day (see Section 5)
Duration	Approximately 8 hours

Table B2 Continued	
Documentation requirements	Operator ID number Instrument serial numbers Sampling locations Start/stop flowrates Start/stop times
SAMPLE HANDLING	
Field handling	No special handling techniques are required
Field storage	Store at room temperature with ends of tubes capped and tubes sealed in uncoated paint cans or sealed jars.
Shipping	Ship in well padded sealed containers. Ship by overnight delivery to laboratory
Laboratory storage	Store at –4° C until analyzed
Chain of custody	Chain of custody required for each sample
SAMPLE ANALYSIS	
Instrumentation Requirements	Gas chromatograph equipped with capillary column and nitrogen selected detector.
Calibration Requirements	Five point calibration covering the expected concentration range. Quinoline used as internal standard (General procedures in IP-2A should be followed)
Number of Field Blanks	One per building
Number of Controls	One per building
Number of Duplicates	One at one indoor location
Analytical System	Daily response of system determined by analysis of intermediate concentration standard.
Chain of Custody	Chain of custody required for each sample
Performance Evaluation (PE) Samples	Analysis of one PE sample prepared by independent laboratory or analysis of one duplicate sample by independent laboratory per building.
Field Audit	Audit of flow calibration devices, pump flows, and sampling procedures required.

Table B3 Protocol for Measurement of Air Handling Unit Airstream CO_2 Concentrations	
MEASUREMENT PARAMETER	CO_2 concentration (ppm)
METHOD DESCRIPTION	CO_2 concentration will be measured in the air handling unit supply and return airstreams using a portable, nondispersive infrared (NDIR) analyzer. A zero leakage sampling pump will be used to draw sample air from the airstream data will be recorded with a datalogger, then downloaded to a laptop computer.
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 50 ppm
Accuracy	± 200 ppm
Resolution	50 ppm
Range (Quantifiable Limit)	0 – 3000 ppm
FIELD INSTRUMENTATION	
Requirements	
Zero Drift	< ± 50 ppm over 8 hrs
Span Drift	< ± 50 ppm over 8 hrs
Operational Temperature Range	0 to 40° C
Operational Relative Humidity Range	10 – 90% RH
Sampling Duration	Up to 56 hours for continuous monitoring (Tuesday through Thursday)
Warm-up Time	Approximately 15 minute
Response Time	≤ 1 minute to 90% concentration
Output	Linear; mV or mA to datalogger (required). Datalogger output must be compatible with laptop computer.
Size	Portable
Power	Battery: 115V AC adapter
Available Instrumentation	*CO_2 Monitor* Metrosonics, Inc. MODEL AQ-501/502 Rochester, NY TSI, Inc. Model 8550 Q-Trak Monitor Saint Paul, Minnesota
CALIBRATION REQUIREMENTS	
Multipoint Calibration	
Method Description	Calibrate at three CO_2 concentration levels plus zero. (0, 350, 1000, and 2000 ppm, recommended)
Frequency	Calibrate at beginning and end of monitoring at each building.
Time Required to Calibrate	Approximately 45 min

Table B3 Continued	
Acceptability Criteria	Correlation coefficient ≥ 0.999; no greater than 2% deviation from the straight line for any standard
Zero and Span	
Method Description	Determine zero reading using compressed air or nitrogen and span reading using 1000 ppm CO_2 in air
Frequency	Perform at beginning and end of the day of monitoring when multipoint calibration is not performed
Time Required to Zero and Span	20 minutes
Acceptability Criteria	Recalibrate (multipoint) if zero differs by more than ± 50 ppm or if concentration at span differs by more than ± 100 ppm
Calibration Equipment	Set of calibration gas cylinders or gas dilution system, regulators for cylinders, and flow adapters for monitors.
MONITORING FREQUENCY AND DURATION	See Section 5
DOCUMENTATION REQUIREMENTS	Operator ID Instrument serial numbers Location Start times/stop times Calibration checks
DATA TRANSFER AND PROCESSING	
Transfers to Electronic Media	Download dataloggers to laptop computer at the end of each day
Back-up	Make a back-up copy of electronic files at time of download.
Field Evaluation	Verify data transferred before turning instrument off.
Labeling, Storage, Shipping	Make a back-up copy of data and documentation; ship or transport separately.
Chain of Custody	Record of data and documentation
Data Output	5 minute average CO_2 concentration measured continuously. Monitor readings will be reported without adjustment for drift if acceptability criteria are met. Otherwise, corrections must be made during data processing
QA/QC REQUIREMENTS	
Multipoint Calibrations	Perform at beginning and end of monitoring at each building.
Zero and Span Checks	Perform at beginning and end of each day of monitoring
External Audits	Required for monitoring instrumentation
Documentation	Documentation logs required
Chain of Custody (COC)	COC forms required

B-1 AIR INFILTRATION RATE IN MECHANICALLY VENTILATED BUILDINGS

Forms 1 through 6 are used to estimate the envelope infiltration rate in mechanically ventilated buildings. This is done by conducting a tracer gas decay test with the air handlers operating to determine the whole building air change rate. The outdoor air intake rate is then measured at the air handlers and subtracted from the whole building air change rate to determine the building infiltration rate. Only one such test is required in each building.

Form 1 Air Infiltration Rate: Test Description

This form is used to describe the sample locations used in the tracer gas decay test.

1. **Date of Test:** Enter the date on which the measurement is conducted.

The tracer gas concentration must be monitored during the decay test at one outdoor location, ten locations within the occupied space, and locations within the air handlers. The outdoor air concentration is monitored at an outdoor air intake. The ten interior locations must be distributed throughout the building in order to verify that the tracer gas concentration is uniform throughout the building prior to and during the decay. The specific locations that are selected will depend on the layout of the building including such factors as number of stories and floor area per story. The tracer gas concentration must also be monitored within the return airstreams of the building air handlers. The forms allow for ten return air locations, although a smaller number may be used depending on the number of air handlers in the building. If there are more than ten major air handlers, additional copies of Form 1 will be required.

2. **Tracer Gas:** Enter the tracer gas employed in the test.

3. **Measurement Location, Outdoor Air:** Describe the location at which the outdoor air tracer gas concentration is measured. Providing the distance from the outdoor air intake grille, designated as upstream or downstream, is preferred.

4. **Measurement Location, Occupied Space # 1:** Describe the first location within the occupied space of the building at which the tracer gas concentration is measured. Use column numbers if available, and note the building floor.

For entries #5 through #13, describe the second through tenth interior sampling location as described in entry #4 above.

14. **Measurement Location, Air Handling Unit:** Describe the first air handler sampling location at which the tracer gas concentration is measured. Enter the air handler number used in the building mechanical plans. Enter the location of the air handler, using a room number from the building plans if available. If no room number is available, enter the floor and location on the floor.

For entries #15 through #23, describe the second through tenth air handler sampling location as described in entry #14 above.

Form 2 Air Infiltration Rate: Supply Airflow Rate

This form is used to measure the supply airflow rate in each air handler serving the entire building. The airflow rate measurement is performed with a pitot tube traverse according to standard procedures contained in the ACGIH Industrial Ventilation Manual, AMCA Publication 203-90 and the ASHRAE Standard III. A traverse with a calibrated hot-wire anemometer is acceptable, using the same procedures as recommended for a pitot traverse. One form is required for each air handler serving the building. The entries on the form are to be completed as follows:

1. **Date of Test:** Enter the date on which the measurement is conducted.

2. **Time:** Enter the time at which the measurement is conducted.

3. **Air Handler Number:** Enter the air handler number used in the building mechanical plans.

4. **Air Handler Location:** Enter the location of the air handler, using a room number from the building plans, if available. If no room number is available, enter the floor and location on the floor.

5. **Location of Duct Traverse:** Describe the point within the supply ductwork at which the traverse is conducted. Provide the distance from the fan, designated as upstream or downstream.

6. **Measurement Device Type:** Describe the device used in the traverse, i.e., a pitot-static tube and differential pressure gauge or a calibrated hot-wire anemometer.

7. **Manufacturer:** In the case of a pitot traverse, enter the manufacturer of the pressure gauge. In the case of a hot-wire anemometer, enter the manufacturer of the anemometer.

8. **Model Number:** Enter the model number of the device.

9. **Serial Number:** Enter the serial number of the device.

10. **Rectangular or Round:** Note whether the duct is rectangular or round.

11. **Duct Area:** Enter the cross-sectional area of the duct at the point of the traverse. Designate the units, either m^2 or ft^2.

12. **Start of Traverse:** Enter the time at which the collection of traverse data began.

13. **End of Traverse:** Enter the time at which the collection of traverse data was completed.

14. **Root Mean Square Velocity Pressure:** In the case of a pitot traverse, calculate the root mean square velocity pressure using the formula contained on the form. In the case of a hot-wire traverse, leave this space blank. Designate the correct units, either $(Pa)^{1/2}$ or $(in.w.g.)^{1/2}$.

15. **Average Air Speed:** In the case of a hot-wire traverse, calculate the average value of the air speed. In the case of a pitot traverse, calculate the average air speed from the root mean square velocity pressure using the appropriate formula contained on the form. Designate the units, either mps or fpm.

16. **Airflow Rate:** Calculate the supply airflow rate by multiplying the duct area at entry # 11 by the average air speed at entry # 15. Designate the units, either m^3/s or cfm.

Form 3 Air Infiltration Rate: Percent Outdoor Air Intake

This form is used to measure the percent outdoor air intake in each air handler serving the entire building. The percent outdoor air intake is determined using a mass balance of air and carbon dioxide based on carbon dioxide concentration measurements in the outdoor air, the return air and the supply air. One form is required for each air handler serving the building. The entries on the form are to be completed as follows:

1. **Date of Test:** Enter the date on which the measurement is conducted.

2. **Time:** Enter the time at which the measurement is conducted.

3. **Air Handler Number:** Enter the air handler number used in the building mechanical plans.

4. **Air Handler Location:** Enter the location of the air handler, using a room number from the building plans if available. If no room number is available, enter the floor and location on the floor.

5. **Air Sample Location, Outdoor Air Intake:** Describe the location at which the outdoor air intake carbon dioxide concentration is measured. Provide the distance from the outdoor air intake grille, designated as upstream or downstream.

6. **Air Sample Location, Supply Air:** Describe the location at which the supply air carbon dioxide concentration is measured. Provide the distance from the supply fan, designated as upstream or downstream.

7. **Air Sample Location, Return Air:** Describe the location at which the return air carbon dioxide concentration is measured. Provide the distance upstream from the point at which the return and outdoor airstreams mix.

8. **Manufacturer:** Enter the manufacturer of the carbon dioxide concentration measurement device.

9. **Model Number:** Enter the model number of the device

10. **Serial Number:** Enter the serial number of the device.

The span and zero of the carbon dioxide monitor will be checked immediately before each determination of the percent outdoor air intake.

11. **Span Concentration:** Enter the carbon dioxide concentration of the span gas used to check the monitor.

12. **Reading:** Enter the response of the carbon dioxide monitor to the span gas.

13. **Reading:** Enter the response of the carbon dioxide monitor to the zero gas.

The concentration measurements are to consist of five successive readings at each of the three locations. At each location, record the concentration reading every 10 seconds. After the five readings, move immediately to the next location in order to complete all the measurements in the minimum amount of time.

14. **Start of Measurement:** Enter the time at which the concentration measurements began.

15. **Outdoor Air:** Enter the five concentration readings from the outdoor airstream.

16. **Return Air:** Enter the five concentration readings from the return airstream.

17. **Supply Air:** Enter the five concentration readings from the supply airstream.

18. **End of Measurement**: Enter the time at which the concentration measurements were completed.

19. Enter the mean of the outdoor air concentration readings.

20. Enter the standard deviation of the outdoor air concentration readings.

21. Enter the mean of the return air concentration readings.

22. Enter the standard deviation of the return air concentration readings.

23. Enter the mean of the supply air concentration readings

24. Enter the standard deviation of the supply air concentration readings.

25. **Percent Outdoor Air:** Calculate the percent outdoor air intake using the formula provided on the form.

26. **Error Estimate:** Calculate the estimated error in the percent outdoor air intake using the formula provided on the form.

Form 4 Air Infiltration Rate: Outdoor Air Intake

This form is used to determine the outdoor air intake rate in each air handler serving the entire building. Two methods are available to make this determination, the first being a pitot-tube traverse of the outdoor air intake duct according to standard procedures contained in the ACGIH Industrial Ventilation Manual, M1CA Publication 203-90 and the ASHRAE Standard III. A traverse with a calibrated hot-wire anemometer is acceptable, using the same procedures as recommended for a hot-wire traverse. The second method involves the multiplication of the supply airflow rate (Form 2) by the percent outdoor air intake (Form 3). Method #1 can only be used if the outdoor air intake is configured such that a traverse is possible (see the referenced documents for the ductwork configurations required for conducting a traverse). One form is required for each air handler serving the building. The entries on the form are to be completed as follows:

1. **Date of Test:** Enter the date on which the measurement is conducted.

2. **Time:** Enter the time at which the measurement is conducted.

3. **Air Handler Number:** Enter the air handler number used in the building mechanical plans.

4. **Air Handler Location:** Enter the location of the air handler, using a room number from the building plans if available. If no room number is available, enter the floor and location on the floor.

5. **Location of Duct Traverse:** Describe the point within the outdoor air intake ductwork at which the traverse is conducted. Provide the distance downstream from the outdoor air intake grille.

6. **Measurement Device Type:** Describe the device used in the traverse, such as pitot-static tube and differential pressure gauge or calibrated hot-wire anemometer.

7. **Manufacturer:** In the case of a pitot traverse, enter the name of the manufacturer of the pressure gauge. In the case of a hot-wire anemometer, enter the manufacturer of the anemometer.

8. **Model Number:** Enter the model number of the device.

9. **Serial Number:** Enter the serial number of the device.

10. **Rectangular or Round**: Note whether the duct is rectangular or round.

11. **Duct Area:** Enter the cross-sectional area of the duct at the point of the traverse. Designate the units, either m^2 or ft^2.

12. **Start of Traverse:** Enter the time at which the collection of traverse data began.

13. **End of Traverse:** Enter the time at which the collection of traverse data was completed.

14. **Root Mean Square Velocity Pressure:** In the case of a pitot traverse, calculate the root mean square velocity pressure using the formula contained on the form. In the case of a hot-wire traverse, leave this space blank. Designate the correct units, either $(Pa)^{1/2}$ or $(in.w.g.)^{1/2}$.

15. **Average Air Speed:** In the case of a hot-wire traverse, calculate the average value of the air speed. In the case of a pitot traverse, calculate the average air speed from the root mean square velocity pressure using the appropriate formula contained on the form. Designate the units, either mps or fpm.

16. **Airflow Rate:** Calculate the outdoor air intake rate by multiplying the duct area at entry # 10 by the average air speed at entry # 14. Designate the units, either m^3/s or cfm.

17. **Supply Airflow Rate:** Enter the supply airflow rate for the air handler from Form 2, entry # 16. Designate the units, either m^3/s or cfm.

18. **Percent Outdoor Air Intake:** Enter the percent outdoor air intake for the air handler from Form 3, entry #26.

19. **Outdoor Air Intake Rate:** Calculate the outdoor air intake rate by multiplying the supply airflow rate in entry # 17 by the percent outdoor air intake in entry # 18 and dividing the result by 100. Designate the units, either m'/s or cfm.

Form 5 Air Infiltration Rate: Tracer Gas Decay

This form is used to record the results of a tracer gas decay test in the building conducted to estimate the whole building air change rate. This test is to be conducted in accordance with ASTM E741. Based on the requirements contained in ASTM E741, this test must be conducted to determine the whole building air change rate. Tracer gas must be released into the entire building such that the concentration is uniform throughout the building. This test cannot be performed by releasing tracer gas into the test space alone. Only a single tracer gas decay test is required, and therefore only one form is needed. However, one can repeat the test if the initial attempt does not provide satisfactory results. This measurement can be conducted using occupant generated carbon dioxide as the tracer gas after the occupants have left the building. The entries on the form are to be completed as follows:

1. **Date of Test:** Enter the date on which the measurement is conducted.
2. **Manufacturer:** Enter the manufacturer of the tracer gas concentration measurement device.
3. **Model Number:** Enter the model number of the device.
4. **Serial Number:** Enter the serial number of the device.
5. **Concentration Units:** Enter the tracer gas concentration units provided by the tracer gas concentration monitor.

The tracer gas concentration must be monitored during the decay test at one outdoor location, ten locations within the occupied space, and locations within the air handlers. The concentration at each location should be measured once every 30 minutes, though the exact time interval is not critical as long as the sample times are recorded accurately. These sampling locations are described in Form 1. If one employs occupant generated carbon dioxide as the tracer gas, then the concentrations at these locations must be monitored after the occupants have left the building, while the interior carbon dioxide concentration is still significantly above the outdoor concentration. The concentration monitoring should begin very soon after the occupants have left the building, before the interior concentrations decays significantly. The tracer gas decay test requires that the interior concentration is significantly above the outdoor concentration and the interior concentration is uniform (within 10%) throughout the building. If either of these conditions is not satisfied, the test will not provide acceptable estimates of the building air change rate.

6. **Initial Reading:**

- Outdoor, Time: Enter the time at which the outdoor conditions are measured.
- Outdoor, Concentration: Enter the outdoor tracer gas concentration.
- Outdoor, Temperature: Enter the outdoor air temperature.
- Outdoor, Wind Speed: Enter the wind speed. Designate the units, either m/s or mph.
- Location #1, Time: Enter the time at which the tracer gas concentration at location #1 is recorded.
- Location # 1, Concentration: Enter the tracer gas concentration at location # 1.

For occupied space locations #2 through #10 and air handlers #1 through #10, enter the time and concentration as described for location # 1.

7. **Second Reading:** Record the information as described above for the initial reading.
8. **Third Reading:** Record the information as described above for the initial reading.
9. **Fourth Reading:** Record the information as described above for the initial reading.
10. **Fifth Reading:** Record the information as described above for the initial reading.

The data analysis involves determining the tracer gas decay rate in air changes per hour at each of the 10 occupied space locations and the air handler locations. This is done by performing a least squares linear regression of the natural logarithm of concentration against time. Based on the assumption of a uniform tracer gas concentration within the building, the tracer gas concentration at each location decays according to the following expression:

$C(t) = C_0\exp(-It)$ where

$C(t)$ = the tracer gas concentration at a location at time t minus the outdoor concentration recorded at the same time

C_0 = the tracer gas concentration at a location time t = 0 minus the outdoor concentration recorded at the same time

I = the tracer gas decay rate at that location

In order to determine I, one rewrites the above equation in log form:

$\ln C = \ln C_0 - It$

This equation can be used to solve for I at each location by regressing the log of the difference between the tracer gas concentration at the location and the outdoor concentration against time. Linear regression techniques are described in many handbooks and are contained in many computer spreadsheet programs, as are procedures for determining the error associated with the estimate of the slope I.

11. **Decay Rates:** Enter the calculated decay rate in air changes per hour for each of the locations and the standard error of this decay rate.
12. **Building Average Decay Rate:** Enter the average of the decay rates at all of the sampling locations.
13. **Standard Deviation:** Enter the standard deviation of the decay rates at all of the sampling locations.
14. **Average Exterior Temperature:** Enter the average of the exterior temperatures measured during the decay.
15. **Average Wind Speed:** Enter the average of the wind speeds measured during the decay. Designate the units, either mps or mph.

Form 6 Air Infiltration Rate: Data Analysis

This form is used to conduct the data analysis necessary to determine the building air infiltration rate. Only one form is required for the building. If there are more than ten air handlers in the building, then additional copies of Form 6 will be required. The entries on the form are to be completed as follows:

1. **Date of Test:** Enter the date on which the measurement is conducted.

2. **Outdoor Air Intake Method:** Enter the method used to determine the outdoor air intake rate using Form 4.

3. **Outdoor Air Intake Rate, Air Handler #1:** Enter the outdoor air intake rate determined for air handler #1 from the Form 4 corresponding to that air handler. Designate the units, either mps or cfm.

For entries #4 through #12, enter the outdoor air intake rate for air handlers #2 through #10 from the Form 4 corresponding to each air handler. If there are more than ten air handlers in the building, then the outdoor air intake rate for the additional air handlers are entered on additional copies of Form 6. Designate the correct units, either mps or cfm.

13. **Total Outdoor Air Intake Rate:** Enter the sum of the outdoor air intake rates for all of the air handlers in the building, contained in entries #3 through #12. If there are more than ten air handlers in the building, then the outdoor air intake rates for the additional air handlers must be included in this sum. Designate the units, either m^3/s or cfm.

14. **Outdoor Air Intake Rate in ACH:** Enter the whole building outdoor air intake rate in units of air changes per hour by dividing entry #13 by the building volume and converting the result to units of air changes per hour.

15. **Total Building Air Change Rate:** Enter the whole building air change rate in units of air changes per hour from entry #12 on Form 5.

16. **Building Infiltration Rate:** Enter the building infiltration rate, equal to entry #15 minus entry #14.

FORM 1 AIR INFILTRATION RATE: TEST DESCRIPTION

One form should be completed for each test

1	Test Date	______________________________
2	Tracer Gas Used	______________________________

Tracer Gas Concentration Measurement Location

3	Outdoor Air	______________________________
4	Occupied Space #1	______________________________
5	Occupied Space #2	______________________________
6	Occupied Space #3	______________________________
7	Occupied Space #4	______________________________
8	Occupied Space #5	______________________________
9	Occupied Space #6	______________________________
10	Occupied Space #7	______________________________
11	Occupied Space #8	______________________________
12	Occupied Space #9	______________________________
13	Occupied Space #10	______________________________
14	#1 Air Handling Unit Number	______________________________
	Location	______________________________
15	#2 Air Handling Unit Number	______________________________
	Location	______________________________
16	#3 Air Handling Unit Number	______________________________
	Location	______________________________
17	#4 Air Handling Unit Number	______________________________
	Location	______________________________
18	#5 Air Handling Unit Number	______________________________
	Location	______________________________
19	#6 Air Handling Unit Number	______________________________
	Location	______________________________
20	#7 Air Handling Unit Number	______________________________
	Location	______________________________
21	#8 Air Handling Unit Number	______________________________
	Location	______________________________
22	#9 Air Handling Unit Number	______________________________
	Location	______________________________
23	#10 Air Handling Unit Number	______________________________
	Location	______________________________

FORM 2 AIR INFILTRATION RATE: SUPPLY AIRFLOW RATE

One form should be completed for each air handling unit

1 Date of Test ______________________________________

2 Test Time ______________________________________

3 Air Handling Unit Number ______________________________________

4 Air Handling Unit Location ______________________________________

5 Location of Duct Traverse ______________________________________

Measurement Device Information

6 Measurement Device Type ______________________________________

7 Device Manufacturer ______________________________________

8 Device Model Number ______________________________________

9 Device Serial Number ______________________________________

Duct Dimensions

10 Rectangular or Round ______________________________________

11 Duct Area ______________________________________m^2 or ft^2

Traverse Data

12 Start Time of Traverse ______________________________________

13 End Time of Traverse ______________________________________

Calculations

14 Root mean square velocity pressure

$S(p_v)^{1/2}$ / number of readings ____________________________(Pa)$^{1/2}$ or (in w.g.)$^{1/2}$

15 Average air speed

Air speed measurements, Sv_s/ number of readings ________________________m/s or fpm

Velocity pressure measurements (Pa), 1.29 x #14 ________________________m/s

Velocity pressure measurements (in W.G.), 4002 x #14 ________________________fpm

16 Airflow rate, #11 x #15 ______________________________________m^3/s or cfm

FORM 3 AIR INFILTRATION RATE: PERCENT OUTDOOR AIR INTAKE

One form should be completed for each air handling unit

1 Date of Test ______________________
2 Test Time ______________________
3 Air Handling Unit Number
4 Air Handling Unit Location

Air Sample Locations

5 Outdoor Air Intake ______________________
6 Supply Air ______________________
7 Return Air

Measurement Device Information

8 Device Manufacturer ______________________
9 Device Model Number ______________________
10 Device Serial Number ______________________

Calibration Check

Span Check
11 Span Concentration ______________________
12 Span Reading ______________________
Zero Check
13 Zero Reading ______________________

Concentration Data

14 Measurement Start Time ______________________

15	**Outdoor Air**	16	**Return Air**	17	**Supply Air**
	________		________		________
	________		________		________
	________		________		________
	________		________		________
	________		________		________

18 Measurement End Time ______________________

Calculations (mean concentrations)

Mean

	Outdoor Air		**Return Air**		**Supply Air**
19	________	21	________	23	________

Standard Deviation

	Outdoor Air		**Return Air**		**Supply Air**
20	________	22	________	24	________

Percent Outdoor Air Intake

25 Value, 100 x (#21-#23)/(#21-#19) ______________________% OA
26 Error Estimate, $100X\#25[(\#22^2+\#20^2)/(\#21-\#19)^2+(\#22^2+\#24^2)/(\#21-\#23)^2]^{1/2}$
______________________%OA

FORM 4 AIR INFILTRATION RATE: OUTDOOR AIR INTAKE RATE

One form should be completed for each air handling unit

1 Date of Test ______________________________
2 Test Time ______________________________
3 Air Handling Unit Number
4 Air Handling Unit Location

METHOD #1 TRAVERSE

5 Location of Duct Traverse ______________________________

Measurement Device Information

6 Measurement Device Type ______________________________
7 Device Manufacturer ______________________________
8 Device Model Number ______________________________
9 Device Serial Number ______________________________

Duct Dimensions

10 Rectangular or Round ______________________________

11 Duct Area ______________________________ m^2 or ft^2

Traverse Data

12 Start Time of Traverse ______________________________

13 End Time of Traverse ______________________________

Calculations

14 Root mean square velocity pressure
$S(p_v)^{1/2}$ / number of readings ______________________ $(Pa)^{1/2}$ or $(\text{in w.g.})^{1/2}$

15 Average air speed

Air speed measurements, Sv_s/ number of readings ____________________ m/s or fpm

Velocity pressure measurements (Pa), 1.29 x #14 ____________________ m/s

Velocity pressure measurements (in W.G.), 4002 x #14 ____________________ fpm

16 Airflow rate, #11 x #15 ______________________________ m^3/s or cfm

METHOD #2 CALCULATION

17 Supply airflow rate from Form 2 #16, same air handling unit ____________ m^3/s or cfm
18 Percent outdoor air from Form 3 #25, same air handling unit ____________ %
19 Outdoor air intake rate, #17 x #18 ____________ m^3/s or cfm

FORM 5 AIR INFILTRATION RATE: TRACER GAS DECAY

One form should be completed for each test

1 Date of test ____________________

Measurement Device Information

2 Device Manufacturer ____________________
3 Device model number ____________________
4 Device serial number ____________________
5 Concentration units ____________________

Data

6 Initial Reading

Outdoor

Measurement Time ____________________
Concentration ____________________
Temperature ____________________ (C or F)
Wind speed ____________________(m/s or mph)

Occupied Space

	Time	**Concentration**		**Time**	**Concentration**
Location #1			Location #6		
Location #2			Location #7		
Location #3			Location #8		
Location #4			Location #9		
Location #5			Location #10		

Air Handling Units

Location #1			Location #6		
Location #2			Location #7		
Location #3			Location #8		
Location #4			Location #9		
Location #5			Location #10		

7 Second Reading

Outdoor

Measurement Time ____________________
Concentration ____________________
Temperature ____________________ (C or F)
Wind speed ____________________(m/s or mph)

Occupied Space

	Time	**Concentration**		**Time**	**Concentration**
Location #1			Location #6		
Location #2			Location #7		
Location #3			Location #8		
Location #4			Location #9		
Location #5			Location #10		

Air Handling Units

Location #1			Location #6		
Location #2			Location #7		
Location #3			Location #8		
Location #4			Location #9		
Location #5			Location #10		

8 Third Reading

Outdoor

Measurement Time ______________________________________

Concentration ______________________________________

Temperature ______________________________________ (C or F)

Wind speed __________________________________(m/s or mph)

Occupied Space

	Time	Concentration		Time	Concentration
Location #1	________	__________	Location #6	________	__________
Location #2	________	__________	Location #7	________	__________
Location #3	________	__________	Location #8	________	__________
Location #4	________	__________	Location #9	________	__________
Location #5	________	__________	Location #10	________	__________
Air Handling Units					
Location #1	________	__________	Location #6	________	__________
Location #2	________	__________	Location #7	________	__________
Location #3	________	__________	Location #8	________	__________
Location #4	________	__________	Location #9	________	__________
Location #5	________	__________	Location #10	________	__________

9 Fourth Reading

Outdoor

Measurement Time ______________________________________

Concentration ______________________________________

Temperature ______________________________________ (C or F)

Wind speed __________________________________(m/s or mph)

Occupied Space

	Time	Concentration		Time	Concentration
Location #1	________	__________	Location #6	________	__________
Location #2	________	__________	Location #7	________	__________
Location #3	________	__________	Location #8	________	__________
Location #4	________	__________	Location #9	________	__________
Location #5	________	__________	Location #10	________	__________
Air Handling Units					
Location #1	________	__________	Location #6	________	__________
Location #2	________	__________	Location #7	________	__________
Location #3	________	__________	Location #8	________	__________
Location #4	________	__________	Location #9	________	__________
Location #5	________	__________	Location #10	________	__________

10 Fifth Reading

Outdoor

Measurement Time	______________________	
Concentration	______________________	
Temperature	______________________	(C or F)
Wind speed	______________________	(m/s or mph)

Occupied Space

	Time	Concentration		Time	Concentration
Location #1	____	____	Location #6	____	____
Location #2	____	____	Location #7	____	____
Location #3	____	____	Location #8	____	____
Location #4	____	____	Location #9	____	____
Location #5	____	____	Location #10	____	____

Air Handling Units

	Time	Concentration		Time	Concentration
Location #1	____	____	Location #6	____	____
Location #2	____	____	Location #7	____	____
Location #3	____	____	Location #8	____	____
Location #4	____	____	Location #9	____	____
Location #5	____	____	Location #10	____	____

Data Analysis

11 Decay Rates, Air changes per hour

Occupied Space

	Value	Standard Error		Value	Standard Error
Location #1	____	____	Location #6	____	____
Location #2	____	____	Location #7	____	____
Location #3	____	____	Location #8	____	____
Location #4	____	____	Location #9	____	____
Location #5	____	____	Location #10	____	____

Air Handling Units

	Value	Standard Error		Value	Standard Error
Location #1	____	____	Location #6	____	____
Location #2	____	____	Location #7	____	____
Location #3	____	____	Location #8	____	____
Location #4	____	____	Location #9	____	____
Location #5	____	____	Location #10	____	____

12 Building average decay rate ______________________ ACH

13 Standard Deviation ______________________ ACH

Outdoor Conditions, Averages

14 Exterior Temperature ______________________ C or F

15 Wind Speed ______________________ m/s or mph

FORM 6 AIR INFILTRATION RATE: DATA ANALYSIS

One form should be completed for each test

1 Date of Test ______________________________

Outdoor Air Intake Rate, From Form 4

2 Determination by Method #1 Traverse or Method #2 Calculation ____________________
3 #1 Air Handling Unit ______________________________ m^3/s or cfm
4 #2 Air Handling Unit ______________________________ m^3/s or cfm
5 #3 Air Handling Unit ______________________________ m^3/s or cfm
6 #4 Air Handling Unit ______________________________ m^3/s or cfm
7 #5 Air Handling Unit ______________________________ m^3/s or cfm
8 #6 Air Handling Unit ______________________________ m^3/s or cfm
9 #7 Air Handling Unit ______________________________ m^3/s or cfm
10 #8 Air Handling Unit ______________________________ m^3/s or cfm
11 #9 Air Handling Unit ______________________________ m^3/s or cfm
12 #10 Air Handling Unit ______________________________ m^3/s or cfm

13 Total Outdoor Air Intake Rate, Add #3 through #12 ____________________ m^3/s or cfm
14 Outdoor Air Intake Rate in air changes per hour, #13 divided by building volume
____________ air changes per hour
15 Total building air change rate, from Form 5, #13 ____________ air changes per hour
16 Building infiltration rate, #15 minus #14 ____________ air changes per hour

APPENDIX C

PROTOCOLS FOR CORE ENVIRONMENTAL PARAMETERS

This appendix describes protocols for core environmental parameters. Core parameters are those parameters for which measurements were required for all EPA-sponsored building studies. Table C1 lists the protocols for all core parameters that were measured in the EPA-sponsored building studies.

Table C1 Protocols for Core Environmental Parameters

Protocol	Table Number
Air Temperature	Table C2
Relative Humidity	Table C3
Carbon Dioxide	Table C4
Carbon Monoxide	Table C5
Sound Level	Table C6
Illuminance	Table C7
Particles (PM_{10} and $PM_{2.5}$)	Table C8
Volatile Organic Compounds	Table C9
Formaldehyde	Table C10
Bioaerosols	Table C11
Biological Agents in Bulk Samples	Table C12
Radon	Table C13

Table C2 Protocol for Measurement of Air Temperature

MEASUREMENT PARAMETER	Air temperature (°C)
METHOD DESCRIPTION	Dry bulb temperature of ambient air will be measured by means of thermocouple, RTD or thermistor-based measurement device. Measurements will be performed at four heights above the floor (0.1, 0.6, 1.1, and 1.7 meters). Short-term measurements will be performed at five indoor locations with a mobile unit and continuously at the fixed indoor and fixed outdoor location. Data will be recorded with a datalogger then downloaded to a laptop computer.
RELEVANT PROTOCOLS	ASHRAE Standard 55
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 1%
Accuracy	± 0.3 °C
Resolution	0.1 °C
Range (Quantifiable Limit)	-20 to +60 °C
FIELD INSTRUMENTATION	
Requirements	
Operational Temperature Range	-20 to +60 °C
Operational Relative Humidity Range	2 to 98%
Sampling Duration	Up to 56 hours for continuous monitoring (Tuesday through Thursday); less than 10 minutes for mobile monitoring
Warm-up Time	≤ 1 minute
Response Time (Rise Time)	≤ 1 minute to 90% of temperature
Output	Linear; mV or mA to datalogger (required). Datalogger output must be compatible with laptop computer.
Size	Portable
Power	Battery, 115V AC adapter
Available Instrumentation	Portable electronic, digital thermometers or thermohygrometers are commercially available. A datalogger and computer are required for recording data electronically Examples of thermohygrometers include the following: Telaire Inc. Model 1058T Rotronic Instrument Company, Inc. Model PA-1 Solomat Model 455 Stamford, CT Vaisala, Inc. Model HM132/HMP 35

Table C2 Continued

CALIBRATION REQUIREMENTS	
Multipoint Calibration	
Method Description	Accuracy, precision and linearity of the measurement device must be demonstrated prior to use in the field by comparison to a NIST- traceable device at a minimum of four points between 4 and 35 °C.
Frequency	Multipoint calibration semi-annually
Acceptability Criteria	See Performance Requirements
Field Calibration Checks	
Method Description	Compare ambient reading to NIST-traceable device
Frequency	Perform at beginning and end of the 2-day monitoring session at each building. Check reasonableness of readings daily.
Acceptability Criteria	If the reading of the measurement device differs from the reference device by greater than 1.2 °C, it is unacceptable for field use; a new multipoint calibration must be performed prior to field use.
Calibration Equipment	NIST –traceable device
MONITORING FREQUENCY AND DURATION	See Section 5
DOCUMENTATION REQUIREMENTS	Operator ID Instrument serial number Location Start times/stops times Calibration checks
DATA TRANSFER AND PROCESSING	
Transfer to Electronic Media	Download dataloggers to laptop computer at the end of each day for fixed site monitors.
Back-up	Make one back-up copy at time of download
Field Evaluation	Verify data transferred before turning instrument off
Labeling, Storage, Shipping	Make back-up copies of documentation; ship or transport copies separately
Chain of Custody	Record of data and documentation transfer required
Data Output	Mobile monitoring: Average 3-minute temperature at monitoring site. Continuous (fixed-sites): 5-minute average temperature readings.
QA/QC REQUIREMENTS	
Multipoint Calibration	Perform semi-annually
Calibration Checks	Perform at beginning and end of 2-day monitoring session by comparison to NIST-traceable device.
External Audits	Required for monitoring instrumentation
Documentation	Documentation logs required
Chain of Custody	COC forms required

Table C3 Protocol for Measurement of Relative Humidity	
MEASUREMENT PARAMETER	Relative Humidity (%)
METHOD DESCRIPTION	A portable thermohygrometer will be used to measure relative humidity at a height of 1.1 m above the floor. Short-term measurements will be performed at five indoor locations with a mobile unit and continuously at the fixed indoor and fixed outdoor location. Data will be recorded with a datalogger then downloaded to a laptop computer.
RELEVANT PROTOCOLS	ASHRAE Standard 55
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 5% relative humidity
Accuracy	± 5% relative humidity for range of 20-90% RH
Range (Quantifiable Limit)	2 to 98%
FIELD INSTRUMENTATION	
Requirements	
Operational Temperature Range	0 – 55 °C
Operational Relative Humidity Range	0 – 100% RH
Sampling Duration	Up to 56 hours for continuous monitoring (Tuesday through Thursday); less than 10 minutes for mobile monitoring
Warm-up Time	Approximately 5 minutes
Response Time (Rise Time)	30 sec. To 90% RH
Output	Linear, V, mV or mA to datalogger (required). Datalogger output must be compatible with laptop computer.
Size	Portable
Power	Battery; 115V AC adapter
Available Instrumentation	Omega Model RH411: F1 Stamford, CT Solomat Model 455 Stamford, CT Rotronic Instrument Company, Inc. Model PA-1 Metrosonics Model AQ501/502 Rochester, NY Vaisala, Inc. Model HM132 / HMP 35

Table C3 Continued

CALIBRATION REQUIREMENTS	
Multipoint Calibration	
Method Description	Accuracy, precision and linearity of the measurement device must be demonstrated prior to use in the field by comparison to a NIST- traceable device at a minimum of three points between 20 and 90% RH
Frequency	Multipoint calibration semi-annually
Acceptability Criteria	See Performance Requirements
Field Calibration Checks	
Method Description	Compare ambient reading to NIST-traceable device
Frequency	Perform at beginning and end of the 2-day monitoring session at each building.
Acceptability Criteria	If the reading of the measurement device differs from the reference device by greater than 5%, it is unacceptable for field use; a new multipoint calibration must be performed prior to field use.
Calibration Equipment	NIST –traceable device (a sling psychrometer is not acceptable in an occupied office space)
MONITORING FREQUENCY AND DURATION	See Section 5
DOCUMENTATION REQUIREMENTS	Operator ID Instrument serial number Location Start times/stops times Calibration checks
DATA TRANSFER AND PROCESSING	
Transfer to Electronic Media	Download dataloggers to laptop computer at the end of each day for fixed site monitors.
Back-up	Make one back-up copy at time of download
Field Evaluation	Verify data transferred before turning instrument off
Labeling, Storage, Shipping	Make back-up copies of documentation; ship or transport copies separately
Chain of Custody	Record of data and documentation transfer required
Data Output	Mobile monitoring: Average short-term (3 min) Relative humidity. Fixed-sites - 5 min average RH values measured continuously.
QA/QC REQUIREMENTS	
Multipoint Calibration	Perform semi-annually
Calibration Checks	Perform at beginning and end of 2-day monitoring session by comparison to NIST-traceable device.
External Audits	Required for monitoring instrumentation
Documentation	Documentation logs required
Chain of Custody	COC forms required

Table C4 Protocol for Measurement of Carbon Dioxide (CO_2)

MEASUREMENT PARAMETER	CO_2 concentration
METHOD DESCRIPTION	CO_2 concentration will be measured with a portable, nondispersive infrared (NDIR) analyzer. Short-term measurements will be made with a battery powered mobile unit at five indoor locations. Continuous measurements will be made at the fixed indoor and fixed outdoor site. Fixed site measurements will be made at 1.1 meters above the floor. Data will be recorded with a datalogger, then downloaded to a laptop computer.
RELEVANT PROTOCOLS	Indoor Air Compendium, Method IP-3A
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 50 ppm
Accuracy	± 200 ppm
Resolution	50 ppm
Range (Quantifiable Limit)	0 – 3000 ppm
FIELD INSTRUMENTATION	
Requirements	
Zero Drift	< ± 50 ppm over 8hrs
Span Drift	< ± 50 ppm over 8hrs
Operational Temperature Range	0 to 40 °C
Operational Relative Humidity Range	10 – 90% RH
Sampling Duration	Up to 56 hours for continuous monitoring (Tuesday through Thursday); less than 10 minutes for mobile monitoring
Warm-up Time	Approximately 15 minutes
Response Time	≤ 1 minute to 90% concentration
Output	Linear; mV or mA to datalogger (required). Datalogger output must be compatible with laptop computer.
Size	Portable
Power	Battery: 115V AC adapter

Table C4 Continued	
Available Instrumentation	Model ZFP-5-2050 CA Analytical Instruments Orange, CA Riken Model RI-411A REA Instruments, Inc. Emerson, NJ Metrosonics, Inc. MODEL AQ-501/502 Rochester, NY Gas Tech, Inc. Model 4776 Neward, CA
CALIBRATION REQUIREMENTS	
Multipoint Calibration	
Method Description	Calibrate at three CO_2 concentration levels plus zero. (0, 350, 1000, and 2000 ppm, recommended)
Frequency	Calibrate at beginning and end of monitoring at each building.
Time Required to Calibrate	approximately 45 min
Acceptability Criteria	Correlation coefficient $\geq$ 0.999; no greater than 2% deviation from the straight line for any standard
Zero and Span	
Method Description	Determine zero reading using compressed air or nitrogen and span reading using 1000 ppm CO_2 in air
Frequency	Perform at beginning and end of the day of monitoring when multipoint calibration is not performed
Time Required to Zero and Span	20 minutes
Acceptability Criteria	Recalibrate (multipoint) if zero differs by more than $\pm$ 50 ppm or if concentration at span differs by more than $\pm$ 100 ppm
Calibration Equipment	Set of calibration gas cylinders or gas dilution system, regulators for cylinders, and flow adapters for monitors.
MONITORING FREQUENCY AND DURATION	See Section 5
DOCUMENTATION REQUIREMENTS	Operator ID Instrument serial numbers Location Start times/stop times Calibration checks
DATA TRANSFER AND PROCESSING	
Transfers to Electronic Media	Download dataloggers to laptop computer at the end of each day for fixed site monitors.

Table C4 Continued	
Back-up	Make a back-up copy of electronic files at time of download.
Field Evaluation	Verify data transferred before turning instrument off.
Labeling, Storage, Shipping	Make a back-up copy of data and documentation; ship or transport separately.
Chain of Custody	Record of data and documentation
Data Output	Mobile unit: average 3-minute CO_2 concentrations. Fixed site: 5-minute average CO_2 concentration measured continuously. Monitor readings will be reported without adjustment for drift if acceptability criteria are met. Otherwise, corrections must be made during data processing
QA/QC REQUIREMENTS	
Multipoint Calibrations	Perform at beginning and end of monitoring at each building.
Zero and Span Checks	Perform at beginning and end of each day of monitoring
External Audits	Required for monitoring instrumentation
Documentation	Documentation logs required
Chain of Custody	COC forms required

Table C5 Protocol for Measurement of Carbon Monoxide (CO)

MEASUREMENT PARAMETER	CO concentration (ppm)
METHOD DESCRIPTION	CO concentration will be measured with a portable, monitor (electrochemical sensor). Short-term measurements may be made at the mobile monitoring locations with a mobile unit. Continuous measurements will be made at each fixed indoor and the outdoor site. Measurements will be made at 1.1 meters above the floor. Data will be recorded with a datalogger, then downloaded to a laptop computer.
RELEVANT PROTOCOLS	Indoor Air Compendium, Method IP-3A
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 1 ppm
Accuracy	± 2 ppm
Resolution	1 ppm
Range (Quantifiable Limit)	2 – 100 ppm
Interferences	Hydrogen, ethylene and acetylene are potential interferences. Interferences must be reduced by using a selective filter.
FIELD INSTRUMENTATION	
Requirements	
Zero Drift	< ± 3 ppm over 24 hours
Span Drift	< ± 3 ppm over 24 hours
Operational Temperature Range	0 to 40 °C
Operational Relative Humidity Range	10 - 90% RH
Sampling Duration	Up to 56 hours for continuous monitoring (Tuesday through Thursday); less than 10 minutes for mobile monitoring
Warm-up Time	approximately 1 minute
Response Time	≤ 1 minute to 90% concentration
Output	Linear; mV or mA to datalogger (required). Datalogger output must be compatible with laptop computer.
Size	Portable
Power	Battery: 115V AC adapter

Table C5 Continued	
Available Instrumentation	National Draeger, Inc. Model 190 CO Datalogger Pittsburgh, PA Metrosonics, Inc. MODEL AQ-501/502 Rochester, NY Langan Products, inc. Model L15 (also records temperature) San Francisco, CA Gas Tech, Inc. Model GX-82 Neward, GA
CALIBRATION REQUIREMENTS	
Multipoint Calibration	
Method Description	Calibrate at three CO concentration levels plus zero. (0, 10, 20, and 35 ppm)
Frequency	Calibrate at beginning and end of monitoring at each building.
Time Required to Calibrate	Approximately 30 minutes
Acceptability Criteria	Correlation coefficient ≥ 0.999; no greater than 2% deviation from the straight line for any standard
Zero and Span	
Method Description	Determine zero reading using compressed air or nitrogen and span reading using 10 ppm CO in air
Frequency	At beginning and end of the day of monitoring when multipoint calibration is not performed
Time Required to Zero and Span	10 minutes
Acceptability Criteria	Recalibrate (multipoint) if concentration at any point differs from the "true" value by more than 3 ppm, or if non-linearity is demonstrated.
Calibration Equipment	Set of calibration gas cylinders or gas dilution system, regulators for cylinders, and flow adapters for monitors.
MONITORING FREQUENCY AND DURATION	See Section 5
DOCUMENTATION REQUIREMENTS	Operator ID Instrument serial numbers Location Start times/stop times Calibration checks
DATA TRANSFER AND PROCESSING	
Transfers to Electronic Media	Download dataloggers to laptop computer at the end of each day for fixed site monitors.
Back-up	Make a back-up copy of electronic files at time of download.

Table C5 Continued	
Field Evaluation	Verify data transferred before turning instrument off.
Labeling, Storage, Shipping	Make a back-up copy of data and documentation; ship or transport separately.
Chain of Custody	Record of data and documentation
Data Output	Mobile unit: average 3-minute CO concentrations. Fixed site: 5-minute average CO concentration measured continuously. Monitor readings will be reported without adjustment for drift if acceptability criteria are met. Otherwise, corrections must be made during data processing
QA/QC REQUIREMENTS	
Multipoint Calibrations	Perform at beginning and end of monitoring at each building.
Zero and Span Checks	Perform at beginning and end of each day of monitoring
External Audits	Required for monitoring instrumentation
Documentation	Documentation logs required
Chain of Custody	COC forms required

Table C6 Protocol for Measurement of Sound Level

MEASUREMENT PARAMETER	Sound Level (dB)
METHOD DESCRIPTION	Sound level will be measured with a commercial Type 2 sound meter. Continuous measurements will be made at each fixed indoor site. Measurements will be made at 1.1 meters above the floor. Data will be recorded with a datalogger, then downloaded to a laptop computer.
RELEVANT PROTOCOLS	None for office spaces
METHOD PERFORMANCE REQUIREMENTS	
Precision	$\pm$ 2 dB
Accuracy	$\pm$ 2 dB
Resolution	0.1 dB
Range (Quantifiable Limit)	30 to 130 dB
FIELD INSTRUMENTATION	
Requirements	
Operational Temperature Range	-10 to +50 °C
Operational Relative Humidity Range	5 to 95%
Sampling Duration	Up to 56 hours for continuous monitoring (Tuesday through Thursday); less than 10 minutes for mobile monitoring
Output	Linear; mV or mA to datalogger, or instrument equipped with internal datalogging capabilities. Datalogger output must be compatible with laptop computer
Size	Portable
Power	Battery, 115V AC adapter
Available Instrumentation	Quest Electronics Model 2400 Kit contains meter and calibrator Oconomowoc, WI Metrosonics, Inc. MODEL AQ-501/502 Rochester, NY CEL 231 Kit includes meter and calibrator Available from Vallen Safety Supply
CALIBRATION REQUIREMENTS	
Multipoint Calibration	
Method Description	Laboratory or manufacturer multi-point calibration should be performed annually
Field Calibration Checks	
Method Description	Portable field calibrator should be used.
Frequency	Verify meter performance prior to each use.

Table C6 Continued	
Acceptability Criteria	If the meter reading differs from the reference device by greater than 4 dB, it is unacceptable for field use and should be recalibrated.
Calibration Equipment	Portable field calibrator.
MONITORING FREQUENCY, DURATION, AND LOCATIONS	
Frequency	See Section 5
DOCUMENTATION REQUIREMENTS	Operator ID Instrument serial numbers Location Start times/stop times Calibration checks
DATA TRANSFER AND PROCESSING	
Transfers to Electronic Media	Download dataloggers to laptop computer at the end of each day for fixed site monitors.
Back-up	Make a back-up copy of electronic files at time of download.
Labeling, Storage, Shipping	Make a back-up copy of data and documentation; ship or transport separately.
Chain of Custody	Record of data and documentation
Data Output	Fixed sites: 5 minute average sound levels measured continuously
QA/QC REQUIREMENTS	
Multipoint Calibrations	Perform annually
Calibration Checks	Perform prior to each use with field calibrator.
External Audits	Required for monitoring instrumentation
Documentation	Documentation logs required
Chain of Custody	COC forms required

Table C7 Protocol for Measurement of Illuminance

MEASUREMENT PARAMETERS	Illuminance (lux)
METHOD DESCRIPTION	Illuminance will be measured with a commercial meter. Continuous measurements will be made at each fixed indoor site. Measurements will be made at 1.1 meters above the floor. Data will be recorded with a datalogger, then downloaded to a laptop computer.
RELEVANT PROTOCOLS	CIE Guide on interior Lighting
METHOD PERFORMANCE REQUIREMENTS	
Precision and Accuracy	± 2% of recording
FIELD INSTRUMENTATION	
Requirements	
Metering Range	1 to 2000 lux
Operational Temperature Range	0 to 40 °C
Operational Relative Humidity Range	5 to 95%
Output	Linear; mV or mA to datalogger, or instrument equipped with internal datalogging capabilities. Datalogger output must be compatible with laptop computer
Size	Portable hand held units
Power	Battery, 115 VAC adapter
Available Instrumentation	Minolta T-1 Illuminance Meter ($625) Minolta Corporation Ramsey, NJ 07446-129 Metrosonics, Inc. MODEL AQ-501/502 Rochester, NY
CALIBRATION REQUIREMENTS	
Multipoint Calibration	
Method Description	Laboratory calibration against known standard annually
Field Calibration Checks	
Method Description	Zero calibration
MONITORING FREQUENCY AND DURATION	
Frequency	See Section 5
DOCUMENTATION REQUIREMENTS	Operator ID Instrument serial numbers Location Start times/stop times Calibration checks
DATA TRANSFER AND HANDLING	
Transfer to Electronic Media	Download dataloggers to laptop computer at the end of each day for fixed site monitors.
Back-up	Back-up copy electronic media.
Chain of custody	Required

Table C7 Continued	
Data Output	Fixed sites: 5 minute average lux levels measured continuously
QA/ QC REQUIREMENTS	
Multipoint Calibration	Perform annually
Calibration Checks	Follow manufacturer's instructions
External Audits	Required for monitoring instrumentation
Documentation	Documentation logs required
Chain of Custody	COC forms required
MEASUREMENT PARAMETER	Particles (PM_{10} and $PM_{2.5}$)
METHOD DESCRIPTION	Ambient air will be passed through a particle size selective device (impactor) at a constant and specified flowrate. For PM_{10}, particles greater than 10 microns are removed from the airstream by impaction and discarded. Particles equal to or smaller than 10 microns are collected on a pre-weighed filter. For $PM_{2.5}$, particles greater than 2.5 microns are removed from the airstream by impaction and discarded. Particles equal to or smaller than 2.5 microns are collected on a pre-weighed filter. The mass of the collected particulate will be determined gravimetrically using an analytical balance. Integrated samples will be collected over an 8-hour period at three indoor and one outdoor location.
RELEVANT PROTOCOLS	Indoor Air Compendium Method IP-10A
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 25%
Accuracy	± 25%
Method Quantifiable Limit (MQL)	10 $\mu g/m^3$ for 8 hour sample
Range (Qualifiable Limit)	10 – 120 $\mu g/m^3$ for 8 hour sample
Interferences	Static electricity and humidity during filter weighing
FIELD INSTRUMENTATION	
Pump Flow Rate	10 L/min
Pump Flow Stability	± 5%
Operational Temperature Range	0 – 40 °C
Operational Relative Humidity Range	0 – 100%

Table C8 Protocol for Measurement of Particles (PM_{10} and $PM_{2.5}$)	
Sampling Duration	8 hours, continuous
Warm-up Time	5 minute (pump)
Size	Portable
Power	115 VAC
Noise	Low-noise pump required
Available Instrumentation	Pump and Impactor Air Diagnostics and Engineering, Inc. RR 1 Box 445 Naples, Maine
PUMP CALIBRATION REQUIREMENT	
Method Description	Performance of the impactor (cut-point, collection efficiency) must be demonstrated prior to use. Pump flowrate is measured from outlet using a soap film bubble meter or a calibrated rotameter. Measure flow rate at the beginning and end of each monitoring period
Acceptance Criteria	Measured flow rate change less than ± 5%
Time Required to Calibrate	Approximately 10 minutes
Calibration Equipment	Flow meter and adapter for impactor head
MONITORING FREQUENCY AND DURATION	
Frequency	Collect at three fixed site indoor locations and one outdoor location on one day (See Section 5).
Duration	Approximately 8 hrs
Documentation Requirements	Operator ID Instrument Serial number Sampling location Start/stop flow rates Start/stop times
SAMPLING HANDLING	
Field Handling	Assembly and disassembly of the filters into the sampling heads should be performed in a relatively dust free environment such as laboratory clean room or designated workroom. Pre-weighed and collected filters must be handled gently with forceps to avoid damage, contamination, or dislodging of collected particles before final weight is determined. Lint free gloves should be worn during filter assembly/disassembly.
Field Storage	Filters must be individually stored in dust-free, low static containers and protected from shock.
Shipping	Hand carried if possible to avoid dislodging particles. Otherwise, overnight delivery in well protected shipping container.

Table C8 Continued

Laboratory Storage	Prior to final weight determination, store filters in temperature and humidity controlled weighing room. Allow filters to condition for at least 24 hours before weighing.
Chain of Custody	Chain of custody required for each sample.
SAMPLE ANALYSIS	
Instrumentation Requirements	Cahn Model 37 micro-balance or equivalent capable of weighing $\pm$ 5 μg. Weighing room with controlled temperature and humidity.
Calibration Requirements	At beginning of each weighing session, adjust zero and calibrate balance with 200 mg NIST traceable reference weights. Check the balance zero and 200 mg NIST weigh after every tenth filter. Readout should be within 0.000 $\pm$ 0.004 mg and 200.000 mg $\pm$ 0.002 mg
QA/QC REQUIREMENTS	
Number of Fields Blanks	One per building.
Number of Duplicates	One indoor location and the outdoor location at each building; minimum of two filters and 5% duplicate weighings (minimum of two) by different individual each weighing session.
Analytical System	In addition to calibration with NIST class "S" weights and zero check after every tenth filter, the first filter in a batch is reweighed at the end of the batch. If weight differs by $\pm$ 0.007 mg, the entire batch is re-weighed.
Chain of custody	Chain of custody required for each sample.
Performance Evaluation Samples	Requirements to be determined
Field Audit	Perform field audit of procedure adherence, pump flows, sample handling, flow calibration devices, etc.
DATA PROCESSING	
Data Output	Report $\mu g/m^3$ for each location, uncorrected for background

Table C9 Protocol for Measurement of Volatile Organic Compounds (VOCs)	
MEASUREMENT PARAMETER	Volatile organic chemical concentrations ($\mu g/m^3$, and ppb). Quantification estimates should be made for TVOCs, total aliphatics, total aromatics, and selected target chemicals, if different from the target analytes, should be identified in the sample and quantitation estimates made. Integrated samples will be collected at the fixed indoor and outdoor location.
METHOD DESCRIPTION	Tenax Cartridge: Approximately ten liters of ambient air will be passed through a glass cartridge containing approximately 1.5 g of Tenax during and 8-hour period. The cartridges will be returned to the laboratory, loaded with external standards and analyzed. Analysis requires thermal desorption of the trapped organics followed by cryofocusing and subsequent injection into a GC/MC system. Samples will be collected in duplicate to maximize data completeness. Summa Canister: Approximately five and one-half liters of ambient air will be collected using an evacuated, pre-cleaned SUMMA canister sampling system. The canisters will be returned to the laboratory, loaded with external standards and analyzed. Analysis requires sampling a known aliquot of the whole air, followed by cryofocusing and subsequent injection into a GC/MS system. Multisorbent Tube: During an 8-hour period, approximately 2.5 liters of ambient air will be passed through a glass cartridge containing sorbent materials consisting of: 1) glass beads; 2) Tenax TA; 3) Ambersorb XE-340; and 4) activated carbon. Each section is separated by glass-wool plugs. The cartridges will be returned to the laboratory, loaded with external standards and analyzed. Analysis requires thermal desorption of the trapped organics followed subsequent injection into a GC/MC system. Samples will be collected in duplicate to maximize data completeness.
RELEVANT PROTOCOLS	Indoor Air Compendium Method IP-1A and IP-1B (1990); Ambient Air Compendium Method TO-1 and TO-14 (1988)
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 20% RSD
Accuracy	± 25%

Table C9 Continued	
Method Quantifiable Limit (MQL)	Specific VOCs - 0.1 to 1.5 $\mu g/m^3$
Range	Specific VOCs - 0.5 to 20 ng/m^3
FIELD INSTRUMENTATION	
Requirements – Tenax Pumps	
Pump Flow Range	15-50 mL/min flow-controlled; 20 mL/min over an 8-hour period is required to collect a 10 liter sample.
Pump Flow Stability	±1 mL/min
Operational Temperature Range	0-40 °C
Operational Relative Humidity Range	0 – 100% RH
Sampling Duration	8 hours. Continuous
Warm-up Time	5 minute (pump)
Size	Portable Pump
Power	Battery
Noise	Low-noise pump required
Available Instrumentation-Tenax	Dupont Alpha-2 Dupont Company Kennet Square, PA SKC Model 222-4 Eighty Four, PA Gilian LFS113 Wayne, NJ
Requirements - SUMMA Canister	
Sample Flow meter Range	0.5 – 20.0 mL/min, required to collect 5 plus liter sample over 8-9 hour period
Meter Flow Stability	± 0.05 cm^3/min
Operational Temperature Range	0 – 40 °C
Operational Relative Humidity Range	0 – 100% RH
Sampling Duration	8 – 9 hrs continuously
Warm-up Time	5 minute (flow meter)
Size	Portable
Power	No power required
Noise	No noise
Available Instrumentation - SUMMA	Andersen Instruments Atlanta, GA SIS Instruments Moscow, ID
Requirements – Multisorbent Pumps	
Pump Flow	5 cm^3/min over an 8 hour period is required to collect a 2.4 liter sample.
Operational Temperature Range	0 – 40 °C
Operational Relative Humidity Range	0 – 100% RH

Table C9 Continued

Sampling Duration	8 hours continuous
Warm-up Time	5 minutes (pump)
Size	Portable
Power	115 VAC
Noise	Low-noise pump required
Available Instrumentation-Multisorbent	*Sample Media* Envirochem, Inc., Part No. ST-032, Kemblesville, PA. *Diaphragm pumps with flow controllers* Berkeley Analytical Associates Richmond, CA
PUMP/METER CALIBRATION REQUIREMENT	
Method Description	Tenax: Pump flowrate is measured from the outlet of the pump with a soap film bubble meter. Multisorbent: Pump flowrate is measured from the outlet of the pump with a soap film bubble meter.
Frequency	Measure at beginning and end of each monitoring period
Time Required to Calibrate	10 minutes
Acceptability Criteria	Readjust pump flowrate at the start of sampling if measurement is greater than 5% of target flow rate shown below: Tenax: 18.5 mL/min to collect a 10 L Tenax sample over a 9-hour period. SUMMA: 10 mL/min to collect a 5.5 L SUMMA sample for 9-hour period. Multisorbent: 5 cc/min to collect a 2.4 liter sample over an 8-hour period is required
Calibration Equipment	Soap film bubble flow meter or mass flow meter
MONITORING FREQUENCY AND DURATION	
Frequency	Collect at fixed site locations each sampling day. (See Section 5)
Duration	Approximately 9 hours per location (workday)
Documentation Requirements	Operator ID number Instrument serial numbers Sampling location Start/stop flowrates Start/stop times

Table C9 Continued	
SAMPLE PREPARATION AND HANDLING	
Cartridge Preparation	Cartridges are prepared using the procedure specified in Method IP-1B. To ensure cleanliness, 10% of all cartridges must be analyzed prior to shipment to the field. Analyses for background contamination are performed by either GC/MS or GC/flame ionization detection. Cartridges are considered acceptable if less than 10 ng of any individual target VOC or less than 50 ng TVOC are found. Clean cartridges are sealed in culture tubes with Teflon lined screw caps. For shipping, Tenax cartridges are placed in uncoated paint cans. Multisorbent sampling tubes are transported in ice chests with ice packs to keep the samplers cool.
Summa Canister Preparation	SUMMA Canisters are prepared using the procedures specified in Method IP-1A. To ensure cleanliness, 10% of all canisters must be analyzed prior to shipment to the field. Analyses for background contamination are performed by either GC/MS or BC/flame ionization detection. Canisters are considered acceptable if less than 10ng of any individual target VOC or less than 50 g packaged in boxes and shipped to the field for monitoring.
Field Handling	Handle Tenax cartridges with white cotton gloves or Kimwipes®. Multisorbent tubes can be handled with ungloved hands, however care must be taken to avoid contamination. Hands should be free of dirt and oil before handling the media. Also, samplers should be held by the middle of the tube to avoid the ends near the openings. Do not touch the SUMMA canister inlets.
Field Storage	Cartridges and/or canisters must be properly stored to ensure that contamination does not occur. On past studies, cartridges sealed in paints cans have been stored in helium-purged Tedlar bags. Multisorbent samplers should be stored in a freezer or refrigerator that is not used for the storage of chemicals.
Shipping	Exposed Tenax cartridges are resealed in culture tubes, placed inside sealed uncoated paint cans, then shipped by overnight delivery to the laboratory in cushioned hardsided shipping containers. Exposed containers are closed and capped and shipped by overnight delivery to the laboratory in shipping containers.

Table C9 Continued

Shipping (continued)	Exposed multisorbent samplers are tightly sealed in glass culture tubes, placed inside a cushioned, hard sided ice chest (with ice packs) and shipped to the laboratory via overnight delivery. SUMMA canisters are placed in their shipping container and shipped to the laboratory via overnight delivery.
Laboratory Storage	Store cartridges sealed in cultures tubes, inside a "clean" freezer at 4 °C. Store canisters in contamination free area. Maximum storage time is 6 weeks after collection.
Chain of custody	Chain of custody required for each sample.
SAMPLE ANALYSIS	
Instrumentation Requirements	Gas chromatograph/mass spectrometer equipped with a thermal desorption interface for Tenax, or multisorbent sample analysis or canister interface for SUMMA sample analysis. Analysis is full scan mode.
Calibration Requirements	Prior to calibration, instrument must meet standard tune criteria for either perfluorotoluene or bromofluorobenzene. Calibration is performed by analyzing four or five cartridges that contain known concentrations of the VOCs and the internal standard. Calibration cartridges and/or canisters can be prepared using tubes, flash evaporation or static dilution. Concentration target VOCs should range from 10 to 1000 ng/cartridge or canister. Relative response factors are generated for each cartridge and/or canister. For the calibration to be considered acceptable, %RSD of the relative response factor must be less than 25%. Each day of analysis two criteria must be met. First, the instrumental tune criteria must be in control. Second, a mid-level calibration standard is analyzed. Relative response factors must agree within 25% of the mean. If this criterion cannot be met, the instrument must be recalibrated. Average response for n-decane, and n-dodecane will be used for total aliphatic concentration estimates.
Data Output	Report ng/m and ppb for each location, not corrected for background contamination (field blanks) or % recovery (field controls).

Table C9 Continued

QA/QC REQUIREMENTS	
Number of Field Blanks	One per building
Number of Control	One per building
Number of Duplicates	One each at one indoor and the outdoor location at each building
Pump flowrates	Beginning and ending flowrate measurements
Analytical System	Analyze response factor cartridge and/or canister daily before analyzing samples
Chain of Custody	Chain of custody required for each sample
Performance Evaluation Samples	Analysis of one PE sample prepared by independent lab or analysis of one duplicate sample by independent laboratory per building.
Field Audit	Audit of flow calibration devices, pump flows, and sampling procedures required.

Table C10 Protocol for Measurement of Formaldehyde	
MEASUREMENT PARAMETER	Formaldehyde concentration ($\mu g/m^3$)
METHOD DESCRIPTION	Ambient air samples will be collected with 2,4-dinitrophenylhydrazine (DNPH) coated silica gel cartridges. Samples are analyzed by reverse phase HPLC using a UV detector operated at 360 nm. Integrated samples will be collected over an 8-hour period at the fixed indoor and outdoor locations.
RELEVANT PROTOCOLS	Indoor Air Compendium Method IP-6A; Ambient Air Compendium Method TO-11
METHOD PERFORMANCE REQUIREMENTS	
Precision	± 25% RSD (for duplicate samples)
Accuracy	± 20%
Method Quantifiable Limit (MQL)	0 5 $\mu g/m^3$ (for 100 L sampling volume)
Range	0 5 to 1000 $\mu g/m^3$
Interferences	Unresolved organic compounds having same retention time and significant absorbance at 360 nm may interfere. Ozone is a known interference that can be removed with a potassium iodide-coated tubular denuder placed upstream of the sampling cartridge. NOTE: Acetonitrile is released from the cartridge during sampling. It must be collected from the pump outlet with a trap containing charcoal to minimize interferences with VOC measurements.
FIELD INSTRUMENTATION	
Requirements	
Pump Flow Range	50 – 1500 mL/min (200 mL recommended for 96 liter sampling volume)
Pump Flow Stability	5%
Operational Temperature Range	0 – 40 °C
Operational Relative Humidity Range	0 – 100%
Sampling Duration	8 hour continuous
Warm-up Time	5 minute (pump)
Size	Portable
Power	Battery,115V AC Adapter
Noise	Low noise pump required
Special Requirements	Outlet of the pump must be fitted with a trap containing charcoal to collect acetonitrile released from Sep-Pak cartridge during sampling

Table C10 Continued	
Available Instrumentation and Media	Prepared Sep-Pak cartridges are available from Waters Associates, Milford, WA Dupont Alpha-2 Pump Dupont Company Kennet Square, PA SKC Model 222-4 Pump Eighty Four, PA Gilian LFS113 Pump Gilian Instrument Corp. West Caldwell, NJ
PUMP CALIBRATION REQUIREMENT	
Method Description	Pump flow rate is measured from the outlet of the pump with a soap film bubble meter.
Frequency	Flow rate measurements at the beginning and end of each monitoring period
Time Required to Calibrate	10 minutes
Calibration Equipment	Soap film bubble flow meter.
MONITORING FREQUENCY AND DURATION	
Frequency	Collect at fixed-site locations on one day (See Section 5)
Duration	Approximately 8 hours
Documentation Requirements	Operator ID number Instrument serial numbers Sampling locations Start/stop flow rates Start/stop times
SAMPLE HANDLING	
Field Handling	Sampler preparation and handling procedures must minimize background contamination
Field Storage	Sampling cartridges are capped with Luer end plugs and placed in sealed glass culture tubes inside sealed uncoated paint can. Paint cans should contain 1 – 2 inches of granular charcoal.
Shipping	Cartridges are shipped sealed in culture tubes, inside sealed uncoated paint cans containing granular charcoal. Paint cans are placed inside cushioned hard-sided shipping containers. Ship by overnight delivery to laboratory.
Laboratory Storage	Store cartridges sealed in culture tubes, inside paint cans, in a "clean" freezer at 4 °C
Chain of Custody	Chain of custody required for each sample
SAMPLE ANALYSIS	
Instrumentation Requirements	HPLC Systems with a variable wavelength UV Detector (360 nm wavelength)

Table C10 Continued	
Calibration Requirements	Five point calibration with calibration standards prepared in acetonitrile from DNPH-formaldehyde derivative. (General procedures in IP-6A should be followed)
DATA PROCESSING	
Data Output	Report $\mu g/m^3$ for each location; not corrected for background contamination (field blanks) or % recovery (field controls).
QA/QC REQUIREMENTS	
Number of Field Blanks	One per Building
Number of Field Controls	One per Building
Number of Duplicates	One each at one indoor location and at the outdoor location
Analytical Systems	Daily response of system determined by analysis of intermediate concentration standard.
Chain of Custody	Chain of custody required for each sample
Performance Evaluation Samples	Analysis of one PE sample prepared by independent laboratory or analysis of one duplicate sample by independent laboratory per building.
Field Audit	Audit of flow calibration devices, pump flows and sampling procedures required.

Table C11 Protocol for Measurement of Bioaerosols

MEASUREMENT PARAMETER	Mesophilic Bacteria, thermophilic bacteria and fungi
METHOD DESCRIPTION	Culturable air spora are collected onto agar by impaction using an Anderson N6 sampler. Media are cultured. Analysis by light microscopy.
RELEVANT PROTOCOLS	Guidelines for the Assessment of Bioaerosols in the Indoor Environment (ACGIH, 1989)
METHOD PERFORMANCE REQUIREMENTS	
Precision	Objectives have not been established
Accuracy	Objectives for the method have not been established
FIELD INSTRUMENTATION	
Requirements	
Pump Flow Rate	28.3 LPM
Pump Flow Stability	± 5%
Sampling Duration	2-minute and 5-minute – two samples of different air volumes for each culture media collected at each location each time period.
Power	AC required for pump
Noise	Use low noise vacuum pump
Required Instrumentation and Materials	
Sampler	Andersen N6 Microbiological Sampler and vacuum pump capable of sampling at 28 LPM
Culture media (20 1 mL per plate)	Bacteria: Trypticase soy agar (TSA) Fungi: Malt extract agar (MEA) Sterility and ability to support growth must be documented
PUMP CALIBRATION REQUIREMENTS	
Method Description	Pump flowrate is measured in the field with a calibrated rotameter in-line between the sampler and pump.
Frequency	Record pump flowrate for each sample collected.
Acceptability Criteria	Adjust pump if flowrate differs by more than ±5% from 28.3 LPM
Field Calibration Equipment	Calibrated rotameter
MONITORING FREQUENCY AND LOCATIONS	
Frequency	Collection at approximately 10:30 a.m. and 3:30 p.m. on Wednesday
Locations	Three fixed-site integrated sampling locations indoors and the one outdoor fixed-site location
Duration	For each culture media, collect samples of 2-minute and 5-minute duration.

Table C11 Continued

Documentation Requirements	Operator ID Instrument serial numbers Sampling location Sampler flowrate Sampling start/stop times Media
SAMPLE HANDLING	
Field Handling	Samples must be handled to avoid contamination by operator
Field Storage	Store in well-insulated boxes
Shipping	Transport (ship) from sampling site for receipt at laboratory within 24 hours of collection
Laboratory Storage	Incubation should begin as soon as possible after receipt
Incubation	Mesophilic Bacteria: 32 ± 2 °C for minimum of 3 days in dark Thermophilic Bacteria: 55 ± 2 °C for minimum of 7 days in dark Fungi: 25 ± 3 °C for minimum of 5 days under fluorescent light
Chain of Custody	Documented chain of custody required for all samples and documentation forms
SAMPLE ANALYSIS	
Instrumentation Requirements	Facilities for culture of media and analysis by light microscopy
Analysis Requirements	Staff performing the analysis should have demonstrated experience in the handling and analysis of environmental isolates. Analyst must be trained in enumeration of counts using the Andersen N6 sampler. "Positive-hole" correction must be used to determine the total colony-forming units (CFU) per m^3
Data Output	Fungi: CFU/m3 by genus Total CFU/m^3 Bacteria: CFU/m^3 for gram positive CFU/m^3 for gram negative Total CFU/m^3
QA/QC REQUIREMENTS	
Number of Field Blanks	One set of each culture media at each building
Number of Field Controls	Not Applicable
Number of Duplicates	One set at an indoor location, one set at the outdoor location

Table C11 Continued	
Performance Evaluation Samples	Replicate analysis of a subset of samples should be performed by a senior microbiologist to determine intra-laboratory variation in counts and identification. Analysis of subset of duplicate plates should be performed by second laboratory to assess inter-laboratory variability
Chain of Custody	Required for all samples
Field Audit	Pump flowrate

Table C12 Protocol for Measurement of Biological Agents in Bulk Samples	
MEASUREMENTS PARAMETERS	Mesophilic bacteria, thermophilic bacteria and fungi
METHOD DESCRIPTION	Fluids from water reservoirs (e.g. humidifiers) or drip pans, scrapings from surfaces) and fibers or particulate matter (e.g. from HVAC ducts) will be collected and analyzed if obvious growth of microbiological organisms is observed.
REVELANT PROTOCOLS	ACGIH Guidelines for Assessment of Bioaerosols in the Indoor Environment, 1989
METHOD PERFORMANCE REQUIREMENTS	
Precision	Objectives for the methods have not been established
Accuracy	Objectives for the methods have not been established
Lower Limit of Detection (LOD)	Not established
FIELD INSTRUMENTATION	
Requirements	Sterile containers, pipettes, and spatulas
CALIBRATION REQUIREMENTS	
Method Requirements	Not field requirements
MONITORING FREQUENCY AND LOCATIONS	
Frequency and Locations	As required (See Section 5)
Documentation Requirements, (as appropriate)	Technician ID Sampling location Sample type Sampling date/time
SAMPLE COLLECTION HANDLING	
Field Collection	All sampling apparatus and containers must be sterile; collect sufficient sample for analysis (specified by analytical laboratory)
Field Handling	Samples must be handled to avoid contamination by operator
Field Storage	Store in well-insulated boxes
Shipping	Transport (ship) from sampling site for receipt at laboratory within 24 hours of collection
Laboratory Storage	Incubation should begin as soon as possible after receipt
Culture Media	Mesophilic bacteria: Trypticase soy agar (TSA) Themophilic bacteria: TSA Fungi: Malt extract agar (MEA)

Table C12 Protocol for Measurement of Biological Agents in Bulk Samples	
Incubation	Mesophilic bacteria: 32 ± 2 °C for minimum of 3 days in dark Themophilic bacteria: 55 ± 2 °C for minimum 7 days in dark Fungi: 25 ± 3 °C for minimum of 5 days under fluorescent light
Chain of Custody	Documented chain of custody required for all samples and documentation forms
SAMPLE ANALYSIS	
Instrumentation Requirements	Facilities for culture of media and analysis by light microscopy
Analysis Requirements	Staff performing the analysis should have demonstrated experience in the handling and analysis of environmental isolates.
Data Output	CFU/g or CFU/mL
QA/QC REQUIREMENTS	
Field Blanks	Not applicable
Field Controls	Not applicable
Number of Duplicates	One set at each building
Performance Evaluation Samples	Replicate analysis of a subset of samples should be performed by a senior microbiologist to determine intra-laboratory variation in counts and identification. Analysis of subset of duplicate samples should be performed by second laboratory to assess inter-laboratory variability
Chain of Custody	Chain of custody required for all samples

Table C13 Protocol for Measurement of Radon Gas

MEASUREMENT PARAMETERS	Radon (pCi/L)
METHOD DESCRIPTION	Radon will be measured using diffusion barrier charcoal canisters placed in the study area and at locations in the ground floor of the building.
RELEVANT PROTOCOLS	Preliminary guidance from EPA based on comments on National School Survey
PERFORMANCE REQUIREMENTS	
Precision	± 20%
Accuracy	± 25%
FIELD INSTRUMENTATION	
Description	Diffusion barrier charcoal canister will be provided by EPA/NAREL. Sample collection by passive diffusion; no pumps or other instrumentation required.
MONITORING FREQUENCY DURATION AND LOCATIONS	
Frequency	One set of samples per building
Duration	Expose canisters for 96 hours (approximately Monday at noon to Thursday at noon)
Locations	One ground contact floor, place one sampler in each occupied room. In open areas place at rate of 1 per 5000 square feet in all occupied areas and 1 per 2000 square feet in all occupied areas. Place one in the base areas of elevators shafts and in the base area of stairwells. On the floor(s) of the test space, place 1 sampler at each stairwell and elevator opening, and at each fixed indoor sampling site.
Documentation	Placement location, start date and time, stop date and time on documentation form to be prepared in consultation with EPA.
SAMPLE HANDLING	
Field Handling, Storage and Shipping	Per EPA standard operating procedures overnight shipping required.
Chain of Custody	COC forms required
SAMPLE ANALYSIS	
Instrumentation Requirements	None; Samples to be analyzed by EPA
Calibration Requirements	None; Samples to be analyzed by EPA
QA/QC REQUIREMENTS	
Number of Field Blanks	Five percent of the number of detectors deployed; minimum of one per building
Number of Field Control	To be determined
Number of Duplicates	Placed in ten percent of all measurement locations; minimum of one per building
Analytical System	Responsibility of EPA
Chain of Custody	Required of each sample
Performance Evaluation Samples	Responsibility of EPA

APPENDIX D

CHECKLISTS FOR SUBJECTIVE OBSERVATIONS

This checklist is designed to collect subjective information about conditions at each mobile site during the monitoring week. Observations should be made by the field team member at each of the five indoor mobile sites during the morning and afternoon monitoring periods.

Site Identification	**Location Description**
Mobile Site 1	______________________________
Mobile Site 2	______________________________
Mobile Site 3	______________________________
Mobile Site 4	______________________________
Mobile Site 5	______________________________

1. During the monitoring period, did you observe any of the following odors near the mobile monitoring locations? If so, check the appropriate box.

Odor	Mobile Sites 1	2	3	4	5	Notes
Body odor						
Cosmetics, (i.e. perfume or aftershave)						
Tobacco smoke						
Fishy smells						
Other food smells (describe at right)						
Musty or “damp basement” smells						
Odors from diesel or other engine exhaust						
Chemical odors (i.e., solvents, cleaning products, consumer products, etc.)						
Other unpleasant odors (describe at right)						

2. During the monitoring period, did you observe any of the following noise near the mobile monitoring locations? If so, check the appropriate box.

Noise	Mobile Sites 1	2	3	4	5	Notes
Intermittent load noise (i.e., office machines)						
Continuous noise (i.e., fans, radio)						
Loud conversations						

3. During the monitoring period, did you observe any of the following pollutant sources in use at the mobile monitoring locations? If so, check the appropriate box.

Sources in Use	Mobile Sites					Notes
	1	2	3	4	5	
Tobacco smoke						
Adhesives, glues, white-out, etc.						
Paints						
Pesticides						
Cleaners						
Photocopying machines						
Other (describe at right)						

4. At the monitoring locations, how would you rate the housekeeping, based on the following parameters?

Housekeeping	Mobile Sites					Notes
	1	2	3	4	5	
a. Surface dust visible on desks and file cabinets						
1. None						
2. Moderate dustiness						
3. Heavy dust layer						
b. Surface dust visible on window sills or bookshelves						
1. None						
2. Moderate dustiness						
3. Heavy dust layer						
c. Cleanliness of non-carpeted floors						
1. No noticeable dust						
2. Some noticeable dust						
3. Heavy dust						
4. Heavy soiling						
d. Cleanliness of carpeted floors						
1. No noticeable soiling/dust						
2. Some soiling						
3. Heavy soiling						
4. Some stains						
5. Many stains						
6. Noticeable water damage stains						

APPENDIX E

PROTOCOLS AND FORMS FOR THE STUDY AREA(S) HVAC SYSTEM MEASUREMENTS

The checklists presented in the table below are used for collecting data on the performance of the air handling unit(s) serving the test space, exhaust fan(s) serving the tests space, and local supply air ventilation performance. Instructions for completing each checklist are provided at the beginning of Appendix E.

Form	Title
Form E Instructions	Checklist Instructions: HVAC System Performance Measurements
Form E1	Air Handling Unit Performance Measurements
Form E2	Local Supply Air Ventilation Performance Measurements
Form E3	Exhaust Fan Operation Checklist
Form E4	Exhaust Fan Performance Measurements
Form E5	Natural Ventilation: Continuous Carbon Dioxide
Form E6	Natural Ventilation: Tracer Gas Decay

CHECKLIST INSTRUCTIONS: HVAC SYSTEM PERFORMANCE MEASUREMENTS

The HVAC system performance measurements employ the following forms:

- FORM E1, AIR HANDLING UNIT PERFORMANCE MEASUREMENTS
- FORM E2, LOCAL SUPPLY AIR VENTILATION PERFORMANCE MEASUREMENTS
- FORM E3, EXHAUST FAN OPERATION CHECKLIST
- FORM E4, EXHAUST FAN PERFORMANCE MEASUREMENTS
- FORM E5, NATURAL VENTILATION – CONTINUOUS CARBON DIOXIDE
- FORM E6, NATURAL VENTILATION – TRACER GAS DECAY

FORM E1 AIR HANDLING UNIT PERFORMANCE MEASUREMENTS

Form E1 is used to document performance measurements conducted on the air handling units serving the test space. These measurements include the determination of air handling unit supply airflow rate, return airflow rate and outdoor airflow rate. Air flow rate measurements are performed with a pitot tube traverse (hot-wire traverse method is also acceptable) according to standard procedures contained in the ACGIH Industrial Ventilation Manual, AMCA Publication 203-90 and the ASHRAE Standard 111. Results of are flow rate measurements are used in the determination of air handling unit percent outdoor air. In addition to the volume method, air handling unit percent outdoor air is also determined by measuring the air handling unit air stream carbon dioxide concentrations (supply air, return air and outdoor air). Other air handling unit performance measurements include the measurement of air stream temperature and relative humidity levels.

The entries on Form E1 are to be completed as follows:

Air Handling Unit Supply Air Measurements

1. **AHU ID:** Enter the identification number of the air handling unit. Record both the number referenced in the mechanical drawings and the two digit test space air handling unit identifier (e.g. “01”, “02”, etc.)

2. **Measurement Location:** Enter the measurement location of the air handling unit supply air traverse.

3. **Instrument Used:** Enter the test instrument used for the air handling unit supply air traverse. Information should include instrument type, model, serial number and any other appropriate identification numbers.

4. **Duct Dimensions:** Enter the dimensions of the duct at the location of the air handling unit supply air traverse. Record duct dimensions as inches x inches for rectangular ducts or inches in diameter for round ducts.

5. **Duct Area:** Enter the area of the duct at the location of the air handling unit supply air traverse. Record duct area as square feet. Note to account for internal duct insulation if duct systems are so equipped.

6. **Measurement Results:** Enter the results of the air handling unit supply air measurement. Record measurement start and stop times, average air velocity and calculated air volume flow rate. Measurements are conducted Tuesday afternoon, Wednesday morning, Wednesday afternoon, Thursday morning, and Thursday afternoon.

Air Handling Unit Outdoor or Return Air Measurements

Ideally, direct measurement should be conducted at the outdoor air intake. However, if conditions at the intake, such as excessive turbulence or limited access, prohibited taking measurements, then measurements should instead be taken of the return airstream. The difference in the measured supply airflow rate and the measured return airflow rate can be used to calculate outdoor airflow rate. The entries required for outdoor air or return air flow rate measurements are as follows:

7. **Measurement Type:** Enter whether a direct measurement is being conducted of air handling unit outdoor air or of air handling unit return air.

8. **Measurement Location:** Enter the measurement location of the air handling unit outdoor air or return air traverse.

9. **Instrument Used:** Enter the test instrument used for the air handling unit outdoor air or return air traverse. Information should include instrument type, model, serial number and any other appropriate identification numbers.

10. **Duct Dimensions:** Enter the dimensions of the duct at the location of the air handling unit outdoor air or return air traverse. Record duct dimensions as inches x inches for rectangular ducts or inches in diameter for round ducts.

11. **Duct Area:** Enter the area of the duct at the location of the air handling unit outdoor air or return air traverse. Record duct area as square feet. Note to account for internal duct insulation if duct systems are so equipped.

12. **Measurement Results:** Enter the results of the air handling unit outdoor air or return air measurement. Record measurement start and stop times, average air velocity and calculated air volume flow rate. Measurements are conducted Wednesday morning, Wednesday afternoon, Thursday morning, and Thursday afternoon.

AHU CO_2, Temperature and Relative Humidity Measurements

13. **Supply Air Measurement Location:** Enter the measurement location of the air handling unit supply air CO_2, temperature and relative humidity measurements.

14. **Return Air Measurement Location:** Enter the measurement location of the air handling unit return air CO_2, temperature and relative humidity measurements.

15. **Outdoor Air Measurement Location:** Enter the measurement location of the air handling unit outdoor air CO_2, temperature and relative humidity measurements.

16. **CO_2 Instrument Used:** Enter the test instrument used for the air handling unit CO_2 measurements. Information should include instrument type, model, serial number and any other appropriate identification numbers.

17. **Temperature Instrument Used:** Enter the test instrument used for the air handling unit temperature measurements. Information should include instrument type, model, serial number and any other appropriate identification numbers.

18. **Relative Humidity Instrument Used:** Enter the test instrument used for the air handling unit relative humidity measurements. Information should include instrument type, model, serial number and any other appropriate identification numbers.

19. **Measurement Results:** Record the results of the air handling unit supply, return and outdoor air measurements of CO_2, temperature and relative humidity. Record start and stop times for each parameter and the measured CO_2, temperature and relative humidity. To ensure measurement stabilization, a total of five measurements are recorded for each parameter at one-minute intervals. Measurements are conducted Wednesday morning, Wednesday afternoon, Thursday morning, and Thursday afternoon.

20. **Percent outdoor air by volume method:** Using the measurement results obtained in #6 and #12, calculate the air handling unit percent outdoor air by the volume method as follows;

Measurement of outdoor air (CFM_{OA}) and supply air flow.

$$\%OA = \frac{CFM_{OA}}{CFM_{SA}} \times 100$$

Measurement of supply air (CFM_{SA}), and return air (CFM_{RA}) flow.

$$\%OA = \frac{CFM_{SA} - CFM_{RA}}{CFM_{SA}} \times 100$$

21. **Percent Outdoor Air by CO_2 Method:** Using the measurement results obtained in #19, calculate the air handling unit percent outdoor air by the volume method as follows;

$$\%OA = \frac{(CO2_{SA} - CO2_{RA})}{(CO2_{OA} - CO2_{RA})} \times 100$$

The CO_2, temperature, and relative humidity measurements performed in #19 are repeated on Wednesday afternoon, Thursday morning and Thursday afternoon. Checklists for these measurements are documented in Form E1, #22 through #27.

FORM E2 LOCAL SUPPLY AIR VENTILATION PERFORMANCE MEASUREMENTS

Form E2 is used to document local supply air ventilation performance in the test space. For these measurements, air flow is measured from the supply air diffusers in the test space using an air for capture hood. Ideally, the goal is to conduct measurements on 100% of the supply air diffusers in the test space. However, for test spaces equipped with a large number of diffusers, measurement logistics problems, (i.e., ceiling height or diffuser dimension issues) the minimum number of measurements should capture no less than 50% of the test space supply diffusers. The entries on the form are to be completed as follows:

1. **Measurement Date:** Enter the date that the measurements are made. As described in Section 5, supply air diffuser measurements are conducted on Tuesday afternoon of the study week.

2. **Instrument Used #1:** Enter the test instrument used for the test space supply diffuser measurements. Information should include instrument type, model, serial number, hood size and any other appropriate identification numbers.

3. **Instrument Used #2:** If more than one instrument is used for the measurements, enter the test instrument information here. Again, information should include instrument type, model, serial number, hood size and any other appropriate identification numbers.

4. **Number of Supply Air Diffusers:** Enter the number of supply air diffusers located in the test space. This information is obtained through the building mechanical design drawings and verified through a walkthrough of the test space. Locations of supply air diffusers should be mapped out on a test space floor plan.

5. **Number of Return Air Diffusers**: Enter the number of return air diffusers located in the test space. This information is obtained using the mechanical design drawings and verified through a walkthrough of the test space. Locations of return air diffusers should be mapped out on a test space floor plan.

6. **Measurement Start Time:** Enter the time that the supply air diffuser measurement round was started.

7. **Measurement Results:** Record the results of the test space supply air diffuser measurements. Record the diffuser number (from the diffuser map created in #5), the time of each measurement, the floor number, the diffuser air volume (units of cfm) and the instrument number used for the measurement. For the diffuser(s) located closest to each mobile monitoring site (see Section 5), record the monitoring site in the appropriate row in Form E2.

8. **Measurement End Time:** Enter the time that the supply air diffuser measurement round was completed.

9. **Number Measured:** Enter the number of supply air diffusers measured during the measurement round.

FORM E3 EXHAUST FAN OPERATION CHECKLIST

Form E3 is used to record the operation of each exhaust fan serving the test space. The operation of the fan is to be checked twice a day, once in the morning and once in the afternoon, on five consecutive working days. One form is required for each exhaust fan serving the test space.

1. **Exhaust Fan Number:** Enter the identification number of the exhaust fan. Record both the number referenced in the mechanical drawings and the two digit test space exhaust fan identifier (e.g. “01”, “02”, etc.).

2. **Exhaust Fan Location:** Enter the location of the exhaust fan using a room number or area from the building plans.

The exhaust fan is checked twice a day to determine whether it is operating or not. The morning and afternoon checks need not occur at any particular time, but they should be conducted when the building is fully occupied, The times on all five days should be reasonably consistent.

Day 1 A.M. Observation

3. **Observation Time:** Enter the time at which the morning operation is checked on Day #1.

4. **Fan Operating:** Enter yes if the fan is operating and no if not.

For entries #5 through #22, enter the time and operating status for days 2 through 5 as described for day 1.

FORM E4 EXHAUST FAN PERFORMANCE MEASUREMENTS

This form is used to measure the air flow rate of each exhaust fan serving the test space. Measurements are made of the total exhaust fan flow rate as well as the local exhaust flow rates within the test space. Total flow rate measurements are generally performed with a pitot tube traverse (hot-wire traverse method is also acceptable) according to standard procedures contained in the ACGIH Industrial Ventilation Manual, AMCA Publication 203-90 and the ASHRAE Standard 111. Local exhaust flow rates from test space exhaust grilles can generally be measured using an air flow capture hood. The entries on the form are to be completed as follows:

Total Exhaust Fan Flow Rate

1. **Exhaust Fan Number:** Enter the identification number of the exhaust fan. Record both the number referenced in the mechanical drawings and the two digit test space exhaust fan identifier (e.g., “01,” “02,” etc.).

2. **Exhaust Fan Location:** Enter the location of the exhaust fan using a room number or area from the building plans.

3. **Measurement Location:** Enter the measurement location of the exhaust fan traverse.

4. **Instrument Used:** Enter the test instrument used for the exhaust fan traverse. Information should include instrument type, model, serial number and any other appropriate identification numbers.

5. **Duct Dimensions:** Enter the dimensions of the duct at the location of the exhaust fan traverse. Record duct dimensions as inches x inches for rectangular ducts or inches in diameter for round ducts.

6. **Duct Area:** Enter the area of the duct at the location of the air handling unit outdoor air or return air traverse. Record duct area as square feet. Note to account for internal duct insulation if duct systems are so equipped.

7. **Start Time:** Enter the measurement start time.

8. **End Time:** Enter the measurement end time.

9. **Air Velocity:** Enter the Enter the average air speed calculated from the traverse results. Record value in units of fpm.

10. **Air Volume:** Enter the exhaust fan air volume by multiplying the velocity (#9) by the duct area (#6).

Test Space Exhaust Flow Rate

11. **Measurement Location:** Enter the measurement location of the local exhaust measurement.

12. **Instrument Used:** Enter the test instrument used for the local exhaust measurement. Information should include instrument type, model, serial number and any other appropriate identification numbers.

13. **Duct dimensions:** If a traverse is being made in the exhaust duct, enter the dimensions of the duct at the location of the traverse. Record duct dimensions as inches × inches for rectangular ducts or inches in diameter for round ducts.

14. **Duct area:** For a traverse measurement, enter the area of the duct at the location of the traverse. Record duct area as square feet. Note to account for internal duct insulation if duct systems are so equipped.

15. **Start Time:** Enter the measurement start time.

16. **End Time:** Enter the measurement end time.

17. **Air Velocity:** For a traverse measurement, enter the average air speed calculated from the traverse results. Record value in units of fpm.

18. **Air Volume:** Enter the exhaust fan air volume. If a traverse was used, calculate volume by multiplying the velocity (#17) by the duct area (#14). If an air flow capture hood was used, enter the result here.

If additional exhaust grilles are located in the test space for complete #11 through #18 for each additional exhaust grille.

FORM E5 NATURAL VENTILATION – CONTINUOUS CARBON DIOXIDE

This form is used to record the results of continuous carbon dioxide monitoring at three locations within the test space. This monitoring is to take place for two full days. Two E5 Forms are required for this test. The entries on the form are to be completed as follows:

1. **Date of Test:** Enter the date on which the measurement is conducted.

2. **Manufacturer:** Enter the manufacturer of the carbon dioxide concentration measurement device.

3. **Model Number**: Enter the model number of the device.

4. **Serial Number:** Enter the serial number of the device.

5. **Measurement Location, Outdoor Air:** Describe the location at which the outdoor air carbon dioxide concentration is measured. A sample location on the roof of the building, at least 20 meters from any exhaust vents, is preferred.

6. **Measurement Location, Occupied Space #1:** Describe the first location within the occupied space at which the carbon dioxide concentration is measured. Use column numbers if available, and note the location on the test space floor plan.

For entries #7 and #8, describe occupied space locations #2 and #3 as was done for occupied space location #1 in entry #6.

The carbon dioxide concentrations at these four locations are to be monitored continuously, with a reading at each location taken every 15 minutes or less. After this data has been recorded, it must be analyzed and the following information extracted.

9. **Outdoor Reading, 6 a.m.:** Enter the outdoor concentration recorded at 6 a.m.

10. **Outdoor Reading, 10 a.m.:** Enter the outdoor concentration recorded at 10 a.m.

11. **Outdoor Reading, 2 p.m.:** Enter the outdoor concentration recorded at 2 p.m.

12. **Outdoor Reading, 6 p.m.:** Enter the outdoor concentration recorded at 6 p.m.

13. **Occupied Space Reading #1, 6 a.m.:** Enter the concentration at occupied space location #1 recorded at 6 a.m.

14. **Occupied Space #1, Morning Maximum Concentration:** Enter the maximum carbon dioxide concentration recorded at occupied space location #1 during the morning.

15. **Occupied Space #1, Morning Maximum Time:** Enter the time at which the morning maximum carbon dioxide concentration occurred at occupied space location #1.

16. **Occupied Space #1, Morning Maximum, Outdoor Concentration:** Enter the outdoor concentration recorded at the same time as the morning maximum carbon dioxide concentration as occupied space location #1.

17. **Occupied Space #1, Afternoon Maximum Concentration:** Enter the maximum carbon dioxide concentration recorded at occupied space location #1 during the afternoon.

18. **Occupied Space #1, Afternoon Maximum Time:** Enter the time at which the afternoon maximum carbon dioxide concentration occurred at occupied space location #1.

19. **Occupied Space #1, Afternoon Maximum, Outdoor Concentration:** Enter the outdoor concentration recorded at the same time as the afternoon maximum carbon dioxide concentration as occupied space location #1.

For entries #20 through #33, record the information on the morning and afternoon maxima at occupied space locations #2 and #3 as described above for location #1.

FORM E6 NATURAL VENTILATION – TRACER GAS DECAY

This form is used to record the results of a tracer gas decay test in the building conducted to estimate the whole building air change rate. This test is to be conducted in accordance with ASTM E741. Based on the requirements contained in ASTM E741, this test must be conducted to determine the whole building air change rate. Tracer gas must be released into the entire building such that the concentration is uniform throughout the building. This test cannot be performed by releasing tracer gas into the test space alone. Only a single tracer gas decay test is required, and therefore only one form is needed. However, one can repeat the test if the initial attempt does not provide satisfactory results. This measurement can also be conducted using occupant generated carbon dioxide as the tracer gas after the occupants have left the building. The entries on the form are to be completed as follows:

1. **Date of Test:** Enter the date on which the measurement is conducted.

2. **Tracer Gas:** Enter the tracer gas employed in the test.

3. **Manufacturer:** Enter the manufacturer of the tracer gas concentration measurement device.

4. **Model Number:** Enter the model number of the device.

5. **Serial Number:** Enter the serial number of the device.

6. **Concentration Units:** Enter the tracer gas concentration units provided by the device.

The tracer gas concentration must be monitored at one outdoor location and ten locations within the occupied space during the decay test. The ten interior locations must be distributed throughout the entire building in order to be able to verify that the tracer gas concentration is uniform throughout the building prior to and during the decay. The specific locations that are selected will depend on the layout of the building including such factors as the number of stories and the floor area per story.

7. **Measurement Location, Outdoor Air:** Describe the location at which the outdoor air tracer gas concentration is measured. A sample location on the roof of the building, at least 20 meters from any exhaust vents, is preferred.

8. **Measurement Location, Occupied Space #1:** Describe the first location within the occupied space of the building at which the tracer gas concentration is measured. Use column numbers if available, and note the building floor.

For entries #9 through #17, describe the second through tenth occupied space sampling location as described in entry #8 above.

The concentration at each location should be measured once every 30 minutes, though the exact time interval is not critical as long as the sample times are recorded accurately. If one employs occupant generated carbon dioxide as the tracer gas, then the carbon dioxide concentrations must be monitored after the occupants have left the building, while the interior carbon dioxide concentration is still significantly above the outdoor concentration. The concentration monitoring should begin very soon after the occupants have left the building, before the interior concentrations decay significantly. The tracer gas decay test requires that the interior concentration is significantly above the outdoor concentration and the interior concentration is uniform (within 10%) throughout the building. If either of these conditions is not satisfied, the test will not provide acceptable estimates of the building air change rate.

18. **Initial Reading**

- Outdoor, Time: Enter the time at which the outdoor conditions are measured.
- Outdoor, Concentration: Enter the outdoor tracer gas concentration.
- Outdoor Temperature: Enter the outdoor air temperature. Designate the units, either °C or °F.
- Outdoor, Wind Speed: Enter the wind speed. Designate the units, either mps or mph.
- Location #1, Time: Enter the time at which the tracer gas concentration at location #1 is recorded.
- Location #1, Concentration: Enter the tracer gas concentration at location #1.

For locations #2 through #10, enter the time and concentration as described for location #1.

19. **Second Reading:** Record the information as described above for the initial reading.

20. **Third Reading:** Record the information as described above for the initial reading.

21. **Fourth Reading:** Record the information as described above for the initial reading.

22. **Fifth Reading:** Record the information as described above for the initial reading.

The data analysis involves determining the tracer gas decay rate in air changes per hour at each of the 10 interior locations. This is done by performing a least squares linear regression of the natural logarithm of concentration against time. Based on the assumption of a uniform tracer gas concentration within the building, the tracer gas concentration at each location decays according to the following expression:

$C(t) = C_0 exp(–It)$ where

$C(t)$ = the tracer gas concentration at a location at time t minus the outdoor concentration recorded at the same time

C_0 = the tracer gas concentration at a location time $t = 0$ minus the outdoor concentration recorded at the same time

I = the tracer gas decay rate at that location

In order to determine I, one rewrites the above equation in log form:

$\ln C = \ln C_0 – It$

This equation can be used to solve for I at each location by regressing the log of the difference between the tracer gas concentration at the location and the outdoor concentration against time. Linear regression techniques are described in many handbooks and are contained in many computer spreadsheet programs as are procedures for determining the error associated with the estimate of the slope I.

23. **Decay Rates:** Enter the calculated decay rate in air changes per hour for each of the ten locations and the standard error of this decay rate.

24. **Building Average Decay Rate:** Enter the average of the decay rates at the ten locations.

25. **Standard Deviation:** Enter the standard deviation of the decay rates at the ten locations.

26. **Average Exterior Temperature:** Enter the average exterior temperature during the decay. Designate the units, either °C or °F.

27. **Average Wind Speed:** Enter the average of the wind speeds during the decay. Designate the units, either mps or mph.

FORM E1 AIR HANDLING UNIT PERFORMANCE

One copy of Form E1 is completed for each test space air handling unit

1	AHU ID	______________________________

Supply Airflow Rate Measurement

2	Measurement Location	______________________________
3	Instrument Used	______________________________
4	Duct Dimensions	______________________________(in x in)
5	Duct area (Account for internal duct insulation if applicable)	______________________________Ft^2

6	Measurement Results				
	TUES PM	WED AM	WED PM	THURS AM	THURS PM
Start time					
End Time					
Air Velocity (fpm)					
Air Volume (cfm)					

Outdoor or Return Airflow Rate Measurement

7	Measurement Type (outdoor or return)	______________________________
8	Measurement Location	______________________________
9	Instrument Used	______________________________
10	Duct Dimensions	______________________________(in x in)
11	Duct Area (account for internal duct insulation if applicable)	______________________________Ft^2

12	Measurement Results			
	WED AM	WED PM	THURS AM	THURS PM
Start Time				
End Time				
Air Velocity (fpm)				
Air Volume (cfm)				

AHU CO_2, Temperature and Relative Humidity Measurements

13	Supply air measurement location	
14	Return air measurement location	
15	Outdoor air measurement location	
16	CO_2 measurement instrument used	
17	Temperature measurement instrument used	
18	Relative humidity measurement instrument used	

Wednesday AM Measurements

19	**Start Time**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Stop Time**
Supply Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
Return Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
Outdoor Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________

20	Percent Outdoor Air by Volume Method	________%OA
	• If outdoor air and supply air is measured directly; % OA = (outdoor air cfm / supply air cfm) x 100 or % OA = (#12 / #6) x 100 • If return air and supply air is measured directly; % OA = ((supply – return air cfm) / supply air cfm)) x 100 or % OA = ((#6-#12)/ #6)) x 100	

21	Percent Outdoor Air by CO_2 Method	________%OA
	$\% OA = (SA_{CO2}-RA_{CO2})/(OA_{CO2}-RA_{CO2})x100$	

Wednesday PM Measurements

22	**Start Time**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Stop Time**
Supply Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
Return Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
Outdoor Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________

23	Percent Outdoor Air by Volume Method ________%OA
	• If outdoor air and supply air is measured directly; % OA = (outdoor air cfm / supply air cfm) x 100 or % OA = (#12 / #6) x 100 • If return air and supply air is measured directly; % OA = ((supply – return air cfm) / supply air cfm)) x 100 or % OA = ((#6-#12)/ #6)) x 100

24	Percent Outdoor Air by CO_2 Method ________%OA
	% OA = $(SA_{CO2}-RA_{CO2})/(OA_{CO2}-RA_{CO2})$x100

Thursday AM Measurements

25	**Start Time**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Temp RH CO_2**	**Stop Time**
Supply Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
Return Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
Outdoor Air	________	________	________	________	________	________	________
	________	________	________	________	________	________	________
	________	________	________	________	________	________	________

26	Percent Outdoor Air by Volume Method ________%OA
	• If outdoor air and supply air is measured directly; % OA = (outdoor air cfm / supply air cfm) x 100 or % OA = (#12 / #6) x 100 • If return air and supply air is measured directly; % OA = ((supply – return air cfm) / supply air cfm)) x 100 or % OA = ((#6-#12)/ #6)) x 100

27	Percent Outdoor Air by CO_2 Method ________%OA
	% OA = $(SA_{CO2}-RA_{CO2})/(OA_{CO2}-RA_{CO2})$x100

FORM E2 LOCAL SUPPLY AIR VENTILATION PERFORMANCE MEASUREMENTS

One copy of Form E2 is completed for each test space. A floor plan should also completed showing all supply air diffusers in the test space. Each supply air diffuser should be referenced by a unique number

1	Measurement Date	________________
2	Instrument Used #1	________________
3	Instrument Used #2	
4	Number of Supply Air Diffusers	________________
5	Number of Return Air Diffusers	________________
6	Measurement Start Time	

7 Study Space Supply Diffuser Measurements

Diffuser #	Time	Floor	Location or Mobile Station	CFM	Instrument #1 or #2

7	Study Space Supply Diffuser Measurements (continued)				
Diffuser #	**Time**	**Floor**	**Location or Mobile Station**	**CFM**	**Instrument #1 or #2**

7	Study Space Supply Diffuser Measurements (continued)				
Diffuser #	**Time**	**Floor**	**Location or Mobile Station**	**CFM**	**Instrument #1 or #2**

8	Measurement End Time	
9	Number of Supply Air Diffusers Measured	____________________

FORM E3 EXHAUST FAN OPERATION CHECKLIST

One copy of Form E3 is completed for each test space exhaust fan

1 Exhaust Fan Number ____________________

2 Exhaust Fan Location ____________________

Day 1 AM Observation 3 Observation Time

4 Fan Operating? (yes or no) ____________________

Day 1 PM Observation 5 Observation Time

6 Fan Operating? (yes or no) ____________________

Day 2 AM Observation 7 Observation Time

8 Fan Operating? (yes or no) ____________________

Day 2 PM Observation 9 Observation Time

10 Fan Operating? (yes or no) ____________________

Day 3 AM Observation 11 Observation Time

12 Fan Operating? (yes or no) ____________________

Day 3 PM Observation 13 Observation Time

14 Fan Operating? (yes or no) ____________________

Day 4 AM Observation 15 Observation Time

16 Fan Operating? (yes or no) ____________________

Day 4 PM Observation 17 Observation Time

18 Fan Operating? (yes or no) ____________________

Day 5 AM Observation 19 Observation Time

20 Fan Operating? (yes or no) ____________________

Day 5 PM Observation 21 Observation Time

22 Fan Operating? (yes or no) ____________________

FORM E4 EXHAUST FAN PERFORMANCE

One copy of Form E4 is completed for each test space exhaust fan

1	Exhaust Fan Number	________________________
2	Exhaust Fan Location	________________________

Total Exhaust Fan Airflow Rate Measurement

3	Measurement Location	________________________
4	Instrument Used	________________________
5	Duct Dimensions	________________________(in x in)
6	Duct Area (account for internal duct insulation if applicable)	________________________Ft^2
7	Start Time	________________________
8	End Time	________________________
9	Air Velocity (fpm)	________________________
10	Air Volume (cfm)	________________________

Test Space Local Exhaust Airflow Rate Measurement

11	Measurement Location	________________________
12	Instrument Used	________________________
13	Duct Dimensions	________________________(in x in)
14	Duct Area (account for internal duct insulation if applicable)	________________________Ft^2
15	Start Time	________________________
16	End Time	________________________
17	Air Velocity (fpm)	________________________
18	Air Volume (cfm)	________________________

FORM E5 NATURAL VENTILATION: CONTINUOUS CARBON DIOXIDE

Two copies of Form E5 is completed, one for each of the two days

1	Test Date	____

Measurement Device Information

2	Manufacturer	____
3	Model Number	____
4	Serial Number	____

Measurement Locations

5	Outdoor Air	____
6	Occupied Space #1	____
7	Occupied Space #2	____
8	Occupied Space #3	____

Data Analysis

Outdoor Reading

9	6 am	____(ppm)
10	10 am	____(ppm)
11	2 pm	____(ppm)
12	6 pm	____(ppm)

Occupied Space #1

13	6 am	______________________________(ppm)
14	Morning Maximum Concentration	______________________________(ppm)
15	Morning Maximum Time	_________________________________
16	Morning Maximum Outdoor Concentration	______________________________(ppm)
17	Afternoon Maximum Concentration	______________________________(ppm)
18	Afternoon Maximum Time	_________________________________
19	Afternoon Maximum Outdoor Concentration	______________________________(ppm)

Occupied Space #2

20	6 am	____________________________(ppm)
21	Morning Maximum Concentration	____________________________(ppm)
22	Morning Maximum Time	_______________________________
23	Morning Maximum Outdoor Concentration	____________________________(ppm)
24	Afternoon Maximum Concentration	____________________________(ppm)
25	Afternoon Maximum Time	_______________________________
26	Afternoon Maximum Outdoor Concentration	____________________________(ppm)

Occupied Space #3

27	6 am	____________________________(ppm)
28	Morning Maximum Concentration	____________________________(ppm)
29	Morning Maximum Time	_______________________________
30	Morning Maximum Outdoor Concentration	____________________________(ppm)
31	Afternoon Maximum Concentration	____________________________(ppm)
32	Afternoon Maximum Time	_______________________________
33	Afternoon Maximum Outdoor Concentration	____________________________(ppm)

FORM E6 NATURAL VENTILATION: TRACER GAS DECAY

One copy of Form E6 is completed

1 Test Date ________________________________

2 Tracer Gas ________________________________

Measurement Device Information

3 Manufacturer ________________________________

4 Model Number ________________________________

5 Serial Number ________________________________

6 Concentration Units ________________________________

Measurement Locations

7 Outdoor Air ________________________________

8 Occupied Space #1 ________________________________

9 Occupied Space #2 ________________________________

10 Occupied Space #3 ________________________________

11 Occupied Space #4 ________________________________

12 Occupied Space #5 ________________________________

13 Occupied Space #6 ________________________________

14 Occupied Space #7 ________________________________

15 Occupied Space #8 ________________________________

16 Occupied Space #9 ________________________________

17 Occupied Space #10 ________________________________

Data

18 Initial Reading

Outdoor

Time ______________________________

Temperature ______________________________(°C or °F)

Concentration ______________________________

Wind Speed ______________________________(m/s or mph)

	Time	Concentration
Location #1	________	________
Location #2	________	________
Location #3	________	________
Location #4	________	________
Location #5	________	________
Location #6	________	________
Location #7	________	________
Location #8	________	________
Location #9	________	________
Location #10	________	________

19 Second Reading

Outdoor

Time ______________________________

Temperature ______________________________(°C or °F)

Concentration ______________________________

Wind Speed ______________________________(m/s or mph)

	Time	Concentration
Location #1	________	________
Location #2	________	________
Location #3	________	________
Location #4	________	________
Location #5	________	________
Location #6	________	________
Location #7	________	________
Location #8	________	________
Location #9	________	________
Location #10	________	________

20 Third Reading

<u>Outdoor</u>

Time ____

Temperature ______________________________________(°C or °F)

Concentration ____

Wind Speed ____________________________________(m/s or mph)

	Time	Concentration
Location #1	____________	____________
Location #2	____________	____________
Location #3	____________	____________
Location #4	____________	____________
Location #5	____________	____________
Location #6	____________	____________
Location #7	____________	____________
Location #8	____________	____________
Location #9	____________	____________
Location #10	____________	____________

21 Fourth Reading

<u>Outdoor</u>

Time ____

Temperature ______________________________________(°C or °F)

Concentration ____

Wind Speed ____________________________________(m/s or mph)

	Time	Concentration
Location #1	____________	____________
Location #2	____________	____________
Location #3	____________	____________
Location #4	____________	____________
Location #5	____________	____________
Location #6	____________	____________
Location #7	____________	____________
Location #8	____________	____________
Location #9	____________	____________
Location #10	____________	____________

22 Fifth Reading

Outdoor

Time	________________________
Temperature	________________________(°C or °F)
Concentration	________________________
Wind Speed	________________________(m/s or mph)

	Time	**Concentration**
Location #1	________	________
Location #2	________	________
Location #3	________	________
Location #4	________	________
Location #5	________	________
Location #6	________	________
Location #7	________	________
Location #8	________	________
Location #9	________	________
Location #10	________	________

Data Analysis

23 Decay Rates, air changes per hour

	Value	**Standard Error**
Location #1	________	________
Location #2	________	________
Location #3	________	________
Location #4	________	________
Location #5	________	________
Location #6	________	________
Location #7	________	________
Location #8	________	________
Location #9	________	________
Location #10	________	________

24 Building average decay rate _____ach 25 Standard Deviation _____ach

Outdoor Conditions, Averages

26 Exterior Temperature ________________________(°C or °F)

27 Wind Speed ________________________(m/s or mph)

APPENDIX F

INDOOR ENVIRONMENTAL QUALITY QUESTIONNAIRE

U.S. ENVIRONMENTAL PROTECTION AGENCY

INDOOR ENVIRONMENTAL QUALITY SURVEY

The U.S. Environmental Protection Agency (EPA) is conducting this survey as part of an information gathering effort to establish baseline information regarding indoor air quality in your building. Measurements of a variety of environmental conditions are being taken in your building throughout the week.

To help determine how these measurements relate to your comfort and health, please complete the attached questionnaire. Your participation in this part of the evaluation of this building is voluntary, but very important. Your completed questionnaire will be collected and analyzed by EPA and your responses WILL NOT BE SEEN BY MANAGEMENT OR UNION REPRESENTATIVES.

"BY COMPLETING THIS QUESTIONNAIRE, I INDICATE MY CONSENT TO PARTICIPATE IN THIS STUDY. I UNDERSTAND CONFIDENTIALITY WILL BE MAINTAINED."

THANK YOU FOR YOUR PARTICIPATION IN THIS STUDY.

U. S. ENVIRONMENTAL PROTECTION AGENCY'S

INDOOR ENVIRONMENTAL QUALITY SURVEY

EPA INDOOR ENVIRONMENTAL QUALITY SURVEY

(OMB NO. 2060-0244)

This survey is being conducted to determine the environmental quality of your building. This questionnaire asks about how you think your building environment and your work affect you. Please answer the questions as accurately and completely as you can, regardless of how satisfied or dissatisfied you are with conditions in the building.

ALL OF YOUR ANSWERS WILL BE TREATED IN THE STRICTEST CONFIDENCE.

I. WORKPLACE INFORMATION

1. How long have you worked *in this building*, to the nearest year?

__ __ years

***If less than one year*, how many months have you worked *in this building*?**

__ __ months

2. On average, how many hours a week do you work *in this building*?

__ __ hours per week

3. During *THIS WEEK*, including today, how many days did you work in this building?

__ days

4. Which best describes the space in which your current workstation* is located?

*For this questionnaire, your "workstation" is the place (desk, cubicle, office, etc.) where you do the majority of your work

__ Single person private office (1)
__ Shared private office (2)
__ Open space with partitions (3)
__ Open space without partitions (4)
__ Other (specify) ________(5)

4a. How many people work in the room in which your workstation is located (including yourself)?

__ 1 __ 2-3 __ 4-7 __ 8 or more

5. Is there carpet on most or all of the floor at your workstation?

__ Yes(1) __ No(2)

6. In general, how clean is your workspace* area?

*For this questionnaire, your "workspace" is the immediate area surrounding your workstation

__ Very clean (1)
__ Reasonably clean (2)
__ Somewhat dusty or dirty (3)
__ Very dusty or dirty (4)

7. Please rate the lighting at your workstation.

__ Much too dim (1)
__ A little too dim (2)
__ Just right (3)
__ A little too bright (4)
__ Much too bright (5)

10. How comfortable is the current set-up of your desk or work table (i.e., height and general arrangement of the table, chair, and equipment you work with)**?**

__ Very comfortable (1)
__ Reasonably comfortable (2)
__ Somewhat uncomfortable (3)
__ Very uncomfortable (4)
__ Don't have one specific desk or work table (5)

8. Do you experience a reflection or "glare" in your field of vision when at your workstation?

__ Rarely (1)
__ Occasionally (2)
__ Sometimes (3)
__ Fairly often (4)
__ Very often (5)

11. Do you work with a computer or word processor?
____ yes(1) ____ no(2)(skip to #12)

11a. About how many hours a day do you work with a computer or word processor, to the nearest hour?
__ __ hours per day

11b. If you use a computer or word processor, do you usually wear glasses when you use these machines?
__ Yes (1) __ No (2)

11c. Do you use a glare screen on your computer?
__ Yes (1) __ No (2)

9. How comfortable is the chair at your workstation?

__ Very comfortable (1)
__ Reasonably comfortable (2)
__ Somewhat uncomfortable (3)
__ Very uncomfortable (4)
__ Don't have one specific chair (5)

12. Which one of the following statements best describes the windows in your work area?

__ There are no windows in my personal workspace and none in the general area visible from my workspace (when I am either standing or seated). (1)

__ There are no windows in my personal workspace, but I can see one or more windows in the general area. (2)

__ There are one or more windows in my personal workspace. (3)

13. If there is a window visible from your workspace, how far (in feet) is the closest window from your desk chair?

______ feet ______ No window

14. During the PAST THREE MONTHS, have the following changes taken place within 15 feet of your current workstation?

	YES (1)	NO (2)
New carpeting		
Walls painted		
New furniture		
New partitions		
New wall covering		
Water damage		

15. How often do you use the following at work? (Check the appropriate box for each item.)

	Several times a day (1)	About once a day (2)	3-4 times a week (3)	Less than 3 times/week (4)	Never (5)
Photocopier					
Laser printer					
Facsimile (FAX) machine					
Self-copying (carbonless) copy paper					
Cleanser, glue, correction fluid, or other odorous chemicals					

II. INFORMATION ABOUT HEALTH AND WELL-BEING

1. Have you ever been told by a doctor that you have or had any of the following?

	YES(1)	NO(2)
Migraine		
Asthma		
Eczema		
Hay fever		
Allergy to dust		
Allergy to molds		

2. What is your tobacco smoking status?

__ never smoked (1)
__ former smoker (2)
__ current smoker (3)

3. Do you consider yourself especially sensitive to the presence of tobacco smoke in your workspace?

__ Yes (1) __ No (2)

4. Do you consider yourself especially sensitive to the presence of other chemicals in the air of your workspace?

___ Yes (1) ___ No (2)

5. What type of corrective lenses do you usually wear at work?

__ none (1)
__ glasses (2)
__ bifocals(3)
__ contact lenses (4)

6. How old were you on your last birthday?

__ under 20(1) __ 20-29 years(2)

__ 30-39 years(3) __ 40-49 years(4)

__ 50-59 years(5) __ over 59 years(6)

7. Are you:

__ male (1) __ female (2)

II. (Cont.) EXAMPLE -- HOW TO ANSWER THE QUESTIONS ON THE NEXT PAGE.

The next page contains questions regarding symptoms you may have experienced while at work during the last 4 weeks. The following **EXAMPLE** shows how an employee might fill out this type of questionnaire.

8. During the **LAST FOUR WEEKS YOU WERE AT WORK**, how often have you experienced each of the following symptoms while working in this building? • If you answer "Not in Last 4 Weeks" for a symptom, please move down the page to the next symptom.					8a.During the **LAST FOUR WEEKS YOU WERE AT WORK**, what happened to this symptom at times when you were away from work? (eg, holidays, weekends)			8b. During **THIS WEEK**, on how many days did you experience this symptom?
SYMPTOMS	**Not in Last 4 Weeks (1)**	**1-3 days in last 4 weeks (2)**	**1-3 days *per wk* in last 4 wks (3)**	**Every or Almost Every Workday (4)**	**Got Worse (1)**	**Stayed Same (2)**	**Got Better (3)**	**Number of Days This Week**
earache	X							
hiccups	X							
toothache		X				X		0
leg cramps				X	X			3

9a. In the LAST FOUR WEEKS how often have any of the symptoms listed above reduced your ability to work? __6__ **days**	**9b. In the LAST FOUR WEEKS how often have any of the symptoms listed caused you to leave work?** __3__ **days**

The above responses show that during the last 4 weeks while at work, **THIS EMPLOYEE**:

1. Did not experience EARACHE or HICCUPS.

2. Experienced TOOTHACHE 1-3 days. Toothache stayed same when away from work. No toothache this week.

3. Experienced LEG CRAMPS almost every day. Leg cramps got worse when away from work. Had leg cramps three days this week.

One or more of the symptoms reduced their ability to work 6 days in the last four weeks. One or more of the symptoms caused them to stay home or leave work 3 days.

(NOTE that the symptoms in this example are for illustration only and are not the same as those on the following page.)

8. During the **LAST FOUR WEEKS YOU WERE AT WORK**, how often have you experienced each of the following symptoms while working in this building? • **If you check column 1 "Not in Last 4 Weeks" for a symptom--move DOWN the page to the next symptom. If you check column 2, 3, or 4 move across the page.**					**8a.** During the **LAST FOUR WEEKS YOU WERE AT WORK**, what happened to this symptom at times when you were away from work? (eg, holidays, weekends)			**8b.** During **THE WEEK**, on how many days did you experience this symptom?
SYMPTOMS	**Not in Last 4 Weeks (1)**	**1-3 days in last 4 weeks (2)**	**1-3 days *per wk* in last 4 wks (3)**	**Every or Almost Every Workday (4)**	**Got Worse (1)**	**Stayed Same (2)**	**Got Better (3)**	**Number of Days This Week**
dry, itching, or irritated eyes								
wheezing								
headache								
sore or dry throat								
unusual tiredness, fatigue, or drowsiness								
chest tightness								
stuffy or runny nose, or sinus congestion								
cough								
tired or strained eyes								
tension, irritability, or nervousness								
pain or stiffness in back, shoulders, or neck								
sneezing								
difficulty remembering things or concentrating								
dizziness or lightheadedness								
feeling depressed								
shortness of breath								
nausea or upset stomach								
dry or itchy skin								
numbness in hands or wrists								

9a. In the LAST FOUR WEEKS how often have any of the symptoms listed above reduced your ability to work? **____ days**	**9b. In the LAST FOUR WEEKS how often have any of the symptoms listed above caused you to stay home or leave work?** **____ days**

III. DESCRIPTION OF WORKPLACE CONDITIONS

1. During the **LAST FOUR WEEKS YOU WERE AT WORK**, how often have you experienced each of the following environmental conditions while working in this building? · **If you put a check in the column "Not in Last 4 Weeks " -- move down the page to the next condition.**					1a. During **THE WEEK**, on how many days did you experience this environmental condition?
CONDITIONS	**Not in** Last 4 **Weeks (1)**	**1-3 days in last 4 weeks (2)**	**1-3 days *per wk* in last 4 wks (3)**	**Every or** Almost Every **Workday (4)**	**Number of Days This Week**
too much air movement					
too little air movement					
temperature too hot					
temperature too cold					
air too humid					
air too dry					
tobacco smoke odors					
unpleasant chemical odors					
other unpleasant odors (e.g., body odor, food odor, perfume)					

How satisfied are you with the following aspects of your workstation?

2. Conversational privacy

__ Very satisfied (1)
__ Somewhat satisfied (2)
__ Not too satisfied (3)
__ Not at all satisfied (4)

3. Freedom from distracting noise

__ Very satisfied (1)
__ Somewhat satisfied (2)
__ Not too satisfied (3)
__ Not at all satisfied (4)

IV. CHARACTERISTICS OF YOUR JOB

1. What is your job category?	2. All in all, how satisfied are you with your job?	3. What is the highest level you completed in school?
__ Managerial (1) __ Professional (2) __ Technical (3) __ Secretarial or Clerical(4) __ Other (specify) ____________(5)	__ Very satisfied (1) __ Somewhat satisfied(2) __ Not too satisfied (3) __ Not at all satisfied (4)	__ 8th grade or less (1) __ Some high school (2) __ High school graduate (3) __ Some college (4) __ College degree (5) __ Graduate degree (6)

4. Conflicts can occur in any job. For example, someone may ask you to do work in a way that is different from what you think best, or you may find that it is difficult to satisfy everyone. **HOW OFTEN do you face problems in your work like the ones listed below? (Check the appropriate box for each statement.)**

	Rarely or Never (1)	Sometimes (2)	Fairly Often (3)	Very Often (4)
Persons equal in rank and authority over you ask you to do things which conflict				
People in a good position to see if you do what they ask give you things to do which conflict with one another				
People whose requests should be met give you things which conflict with other work you have to do				

5. **The next series of questions asks HOW OFTEN certain things happen at your job.**
(Check the appropriate box for each question.)

	Rarely (1)	Occasionally (2)	Sometimes (3)	Fairly Often (4)	Very Often (5)
How often does your job require you to work very fast?					
How often does your job require you to work very hard?					
How often does your job leave you with little time to get things done?					
How often is there a great deal to be done?					
How often are you clear on what your job responsibilities are?					
How often can you predict what others will expect of you on the job?					
How much of the time are your work objectives well defined?					
How often are you clear about what others expect of you on the job?					

6. **In order to better understand your responsibilities outside your normal working day, the next series of questions deals with other significant aspects of your life.**

RESPONSIBILITY	YES (1)	NO (2)
Major responsibility for child care duties		
Major responsibility for housekeeping duties		
Major responsibility for care of an elderly or disabled person on a regular basis		
Regular commitment of five hours or more per week, paid or unpaid, outside of this job *(include educational courses, volunteer work, second job, etc.)*		

PLEASE USE THE REMAINING SPACE TO DISCUSS ANY ASPECTS OF THE BUILDING ENVIRONMENT OR EMPLOYEE HEALTH THAT YOU FEEL APPROPRIATE

__/__/__/__/__/__/__/

APPENDIX G

STEERING COMMITTEE MEMBERS

STEERING COMMITTEE MEMBERS

Mr. Robert Axelrad	U.S. Environmental Protection Agency
Dr. Larry G. Berglund	J.B. Pierce Foundation
Mr. Terry Brennan	Camroden Associates
Mr. Jack Buckley	I.A. Naman & Associates, Inc.
Dr. Harriet Burge	Harvard School of Public Health
Prof. William S. Cain	J.B. Pierce Foundation
Ms. Lillie Clark	Occupational Safety and Health Association
Dr. Belinda Collins	National Institute of Standards and Technology
Mr. Michael Crandall	National Institute for Occupational Safety and Health
Dr. Ann Fidler	National Institute for Occupational Safety and Health
Mr. Bill Fisk	Lawrence Berkeley Laboratory
Mr. John R. Girman	U.S. Environmental Protection Agency
Dr. David Grimsrud	Minnesota Building Research Center
Dr. Allen Hedge	Cornell University
Mr. Jeff Hicks	Radian Corporation
Mr. Ross Highsmith	U.S. Environmental Protection Agency
Dr. Michael Hodgson	University of Connecticut
Dr. Joe Hurrel	National Institute for Occupational Safety and Health
Dr. Kay Kreiss	National Jewish Center for Immunology and Respiratory Medicine
Mr. Andy Lindstrom	U.S. Environmental Protection Agency
Dr. Brian Leaderer	J.B. Pierce Foundation
Mr. Hal Levin	Levin & Associates
Mr. Ed Light	Pathway Diagnostics, Inc.
Dr. Jack McCarthy	Environmental Health & Engineering, Inc.
Dr. Mark Mendell	National Institute for Occupational Safety and Health
Dr. Vivian Mills	General Services Administration
Dr. Philip E. Morey	Clayton Environmental Consultants
Dr. Niren Nagda	ICF, Inc.
Mr. C. J. Nelson	U.S. Environmental Protection Agency
Mr. J. Francis Offerman	Indoor Environmental Engineering
Dr. Andrew Persily	National Institute of Standards and Technology
Dr. Linda Sheldon	Research Triangle Institute
Mr. Scott Sylvester	Occupational Safety and Health Administration
Mr. John Talbot	U.S. Department of Energy
Dr. Kevin Teichman	U.S. Environmental Protection Agency
Mr. Robert Thompson	U.S. Environmental Protection Agency
Mr. William A. Turner	H. L. Turner Group, Inc.
Dr. Lance Wallace	U.S. Environmental Protection Agency
Mr. Kenneth M. Wallingford	National Institute for Occupational Safety and Health
Dr. Roy Whitmore	Research Triangle Institute
Dr. Tom Wilcox	National Institute for Occupational Safety and Health
Dr. Deborah Winn	National Center for Health Statistics
Dr. James Wood	Virginia Polytechnic Institute

APPENDIX H

THE INDOOR AIR DATA COLLECTION SYSTEM (IADCS)

The IADCS Software and Documentation is available upon request by contacting

Indoor Environments Division (6609J)
U.S. Environmental Protection Agency
1200 Pennsylvania Ave., NW
Washington, DC 20460