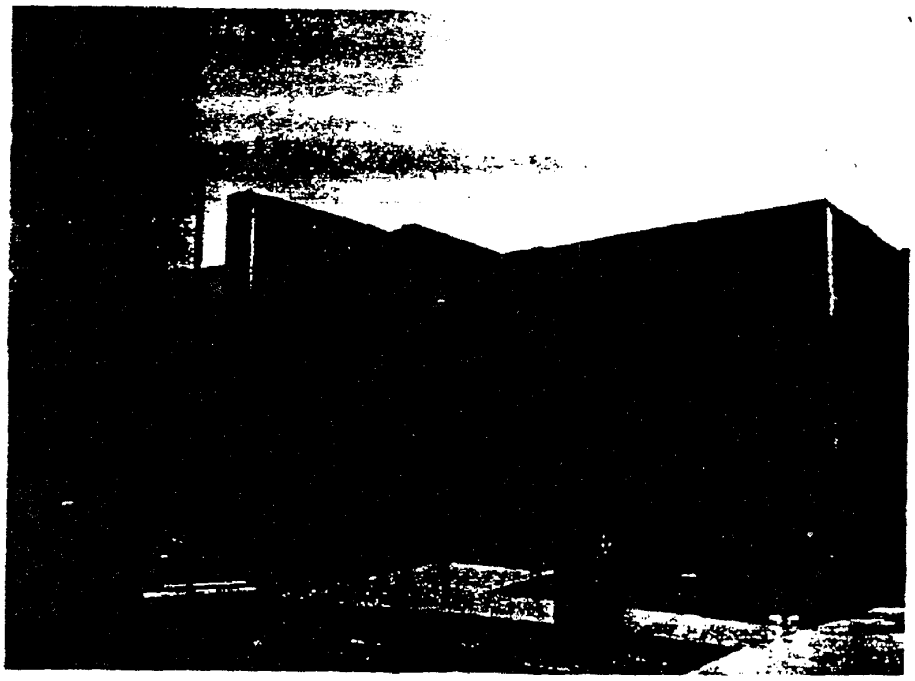
ACVA Atlantic Incorporated

WISCONSIN STATE AFL-CIO
6333 West Blue Mound Road
Milwaukee, Wisconsin

ACVA INDOOR AIR QUALITY INSPECTION

April 1989



TI DN 0014818

1.1 General Introduction

This is the report of the ACVA Indoor Air Quality Inspection of the Wisconsin State AFL-CIO building located at 6333 West Blue Mound Road in Milwaukee, Wisconsin, and includes the results of the measurements and sampling made of the air supply systems to the occupied areas of this building.

The inspection was completed on the 19th of April 1989.

The object of the survey was to assess the amounts of particulate and microbial contamination present within the air supply systems; to trace the source of such contamination; to make observations on the structural condition of the various parts of the system inspected; and to generally evaluate the quality of the air being supplied in various parts of this building.

Quantitative and qualitative evaluations of the air conditioning systems and the air being transported were made using electronic particle counting instruments and samples were taken for particulate and microbiological counting and analysis.

Visual inspections of the internals of the air handling ducts were made directly using existing access panels, grilles, diffusers, etc., where possible, and indirectly by way of ACVA Points inserted into otherwise inaccessible sections of ductwork and the insertion of an industrial borescope fitted with its own fiber-optic light supply system.

All the measurements and observations recorded on-site and the laboratory results from the samples collected were collated, analyzed, and evaluated. It is from these readings along with the extensive data base of information on similar air systems available to ACVA Atlantic that the conclusions and recommendations in this report are made.

1.2 ACVA Point Installation

ACVA Access Points are installed to gain access into the internal air duct system. Typically one ACVA Point is installed at each air handling unit on the main air supply duct and other Points are placed downstream on the supply system at locations adjacent to occupied areas.

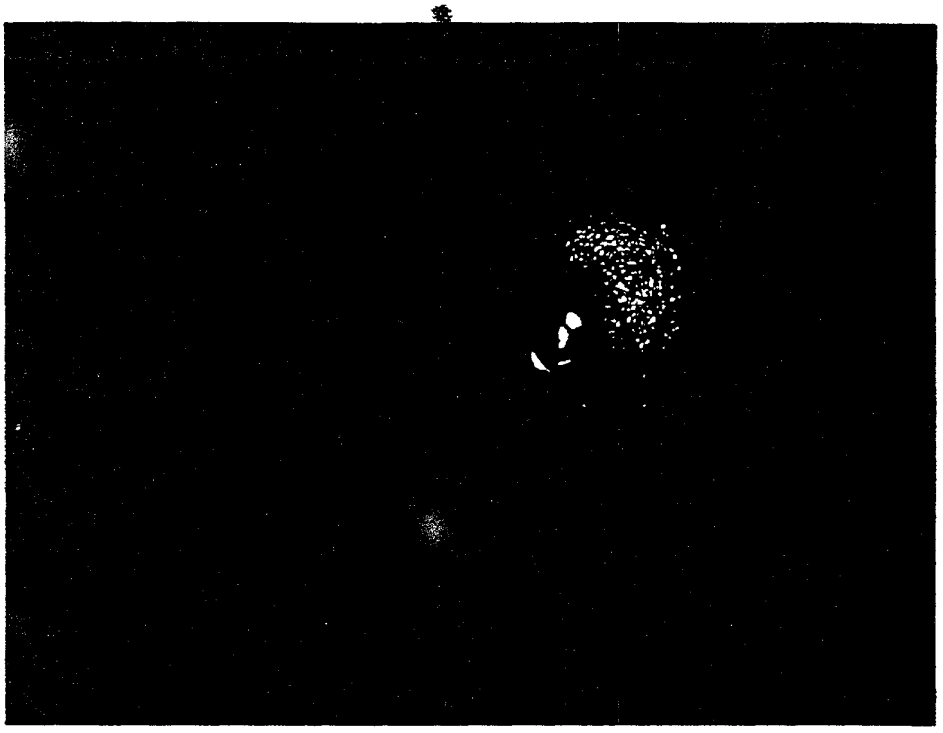
The ACVA Points are small "port holes" having an internal diameter of 1.25 inches. They are installed directly or indirectly into the ductwork making an airtight seal. They are fitted with an easily removable screw cap which then allows permanent and easy access to otherwise difficult or usually inaccessible lengths of ductwork for inspection, particulate and microbial sampling, air pressure and air velocity measurements, and when necessary for controlling cleaning and sanitizing operations. All these operations involve the use of appropriate instruments, materials, and techniques, many of which have been specifically developed for the ACVA System.

1.2.2 ACVA SAMPLAIRES

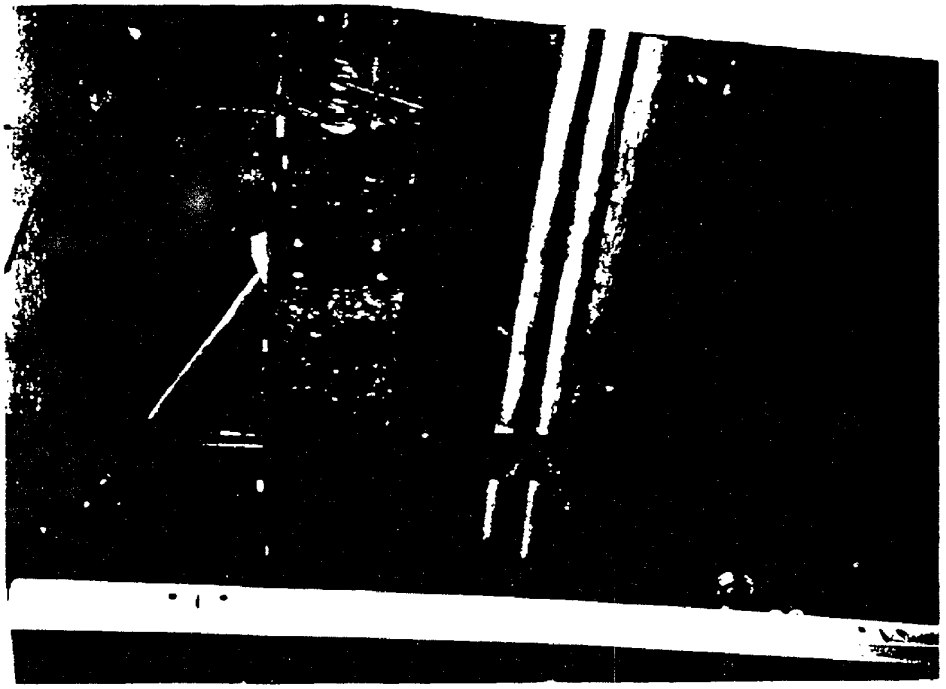
Following the initial inspection via the ACVA Point, the screw cap may be substituted with another cap attached to a specially designed filter capsule. This attachment permits a small fraction of the ducted air to be bled off and passed over a filter membrane. After an extended period of operation, typically six months in the case of a commercial office block, these filters can be inspected, compared, and/or analyzed to allow for future investigations of the extent and nature of any airborne particulate contamination that passes through the ductwork systems. Thus, when necessary, such constant monitoring gives early warning of potential problems and allows for the budgeting of preventive maintenance to obviate the spread of such contamination problems to other areas of the systems. For aesthetic purposes and to reduce interference with the filters, the ACVA Point and its attached filter capsule is then fitted with a protective aluminum cover. The complete unit is defined as an ACVA SAMPLAIRE.

1.2.3 On-Going Monitoring

On this occasion, the ACVA SAMPLAIRES and on-going monitoring were not requested, however, these can be installed at a later date in the existing ACVA Points.



2nd floor east A/C thermostat controls temperature on entire floor.



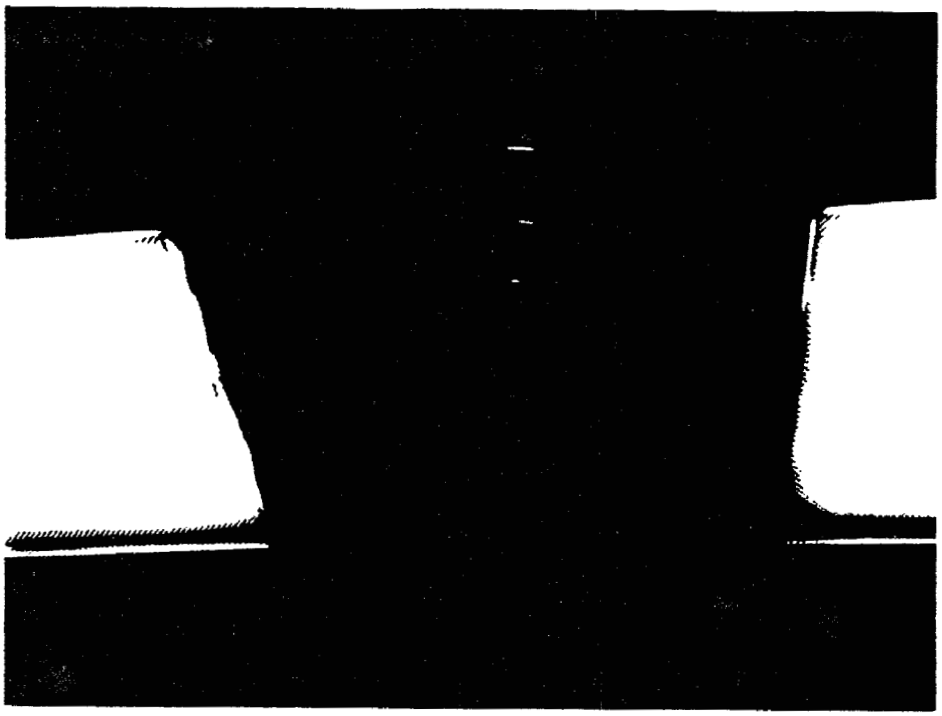
1st floor north - external view of steam heat coil and branch A/S duct.

2.1 General Description of the Systems

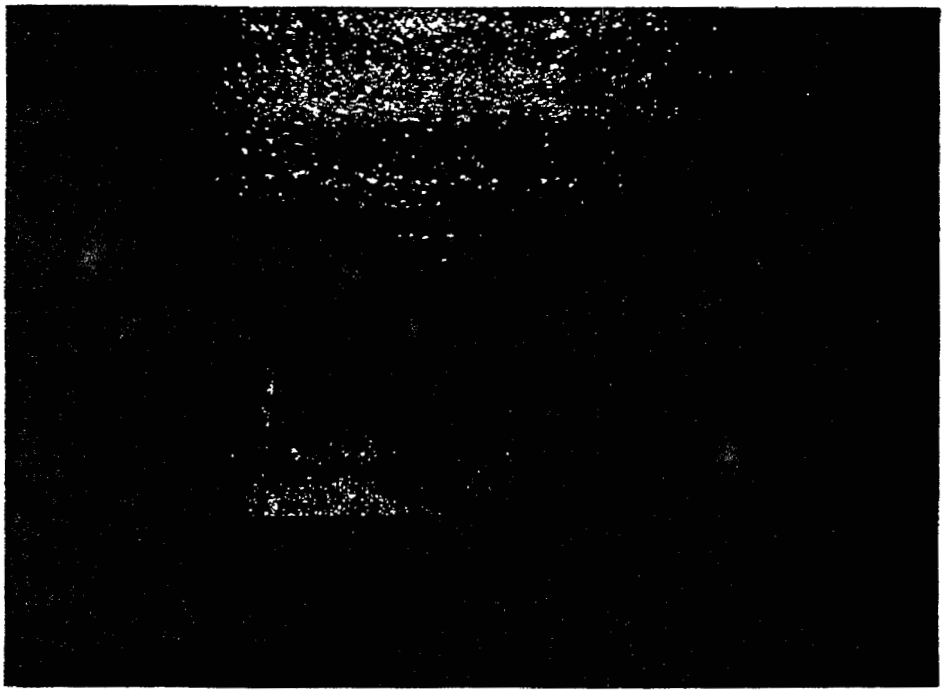
The Wisconsin State AFL-CIO building is approximately 32 years old and consists of two floors totalling 6,000 square feet. Heating, air conditioning, and ventilation needs for the building are provided by two main air handling units (AHUs) located within the basement mechanical room. AHU #1 serves the entire first floor and AHU #2 serves the second floor. The system is a constant volume system with temperatures controlled by wall mounted thermostats in the east hall, fifteen feet from the main return air grille on each floor. The units are run from 9 a.m. to 5 p.m. on weekdays and shut off during unoccupied times and weekends.

Fresh air is drawn in from the east end of the building at street level and passed through a non-insulated sheet metal duct. The fresh air is dampered by a pneumatic damper set at 60°F. When the ducting reaches the basement mechanical room, it splits into two externally insulated sections of duct to serve each unit. After splitting the fresh air is mixed with return air and pulled through first a one inch polyester tackified filter and then through a refrigerant chill coil by a dual induction fan to be delivered into the main air supply ducting. Both units have the same configurations except the sheet metal ducting for AHU #2 is externally insulated and the sheet metal ducting for AHU #1 is neither internally or externally insulated. Each unit's ducting travels up to its respective floor where it gives off to two main north and south branches. The north and south branches are equipped with in-duct hot water coils, which are boiler supplied. These branches give off to further flex ducting connected to ceiling mounted circular diffusers or give off to wall mounted slot diffusers.

Return air is drawn through door grilles to the hallways to a main return air grille, which is connected to non-insulated sheet metal ducting. This main return air grille is located in the east end hallway on both floors. The return air is ducted back to the unit to repeat the cycle. Exhaust for the building is pulled out of the bathrooms and lunchroom through circular ceiling diffusers into non-insulated sheet metal ducting and exhausted out of the building by two roof-mounted exhaust fans.



2nd floor SE - typical
circular air supply diffuser.



1st floor north - typical wall
mounted air supply diffuser.

2.2 Visual Inspections of the Air Handling Units

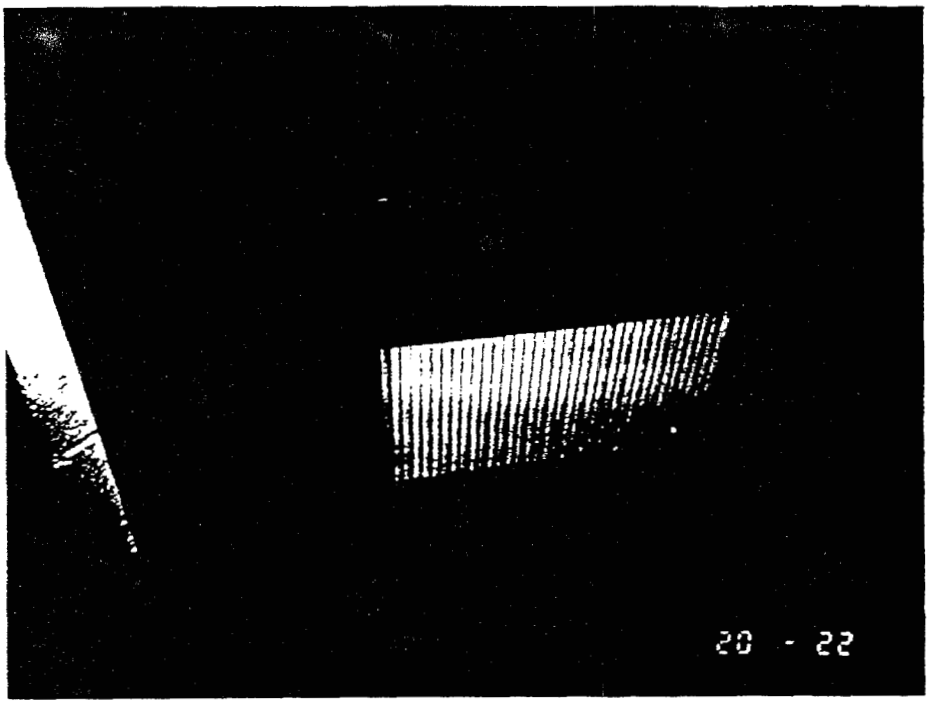
2.2.1 AHUs #1 and 2

Both units were found to be operating with the fresh air dampers 100% open and the return air system 100% open with no blockages. The one inch filters for both units were well fitted in metal frames with light loadings of mixed granular deposits. The refrigerant chill coils displayed light amounts of light brown and brown granular deposits and trace to light fibrous deposits. The condensate tray for unit #1 was dry with heavy mixed debris, while the tray for unit #2 was also dry with heavy scale and light rust. The dual induction fans showed moderate amounts of mixed granular particulate on all components. Overall both units showed moderate amounts of mixed granular deposits on the internal components and surfaces, and had torn and soiled internal insulation which was releasing fibers into the air supply. The internal insulation for both units should be repaired or encapsulated to prevent any further release of fibers into the air supply and each unit should receive a general cleaning to remove all particulate. After cleaning the condensate trays, fresh chemical packs should be installed.

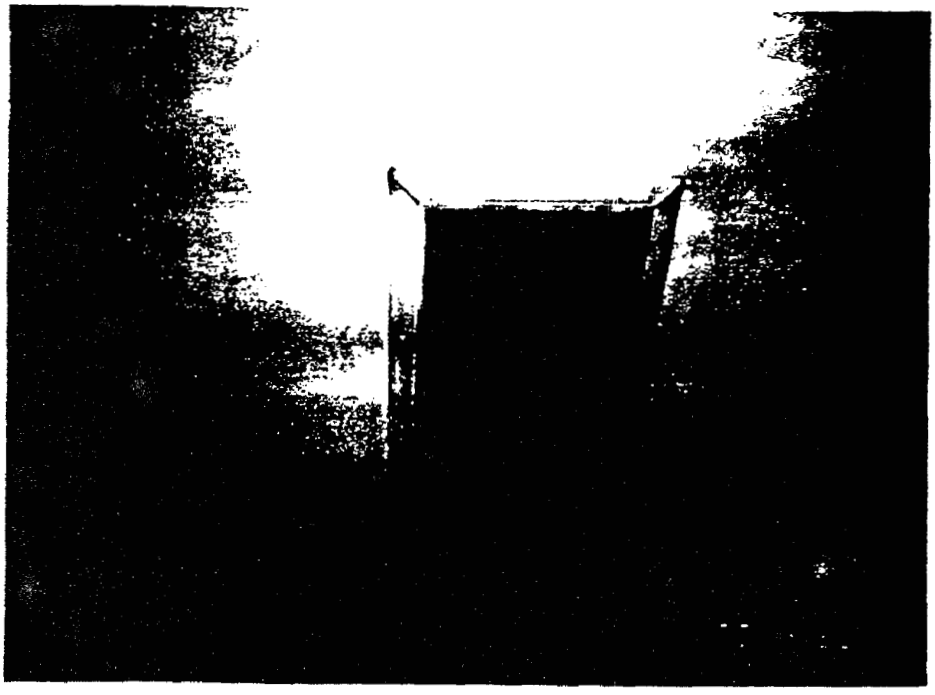
2.2.2 General Observations

2.2.2.1 We can predict that indoor air pollution problems will manifest themselves during periods of the year when the temperature falls below 60°F. This is due to the fact that the fresh air dampers are controlled by a pneumatic mechanism which causes the dampers to close down at temperatures below 60°F. Because temperatures are below this level for a large percentage of the year in this area of the country, the dampers will close and the air handling units will run on recycled air. When this occurs all indoor pollutant concentrations will increase. As well as possible complaints of stale air, any allergy suffers are likely to feel distress. Lowering the temperature setting for the dampers will not entirely solve the problem because other problems will manifest themselves, such as cold drafts within the building. The optimal solution is to add a heat coil prior to the dampers within the duct so that fresh air can be utilized year round. It should be noted that ASHRAE specifies that a minimum fresh air make-up of 20 cfm/person (20 cubic feet per minute per person) be obtained during all times of year. To obtain this recommended level, these dampers should remain opened to a minimum setting during all times of year, even during extremes of temperatures. Additionally, based on the relatively small size of the fresh air intake, the minimum setting to achieve 20 cfm per person of fresh air will require the dampers to remain close to the 100% open position at all times.

2.2.2.2 The outside air intake should be raised to prevent the infiltration of organic matter such as leaves into this ductwork and further downstream in the system. Organic matter combined with dirty damp ductwork provides optimal conditions for bacterial and fungal growth.



1st floor north - common door mounted return grille.



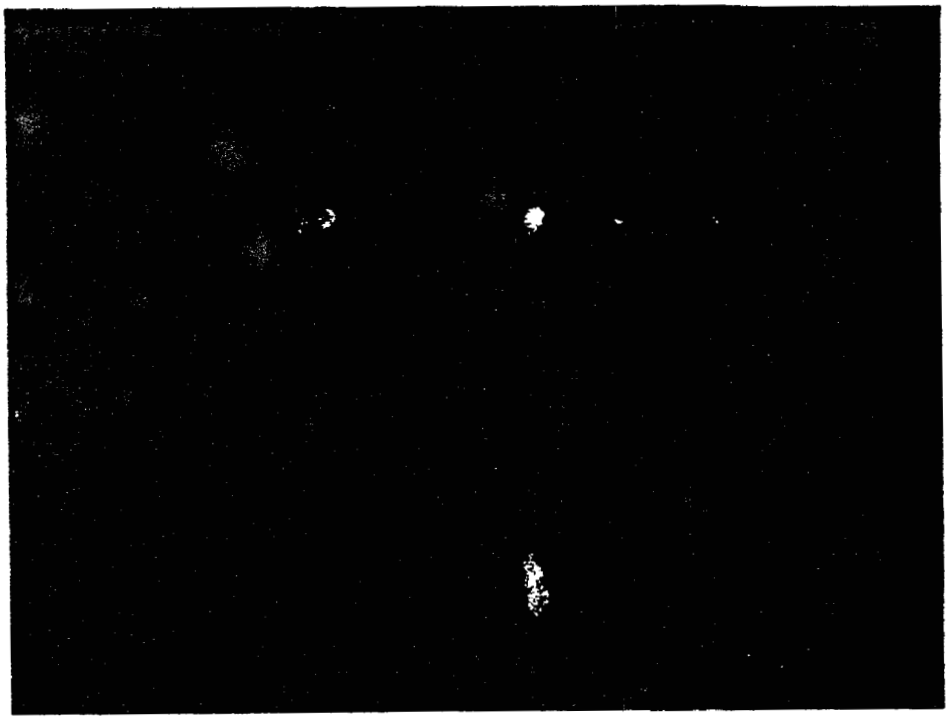
1st floor NW - typical toilet exhaust grille with moderate deposits.

2.3 Visual Inspections of Air Supply Duct Internals

Point No.	Location	Observations
1	Basement mech. room F/A intake	Heavy mixed deposits, including leaves
2	Basement mech. main A/S AHU #1	Light deposits light brown, brown and black granular
3	Basement mech. main A/S AHU #2	Moderate amounts gray, light brown, brown and black granular, fluff, and fibrous deposits. Severely torn internal insulation
4	1F N hall branch A/S, AHU #1	Moderate amounts mixed granular, fluff, and fibrous deposits. Moderate mixed deposits on heat coils
5	1F S hall branch A/S, AHU #1	Moderate light brown, brown, and black granular, fluff, and fibrous deposits. Light mixed deposits on heat coils
6	2F N hall branch A/S, AHU #2	Light deposits light brown, brown and black mixed material. Light mixed deposits on heat coils; moderate fluff on internal screws
7	2F S hall branch A/S, AHU #2	Light deposits light brown, brown and black granular. Light to moderate fluff on internal screws

CONCLUSIONS

For the most part these observations are to be expected of a building of this age. At this time we recommend that you clean the fresh air intake duct to remove any dirt and debris that have accumulated and raise the fresh air intake to prevent the infiltration of such deposits as leaves. Additionally, the severely torn insulated noted at Point #3 should be removed or encapsulated to prevent the release of fibers in the air supply and the heat coils in the north and south branch ducts should be cleaned to remove any accumulations. If the levels of contamination continue to increase within the ductwork, a full scale cleaning operation will be necessary in the future. These levels should be monitored on a periodic basis.



1st and 2nd floor exhaust fan
located centrally on roof top.

Outside air duct with pneumatic
dampers splitting to each AHU

2.4 General Background Information

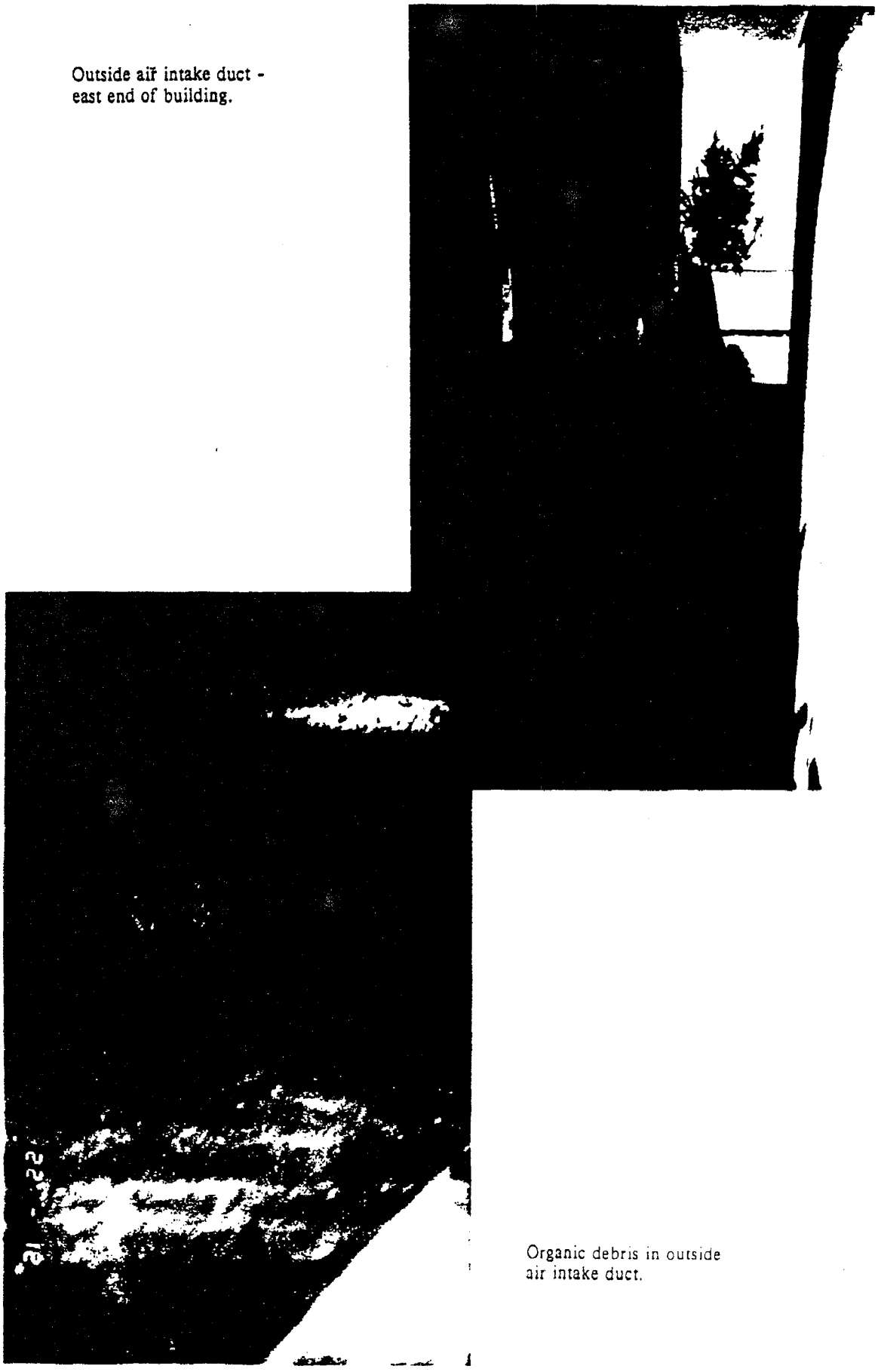
When ductwork is installed it has an inherent capacity to absorb dust and dirt. The rate at which this capacity is used up depends on how dirty the ductwork was when it was installed, how efficient the filters are at the head of the system, and how much contamination enters the system from those parts of the air handling equipment downstream of the filters. Even if no rust and corrosion are allowed to develop on the air handling equipment and the equipment is kept scrupulously clean, since no filter can be 100 percent effective, it is inevitable that sub-micron and near micron sized particles will pass it. These will be carried down the supply ducts and will be deposited in the lee of protuberances, at bends, on dampers and grilles, and at other areas of reduced air velocity. They will be added to with time until they become too big for their anchorages, or are dislodged into the airstream by variations in air flow velocity or by vibrations along the duct to be deposited farther down the duct on supply grilles and diffusers, or to be carried into the occupied areas.

Our experience in air conditioning plants and ductwork has shown that the numbers of bacterial and fungal cells and/or spores present are directly proportional to the amounts of dust and dirt and other debris allowed to gather there. Variations in the amounts of microbes present will occur due to the nature of the materials in the environment and the availability of free water. In printing works for example, it is known that bacteria multiply rapidly in the ductwork where nutrition is readily available in the cellulose from the paper dust. If quantities of free water also occur from time to time then the conditions for maximum multiplication are optimum and the numbers of bacteria and fungi and their spores accompanying the airborne particulate contamination in the supply air to be delivered to the occupied areas of a building can be considerable.

Wherever dust and dirt are allowed to accumulate, bacteria and fungi will inevitably multiply, especially when free water is available. When parts of an air supply system harbors large numbers of them, the effects they produce, the noxious odors, the allergic reactions, and the respiratory infection, are bound to reach a greater number of people than might otherwise be the case, simply because the ductwork carries the contaminated air supply to all parts of the building.

The types of bacteria and fungi isolated are not specific for air conditioning systems, but they reflect the nature of the activities carried out in the building itself. Thus in hospitals the incidence of potential pathogens found tends to be higher than in offices, hotels, or factories.

Outside air intake duct - east end of building.



Organic debris in outside air intake duct.

2.4 General Background Information (continued)

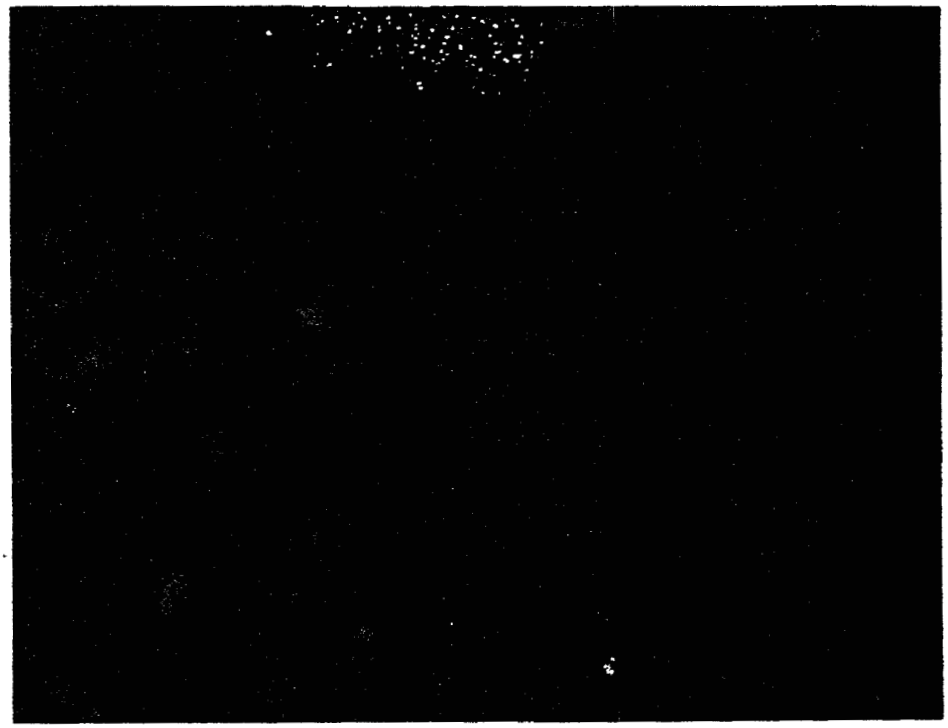
Among the bacteria frequently isolated from the air conditioning systems of offices are:

Staphylococcus aureus, Staphylococcus epidermidis, Coliform species, Diphtheroid bacilli, Pseudomonas species, Proteus species, Bacillus species, and Serratia species.

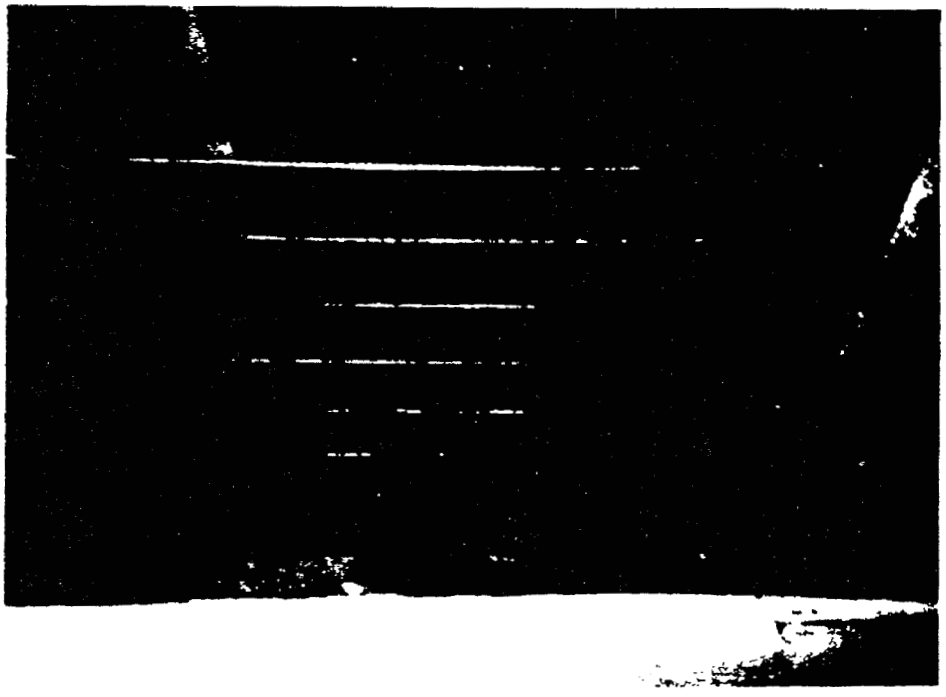
The fungal isolates often include *Cladosporium species, Penicillium species, Mucor species, Aspergillus species, Alternaria species, Rhizopus species Fusarium species, and Cephalosporium species.*

These species are found not only in air conditioning systems but also can be expected to be cultured in dirty, dusty areas frequented by humans. Some of these strains are known to cause infections and/or allergies in people.

As in easily accessible areas of the building where the amounts of visible dust and dirt are kept down to acceptable levels, the removal of a large portion of the accumulated dust and dirt from the air handling plant and its ductwork will reduce the numbers of bacteria and fungi and their spores there. The remaining small and often acceptable numbers of microbes can then be kept in check by means of effective sanitizing treatments on a regular basis accompanied by appropriate monitoring.



One inch double polyester filter
in metal frame.



Light fluff on chill
coil fins.

3.1 Environmental Control Introduction

This section contains analysis descriptions, tests, and results concerning the air handling system environment in relation to the supply and return air. These tests were carried out during the on-site inspection and help to form the basis for on-going monitoring programs.

Supporting laboratory analysis results from the other sampling appears in the Section following, "Laboratory Analysis."

3.2 Air Filtration Evaluation

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) Standard 52-76 request that filter manufacturers specify both a weight test and a dust spot test for each class of filter. Since both of these are used indiscriminately by some filter manufacturers in describing their filter efficiency, we draw your attention to the relevance of these standards.

3.2.1 Arrestance

A standardized synthetic dust consisting of various particle sizes is fed into the filter and the weight fraction of the dust removed is determined. Note: The synthetic dusts used are considerably coarser than typical atmospheric dusts in general and indoor air particulate in particular. Since most of the weight of dusts is in the larger particles, the arrestance values are usually high, but these values give no indication of the filter's capability to remove the smaller particles. In general, arrestance values are virtually useless in choosing the suitability of filters for indoor air.

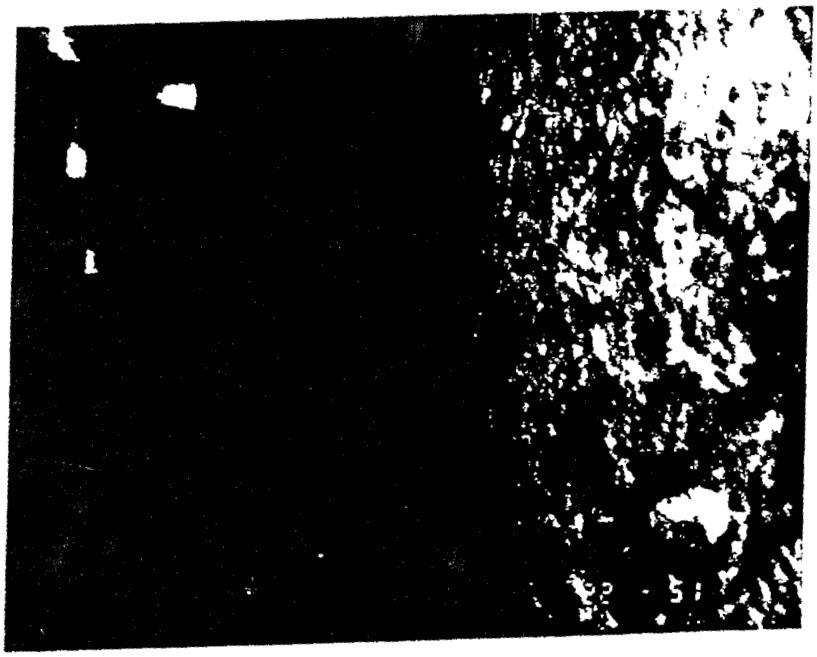
3.2.2 Atmospheric Dust Spot Test

Atmospheric dust is passed into the filter and the discoloration effect of the cleaned air is compared with the incoming air. This test does pick up many of the smaller particles since, although they are small and light, these particles do still soil walls, etc. A disadvantage of this test exists due to the variability of atmospheric dusts, which may cause the same filter to yield different efficiencies at different times or locations. Even this atmospheric dust spot test is still unreliable at the smaller particle size range, i.e., below 1.0 microns in diameter. All the ASHRAE Atmospheric Dust Spot Test results give efficiency ratings that are representative of particles greater than 1.0 micron. However, when we consider the suitability of filters from a point of view of human health, we need to be concerned about the sub-micron size particles since these are the ones that penetrate deep into the respiratory system and into the lungs. In general, the sum of all the particles of less than 3.5 microns in diameter are described as the Respirable Suspended Particulate (RSP), although most of these particles are less than 1 micron in diameter.

3.2.3 ACVA Estimated RSP Efficiency

Over the course of investigating over 60 million square feet of properties using electronic particle counters and piezomicrobalances, ACVA has evaluated the capability of each filter to stop the RSP content of indoor air. Average readings have been taken hundreds of times for each class of filter encountered. Using these averages, and after assessing the integrity of installation of your filters, we have estimated the efficiency of your filters at removing the RSP fraction of the indoor air. We believe that this efficiency rating more precisely describes the suitability of these filters in protecting your staff and/or tenants from airborne particulate.

Torn and dirty insulation
of AHU #2.



Heavily torn insulation in
air supply fan chamber AHU #1.

3.2.4 AHUs #1 and 2

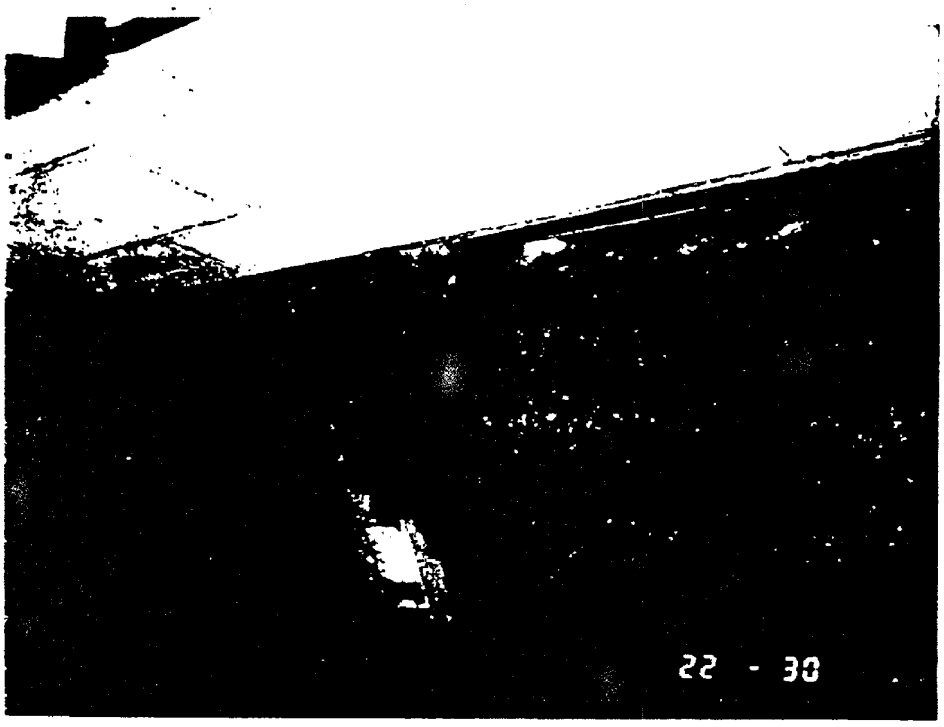
Filter type: One inch polyester tackified
Location in AHU: Before chill coils

AHU #	Condition	Loading	Fit
1	Good	Light	Good
2	Good	Light	Good

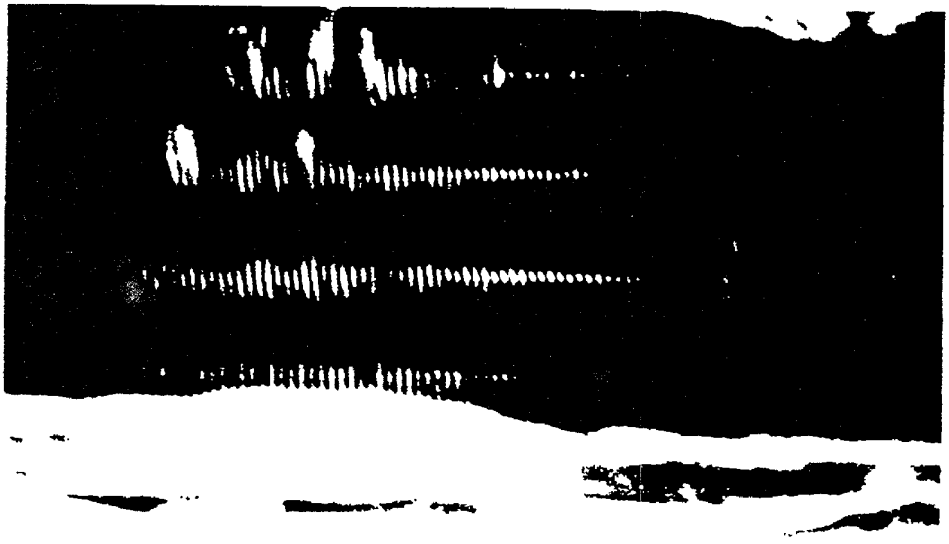
ASHRAE 52-76 Arrestance: 70-80%
ASHRAE 52-76 Dust Spot: <30%
ACVA estimated RSP: <20%

CONCLUSIONS

This materials falls slightly below our recommended standards for this type of building. As a minimum requirement, we would recommend efficiencies of around 40% according to ASHRAE Dust Spot Test. Pleated panel filters with efficiency ratings above 40% or equivalent would be a better filtration choice for this building. The presently installed polyester filters would serve as a good prefilter for pleated panel filters.



Torn and dirty insulation on access panel of AHU #2.



1st floor SW showing light mixed deposits on heat coil fins.

3.3 Airborne Particle Counts

3.3.1 Suggested Standards

The levels of airborne particulate contamination in a building's air supply depend on many variable factors such as the type of filtration system installed and its condition; the quality of the air entering the system; the condition of those parts of the plant downstream of the filters; the type and condition of the humidifying system installed; the type and condition of the main air supply ducts; the amount of recirculated air; the types of operations carried out in the receiving areas; the numbers of people in the receiving areas; and the type and condition of the final distribution equipment in the receiving areas.

Absolute standards of air cleanliness can only readily be applied where air of very low particulate content is required and supplied. Such areas are hospital operating rooms, pharmaceutical filling areas, and industrial process areas where high efficiency filters, terminal filters, and other airborne dust reducing equipment is installed. The maximum allowable recommended levels increase as "the degree of cleanliness requirement" decreases for the various types of operational conditions.

The U.S. Federal Standard 209C divides the various requirements into classes related to the maximum allowable number of airborne particles at the 0.5 micron diameter size and larger per cubic foot of air. Thus the high quality super clean room, Class 100 should have no more than 100 particles per cubic foot of air of 0.5 micron size or larger. This is the very high standard adopted by the electronic micro-chip manufacturing plants.

For your type of building and its air supply system and filters we recommend that the supply air should contain no more than 150,000 particles of 0.5 microns and larger per cubic foot of air as measured in the supply ducts at the ACVA Points. The air in the rooms and areas themselves can have counts higher than this depending on the activities being pursued at the time of counting.

Moderate mixed deposits in AHU =2 main A.S. Note torn insulation.

3.3.2
TEST — Counting of airborne particulate contamination in supply air ducts.

OBJECTIVE — To assess the degree of airborne particle contamination at the various locations in the air systems and the areas supplied.

METHOD — Sampling and counting of particles by an electronic light scattering particle counter.

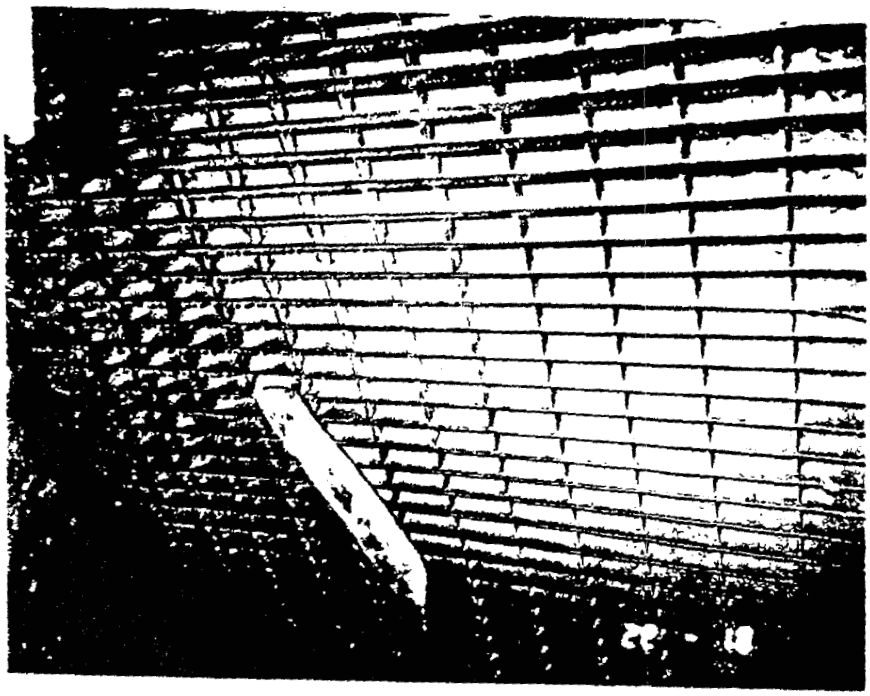
RESULTS

Point No.	Location	No. particles per cubic foot of air equal or > stated size 0.5 microns	1.0 microns
1	Basement mech. room F/A intake	278,500	27,600
2	Basement mech. main A/S AHU #1	261,100	24,200
3	Basement mech. main A/S AHU #2	306,800	23,800
4	1F N hall branch A/S, AHU #1	265,400	18,600
5	1F S hall branch A/S, AHU #1	261,500	17,700
6	2F N hall branch A/S, AHU #2	360,700	26,400
7	2F S hall branch A/S, AHU #2	316,300	27,800

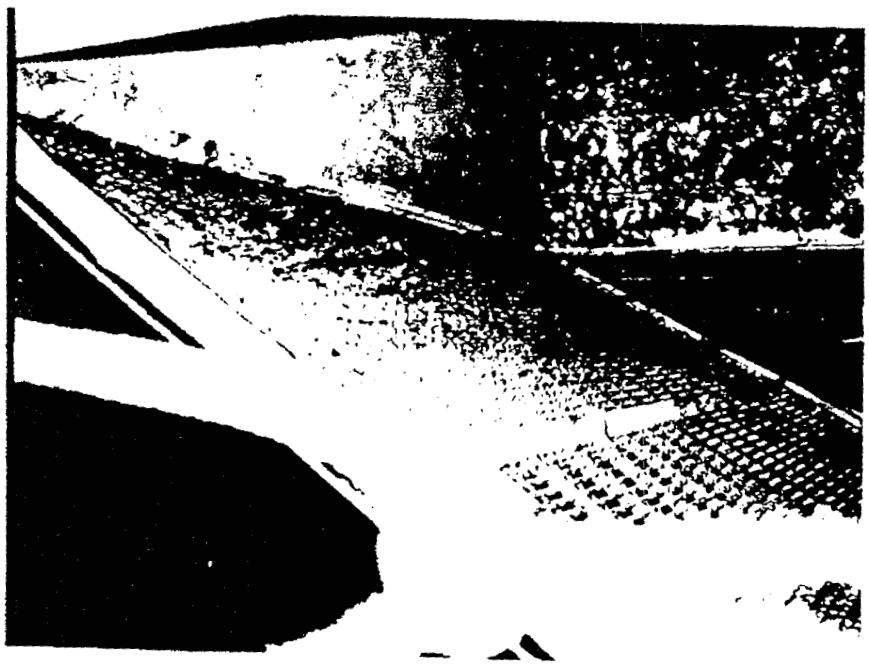
(1 micron = 1/25,400 inches)

CONCLUSIONS

The particle counts in all areas tested are well above the suggested limit of 150,000 particles of 0.5 microns and larger per cubic foot of air and are therefore considered unsatisfactory. Upgrading the filtration and cleaning the internal components and surfaces of both air handling units, along with encapsulating or removing damaged internal insulation should significantly reduce the particle counts to an acceptable level.



Debris on AHU #1 turning vanes in main air supply.



Light to moderate fluff on back of return grille.

3.3.3

TEST Weighing of airborne particles in occupied areas.

OBJECTIVE To assess the degree of respirable airborne particle contamination at the various locations in occupied areas of the building.

METHOD Sampling and weighing of particles by piezoelectric microbalance.

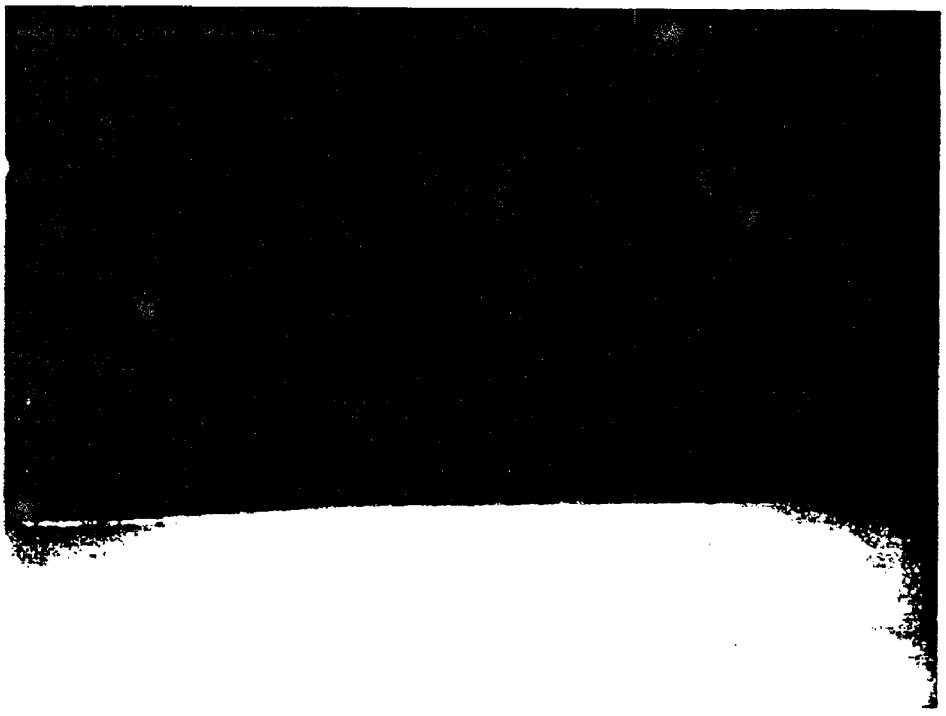
RESULTS

Sample No.	Location	Weight of particles microgram/cubic meter of air
1	Outside near fresh air intake	20
2	Floor 1 SE copy room	50
3	Floor 1 NE reception area	40
4	Floor 1 north, president's office	30
5	Floor 1 west COPE department	60
6	Floor 1 lunch room	40
7	Floor 1 south central	60
8	Floor 2 SE office	80
9	Floor 2 north central nurse fed.	40
10	Floor 2 NW lobby/atrium	30
11	Floor 2 SW area	30
12	Floor 2 south central	30

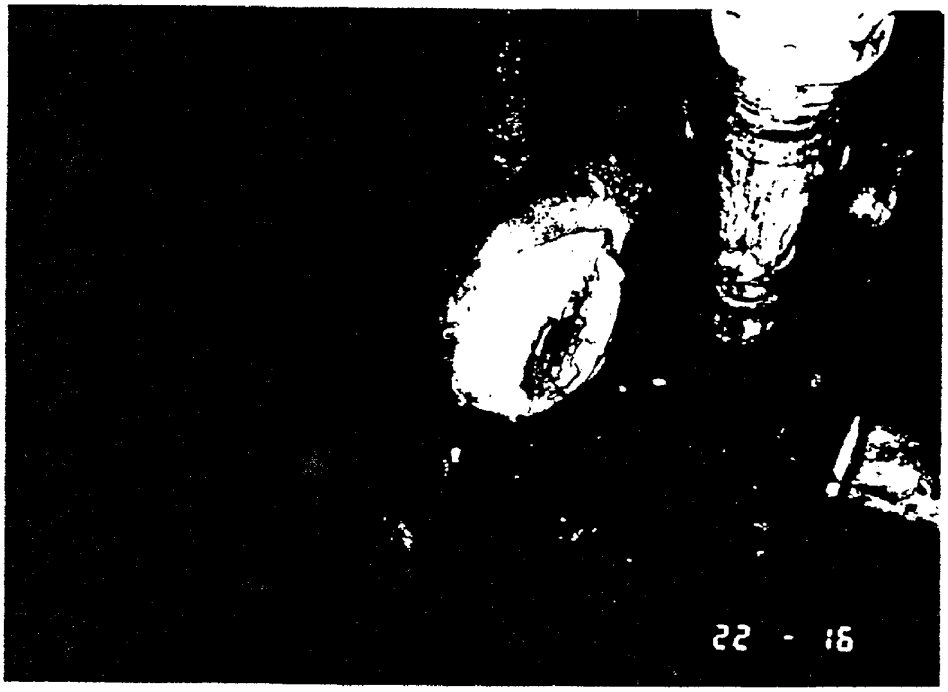
CONCLUSIONS

Some countries have set an indoor standard of 150 micrograms per cubic meter of air for total suspended particulate (TSP). We believe that for the respirable size fraction of these, i.e. the respirable suspended particulate (RSP), a figure of 75 micrograms per cubic meter of air is a realistic upper limit for general office areas.

In your building, the levels were rarely exceeded and, therefore, are not a cause for concern. However, in colder weather when the thermostat causes the fresh air dampers to close down and the system runs on entirely recycled air there will be less dilution and exhaust of internally generated particles and we would thus expect these particle weight values to generally increase.



Return duct with moderate deposits of mixed fluff.



Damaged asbestos on pipe elbow (common to all pipe runs).

3.5

TEST Static air pressure measurements.

OBJECTIVE To check the air pressure at various points in the air systems to establish if any gross imbalances or blockages exist.

METHOD Static pressure readings taken at the ACVA Points installed using a mini manometer.

RESULTS

Point No.	Location	Static pressure in inches of water in supply ducts
1	Basement mech. room F/A intake	0.05
2	Basement mech. main A/S AHU #1	0.53
3	Basement mech. main A/S AHU #2	0.69
4	1F N hall branch A/S, AHU #1	0.15
5	1F S hall branch A/S, AHU #1	0.23
6	2F N hall branch A/S, AHU #2	0.30
7	2F S hall branch A/S, AHU #2	0.28

CONCLUSIONS

It should be noted that static pressure readings will vary according to local changes of damper settings (manually or automatically) and with variations in fan speed or volume control mechanisms.

They are useful in identifying gross blockages or imbalances and they are valuable for comparative purposes in future re-inspections or on-going monitoring programs. In this instance no gross blockages or imbalances were observed.

6"x4" opening in outside air
intake duct for pipe access.

3.6
TEST — Monitoring of carbon dioxide and carbon monoxide

OBJECTIVE — To confirm that normal conditions are present in the building and, using the carbon dioxide levels, pass judgment on the efficiency of ventilation.

METHOD — Carbon dioxide levels were measured by the use of a non-dispersive infrared absorption detector; carbon monoxide was measured using an electro-chemical detector.

RESULTS

Sample No.	Location	Time	CO ppm	CO_2 ppm
1	Outside near fresh air intake	9:15	3	350
		1:30	3	350
2	Floor 1 SE copy room	9:47	4	450
		1:37	5	450
3	Floor 1 NE reception area	9:55	4	500
		1:49	5	550
4	Floor 1 N. president's office	10:03	4	450
		1:55	5	500
5	Floor 1 west COPE department	10:15	5	450
		2:10	5	500
6	Floor 1 lunch room	10:20	5	500
		2:20	5	550
7	Floor 1 south central	10:28	4	500
		2:28	5	550
8	Floor 2 SE office	10:37	5	450
		2:36	5	450
9	Floor 2 north central nurse fed.	10:48	5	450
		2:43	4	500
10	Floor 2 NW lobby/atrium	10:59	5	500
		2:49	5	500
11	Floor 2 SW area	11:04	5	500
		2:59	5	550
12	Floor 2 south central	11:10	5	550
		3:05	5	500

(CO = carbon monoxide; CO_2 = carbon dioxide; ppm = parts per million)

3.6 Carbon Dioxide and Carbon Monoxide Measurements (continued)

CONCLUSIONS

Carbon Dioxide

Historically, the accepted upper limit for carbon dioxide has been that proposed by the American Conference of Government Industrial Hygienists (ACGIH). This was 5,000 ppm TWA (Time Weighted Average) for a normal eight hour day.

However, as we progressed towards tighter buildings in an endeavor to maximize energy conservation, complaints arose about the quality of the indoor air. Experience has taught us that when we fail to maintain a minimum fresh air intake to a building, then all indoor pollutant levels rise, including carbon dioxide exhaled by all building occupants.

When carbon dioxide levels exceed 1,000 ppm in the indoors, many staff experience discomfort, headaches, tiredness and general lethargy. Even at levels of between 800-1,000 ppm, a proportion of the staff are adversely affected. It is generally accepted that it is not necessarily the carbon dioxide itself causing the problem, but the sum of all indoor pollutants that must be trapped at the same time as is the carbon dioxide. Thus, we now recognize the value of carbon dioxide as a surrogate indicator of the effectiveness of overall ventilation.

For this reason, several countries in Europe and Japan have recently moved to set 1,000 ppm as an upper limit for carbon dioxide in the indoor air.

Furthermore, ASHRAE had adopted the 1,000 ppm ceiling in raising its overall minimum ventilation rate for office buildings. The rate to be adopted in 1989 specifies a minimum fresh air make-up rate of 20 cfm/person (20 cubic feet per minute per person). This is the minimum requirement at all times of building occupancy. With normal staffing levels and using the 20 cfm/person, fresh air intake rate the carbon dioxide levels will be maintained below 800 ppm.

In your building, carbon dioxide levels were well below 800 ppm, indicating adequate ventilation at the time of inspection and no build-up of this gas. This was not surprising since the outside temperatures on the day of inspection ranged from 64°F in the morning and 78°F in the afternoon. Under these conditions the fresh air dampers remain 100% open. However, consider the situation of temperatures below 60°F when the dampers close. On such days the system will run on mostly recycled air and allow carbon dioxide levels to build up to levels above 800 ppm.

3.6 Carbon Dioxide and Carbon Monoxide Measurements (continued)

Carbon Monoxide

As in the case with carbon dioxide, Japan and some European countries have already defined new indoor standards for carbon monoxide and 9 ppm is the generally acceptable new level. Indoor readings tend to reflect the prevailing outdoor levels and this was the case with these readings, indicating that no significant sources of carbon monoxide were prevalent in your building over the test period.

3.7

TEST — Sampling and analysis of building air for formaldehyde content.

OBJECTIVE — To measure the levels of formaldehyde gas present and compare with standards.

METHOD — Passing known volumes of air through a solution of sodium bisulfite and analyzing by chromotrophic acid procedures using NIOSH Method P&CAM 125M.

RESULTS

Sample No.	Location	Formaldehyde concentration (ppm)
1	Floor 1 southeast mail room	0.02
2	Floor 1 central storage room	0.02
3	Floor 2 central storage room	0.04
4	Floor 2 southeast copy room	0.04

CONCLUSIONS

The minimum detection level for the above NIOSH (National Institute of Occupational Safety and Health) method is 0.01 ppm and the indoor standard recommended by ASHRAE is 0.1 ppm, therefore on the days of our tests no significant levels of formaldehyde were detected.

3.8

TEST — Screening for miscellaneous gases in various parts of the building.

OBJECTIVE — To establish if any known toxic gases are present in the air in the building.

METHOD — Sampling of ambient air with a precision pump and measurement with direct reading calibrated detector tubes.

RESULTS

Sample No.	Location	NO_2 ppm	L-HC (%)	H-HC ppm	SO_2 ppm	O_3 ppm	NH_3 ppm
1	Outside near F/A intake	<0.2	<0.01	<20	<0.1	<0.05	<0.15
2	Floor 1 SE copy room	<0.2	<0.01	<20	<0.1	<0.05	<0.15
3	Floor 1 president's office	<0.2	<0.01	<20	<0.1	<0.05	<0.15
4	Floor 1 lunch room	<0.2	<0.01	<20	<0.1	<0.05	<0.15
5	Floor 2 SE office	<0.2	<0.01	<20	<0.1	<0.05	<0.15
6	Floor 2 NW lobby/atrium	<0.2	<0.01	<20	<0.1	<0.05	<0.15

Key:

NO_2 = Nitrogen dioxide
L-HC = Hydrocarbons - lower
H-HC = Hydrocarbons - higher
O_3 = Ozone
SO_2 = Sulfur dioxide
NH_3 = Ammonia

Notes:

a. ppm = parts per million
b. "Lower" and "higher" refers to the molecular weight of the hydrocarbon compounds.

CONCLUSIONS

None of the above gases were present in large enough amounts to be measured by the test. The minimum measurable concentrations for each test (as indicated in the results) are all well below the recognized threshold limit value time weighted averages where recommended by the American Conference of Governmental Industrial Hygienists (ACGIH).

3.9

TEST — Temperature and relative humidity measurements.

OBJECTIVE — To confirm that ambient room temperatures and relative humidities are satisfactory.

METHOD — Measurement of ambient temperature and relative humidities by the use of an electronic thermohygrometer.

RESULTS

Sample No.	Location	Temp. °F	Relative humidity %
1	Outside near fresh air intake	64	28
2	Floor 1 SE copy room	68	44
3	Floor 1 NE reception area	72	39
4	Floor 1 north, president's office	72	38
5	Floor 1 west COPE department	73	38
6	Floor 1 lunch room	73	40
7	Floor 1 south central	73	38
8	Floor 2 SE office	73	38
9	Floor 2 north central nurse fed.	73	37
10	Floor 2 NW lobby/atrium	73	38
11	Floor 2 SW area	73	38
12	Floor 2 south central	75	37

CONCLUSIONS

On the day of our inspection, the ambient temperature readings made throughout the office areas ranged from 68°F to 75°F and the relative humidities ranged from 37% to 44%.

ASHRAE recommends year round comfort temperature ranges of 20 to 26°C (68 to 78.8°F) for winter and 22 to 26°C (71.6 to 78.8°F) for summer and the temperatures recorded are sufficiently close to these to satisfy the majority of building users.

Below relative humidity readings of 20%, the mucus membranes of the nasal passages, throat, and eyes of people begin to dry out, possibly rendering them more susceptible to microbial infections at these sites.

On the day of our measurements the relative humidity readings were satisfactory.

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4.1

TEST — Sample wipes from the internal surfaces of the air handling units and their associated ductwork systems.

OBJECTIVE — To assess the degree and nature of the dirt contaminating the ducts.

METHOD — Sampling with wipes and subsequent laboratory examination using microscopic and analytical techniques.

RESULTS

AHU Location	Particle types found, see key below A	B	C	D	E	F	G	H
Basement mech. room F/A intake	Md	Lt	Tr	-	-	-	Md	-
Basement mech. main A/S AHU #1	Lt	Lt	Lt	-	-	-	Tr	Lt
Basement mech. main A/S AHU #2	Md	Lt	Lt	-	-	-	Tr	Tr
1F N hall branch A/S, AHU #1	Md	Lt	Lt	-	Tr	-	-	Md
1F S hall branch A/S, AHU #1	Md	Lt	Tr	Tr	-	Tr	-	Tr
2F N hall branch A/S, AHU #2	Lt	Lt	Tr	-	Tr	-	Tr	-
2F S hall branch A/S, AHU #2	Lt	Lt	Tr	Tr	-	Tr	-	Tr

Key to symbols:

A = Carbonaceous
B = Fine particle agglomerations
C = Rust/iron oxides
D = Crystalline particles, plaster, etc.
E = Textile fibers
F = Paper dust
G = Organic matter
H = Fiberglass

Ex = Excessive
Hv = Heavy
Md = Moderate
Lt = Light
Tr = Trace
- = none observed

CONCLUSIONS

These sample wipes contain a mixture of commonly found products of urban pollution. Most of the carbonaceous materials will be by-products of oil or gas combustion, vehicle exhausts, and automobile tire fragments.

The fine particle agglomerations are made up of numerous tiny particles that were once fine enough to pass the filters and have later agglomerated by adhesion and/or electrostatic attraction. Also present are particles contributed from the building itself, such as plaster dust, water salts, fibers from the shedding of insulation, textiles, and rust from the heater frames and downstream sections of the air handlers, etc., and textile fibers and paper dust from the office areas entrained in the return air.

No potentially harmful materials were found apart from the moderate amounts of organic material at point #1. This area of the ductwork should be cleaned to remove all dirt and debris.

4.2

TEST — Microbiological testing of systems' internal surfaces.

OBJECTIVE — To assess the degree of bacterial and fungal contamination present.

METHOD — Sampling with Random Organism Detecting and Counting (RODAC) agar plates followed by subsequent laboratory incubation and examination.

RESULTS

Sample No.	Location	Number of colonies found per plate Bacterial	cfu	Fungal	cfu
1	2F north branch A/S outlet	Bacillus sp. Micrococcus sp.	1 1	Alternaria sp. Cladosporium sp.	2 4
2	AHU #2 main A/S duct	Bacillus sp. (P) Diphtheroids Micrococcus sp.	OV	Alternaria sp. Aspergillus sp Oospora species	2 1
3	AHU #1 A/S fan chamber	Bacillus sp. (P) Diphtheroids Micrococcus sp.	OV	Alternaria sp. Aspergillus sp. Cladosporium sp. Oospora species Penicillium sp.	OV
4	AHU #2 A/S fan housing	Bacillus sp. (P) Diphtheroids Micrococcus sp.	OV	Alternaria sp. Candida sp. Chaetomium sp. Cladosporium sp. Oospora species Penicillium sp.	OV
5	1F A/S diffuser	Bacillus sp. Diphtheroids Micrococcus sp.	2 3 1	Alternaria sp. Cladosporium sp. Oospora species	2 5 1
6	1F west perimeter office carpet	Bacillus sp. Diphtheroids	2 1	nil	--
7	2F SE hall ceiling	nil	--	Alternaria sp.	2
8	2F north central nurses federation A/S diffuser	Bacillus sp. (P) Diphtheroids Micrococcus sp.	OV	Alternaria sp. Candida sp. Cladosporium sp.	4 3 31

Key: OV = Overgrown with spreading colonies, no count possible
cfu = colony forming units
P = Predominant organism
TN = Too numerous to count
sp. = species

TI DN 0014854

4.2 Surface Microbiological Testing (continued)

CONCLUSIONS

Sampling by contact plates (RODACS) yields data that is often difficult to interpret due to irregularities found in surface sampling. They are accurate in a qualitative sense, excessive numbers of specific microbial types forewarns of a potential risk condition.

In the above samples, no serious pathogenic bacteria were identified. The bacterial species isolated were all common and relatively harmless dust organisms. Naturally, these counts increase with dust levels, but in this instance we see no cause for concern.

In the case of the fungi there were a number of species identified, some of which are known allergens such as Cladosporium, Penicillium, and Aspergillus species. Because these are known to cause allergic reactions in sensitive people, preventive measures should be taken to keep these fungal species in check. In order to accomplish this the internals of each air handling unit should be sprayed down with a safe, broad spectrum biocide. This should be done just prior to a weekend and the units run at least overnight to allow any odors to dissipate. Suitable products for this include Microban Institutional Spray from Unsmoke Systems in Homestead, Pennsylvania, or equivalent. The addition of chemical packs to the condensate trays will also keep the numbers of bacterial and fungal organisms in check.

The air supply diffusers showed a range of similar fungal organisms and should also be cleaned and wiped down with a sanitizing agent.

4.3

TEST — Testing for airborne microbial content.

OBJECTIVE — To assess the numbers and types of bacteria and fungi present in the building air.

METHOD — Sampling with an RCS Centrifugal Air Sampler using agar strips containing tryptic soy agar for bacteria and rose-bengal agar for fungi.

RESULTS

Sample No.	Location	No. of colonies found per cubic meter of air
1	Outside near fresh air intake	563
2	Floor 1 SE copy room	175
3	Floor 1 lunch room	125
4	Floor 1 N president's office	1,413
5	Floor 2 southeast	163
6	Floor 2 NC Fed. Nurse's office	250
7	Floor 2 southwest	125
8	Floor 2 south central	175

CONCLUSIONS

Identification of the species from these airborne samples shows them to be similar to those isolated from the internals of the air supply and return systems. In this instance the counts are for the most part lower than the suggested maximum acceptable level of 750 colonies per cubic meter of air.

The suggested level of 750 colonies per cubic meter of air is a total count, but we feel that even where the total count is lower and where specific fungi known to cause allergenic reactions and infections are isolated, some action should be taken in the form of sanitizing of the system internals to reduce or eliminate such species.

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4.4

While conducting the air quality inspection in this building, materials were noted which could contain asbestos. Samples were taken for bulk analysis and the results are given below. These are random samples only and these results do not constitute a full asbestos survey.

TEST — Bulk asbestos analysis.

OBJECTIVE — To establish the presence of asbestos in samples of insulating material.

METHOD — Polarized light microscopy and dispersion staining under EPA bulk asbestos proficiency guidelines.

RESULTS

SAMPLE #1

Source — Basement mechanical room pipe elbow insulation.

Description — Off-white compacted fibrous layer over fiberglass.

Analysis

Total percent asbestos	40-45%
Types: Amosite - 20-25%	
Chrysotile - 15-20%	
Fibrous glass	5-10%
Non-asbestos, non-fibrous	40-45%

CONCLUSIONS

Because this material was found to contain asbestos and because this material was damaged, we recommend removal by a specialist contractor. Additionally, the hole in the fresh air duct that was noted should be sealed to prevent any infiltration of asbestos containing materials from the basement. However, we emphasize that this sample does not constitute a full asbestos survey or hazard assessment for this building.

4.5

TEST — Sampling and analysis of volatile organic compounds.

OBJECTIVE — To estimate the amounts of any volatile organic compounds present in the building air.

METHOD — Air sampling using Tenax Sorbent Tube and subsequent analysis using chromatography and mass spectroscopy.

RESULTS — A total of fifteen (15) target compounds were searched for in each sample. The following table shows the airborne concentration at which they were found or the lower detection limit indicated by a "less than" (<) sign in those cases where they were not found.

Compound	Floor 1 SE mail room ug/m^3	2F north central nurses union office ug/m^3
Acetone	9.8	49.1
Benzene	4.8	10.4
2-Butanone	<1.6	<1.6
Carbon Tetrachloride	<0.8	<0.8
Chlorobenzene	<0.8	<0.8
Chloroform	<0.8	<0.8
Ethylbenzene	1.6	2.6
Methylene Chloride	3.0	3.3
Styrene	1.3	4.4
1,1,2,2-Tetrachloroethane	<0.8	<0.8
Toluene	13.9	30.9
1,1,1 Trichloroethane	42.6	416.7
Trichloroethene	<0.8	<0.8
Vinyl Chloride	<1.6	<1.6
Xylene (Total)	5.1	8.3

(ug/m^3 = micrograms per cubic meter)

CONCLUSIONS

Levels found for the fifteen (15) volatile organic compounds tested were well below the American Conference of Governmental Industrial Hygienists (ACGIH) recommended levels for industrial areas. In many cases, levels were below the minimum detection limit. However, it is not known at this time by any agencies, such as ACGIH, what the combined effect of low levels of these compounds might be. Maintaining proper ventilation rates at all times should prevent the build-up of many of these compounds.

4.6

TEST Measurement of environmental tobacco smoke (ETS) in selected areas.

OBJECTIVE To establish average levels of tobacco smoke in the room air and compare with permissible occupational exposure limits.

METHOD Sampling of airborne particulate matter, nicotine, and carbon monoxide in occupied areas, together with carbon dioxide measurements as an indicator of ventilation efficiency at the time of sampling.

RESULTS

Location	1F reception	Lunch room	2F nurses U office	2F employ U office
Carbon dioxide (ppm)	465	520	475	460
Carbon monoxide (ppm)	3.6	4	5.1	5.1
Airborne particulates (RSP) (ug/m^3)	57	52	29	35
Airborne nicotine (ug/m^3)	2	28.7	6.2	3.8
Number of people	2	6	2	2
No. cigarettes smoked	4	6	3	1

(ug/m^3 = micrograms per cubic meter of air)

DISCUSSION

Particulate Matter

With respect to the particulate matter readings, some researchers focus on the total dust content of the air, the so-called Total Suspended Particulates (TSP). These include all particles found suspended in the air. Usually particles larger than 15 microns settle out of the air or are rarely inhaled. The human nose then filters out most of the larger particles of about 10 to 15 microns. Then the cilia in the windpipe and throat capture and expel the particles from about 4 to 10 microns, leaving only the finer particles of 3 to 4 microns or less in diameter that penetrate into the lung. These finer particles, the so-called Respirable Suspended Particulates (RSP) are the important fraction from the human health point of view and our measurements of particulate matter are limited to this RSP fraction.

4.6 Measurement of Environmental Tobacco Smoke (continued)

Respirable Suspended Particulates (RSP)

The long term exposure limit for respirable dusts (eight hour time weighted average) as used by the British Health and Safety Executive is 5,000 ug/m^3. This is the same as the U.S. Environmental Protection Agency (EPA) standard for the ambient or outside air. However, these figures are generally considered to be unsuitable for use in evaluating indoor air quality and no recommended limit exists other than in Japan, which has set an upper limit of 150 ug/m^3 for the total suspended particulates (TSP). We believe that an upper limit of 75 ug/m^3 should be acceptable for the RSP fraction for typical office use.

Nicotine

The long term occupational exposure limit (eight hour TWA) as used by the British Health and Safety Executive is 500 ug/m^3 and a short term, ten minute exposure limit of 1,500 ug/m^3. This standard was adopted as an industrial health practice to limit worker exposure to nicotine in a work environment. ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) suggests that when we consider the indoor environment of offices, it would be cautious to err on the safe side in suggesting acceptable indoor limits. Specifically ASHRAE suggest a reduction to one-tenth of the TWA value, which in the case of nicotine would be 50 ug/m^3. This standard is now adopted by ACVA. The safety factor helps recognize that the general population is more varied than the industrial population in susceptibility to injury due to greater variation in age and in health status. Furthermore, the industrial population is often under continual health supervision, which is not so common in the case of the general public.

In our previous studies of approximately 100 offices sampled on a worldwide basis where smoking was allowed, the average airborne concentration of nicotine was 4.0 ug/m^3.

Another way of expressing the relative meaning of the nicotine concentrations in air is in terms of "cigarette equivalents." Cigarette equivalents are an estimate of exposure, based on the nicotine content in an average cigarette and published breathing rates for activity levels similar to miscellaneous office work. In this way a measured nicotine concentration may be expressed as cigarette equivalents.

Using breathing rates as published by ASHRAE (American Society of Refrigeration and Air Conditioning Engineers), the average individual in an office inhales 8.6 liters of air per minute or 4.13 cubic meters of air per eight hour day. If the average nicotine content of that air was 4.0 ug/m^3, each individual would inhale 16.52 micrograms of nicotine throughout the course of each day.

4.6 Measurement of Environmental Tobacco Smoke (continued)

Since the average smoker in the USA inhales 880 micrograms of nicotine per cigarette, the non-smoker exposed to 16.52 micrograms per day could inhale 0.019 "cigarette equivalents" per eight hour day.

CONCLUSIONS

The carbon dioxide levels in each of the four areas tested were below the recommended level of 800 ppm, however the elevated reading of 620 ppm in the lunchroom indicates that a ventilation problem may be present. The carbon monoxide levels were all below the recommended standard of 9 ppm. The respirable sized particulates were all below our recommended level of 75 ug/m^3.

With respect to nicotine, very low levels were found in all areas tested except for the lunch room. The elevated reading found in the lunch room is not at a level that would cause concern, but could be easily reduced with proper ventilation. To achieve this, it may be necessary to add a dedicated exhaust for this area. Of particular concern is the fact that during temperatures below 60°F when the fresh air dampers close, nicotine levels will tend to build up due to lack of ventilation. ASHRAE's recommended ventilation rate of 20 cfm per person of fresh air should be met on a year round basis in all areas of the building.

5.1 An ACVA Indoor Air Quality Inspection was carried out at the Wisconsin State AFL-CIO building located at 6333 West Blue Mound Road in Milwaukee, Wisconsin on the 18th and 19th of April 1989.

5.2 Visual inspections of the air handling units serving this building found them to be in need of a general cleaning and the soiled and torn internal insulation in both units was releasing fibers into the air supply.

5.3 With the current setting of the fresh air dampers in your building adequate fresh air is being supplied to the building. However, we were concerned that during temperatures below 60°F that indoor airborne pollutants would be allowed to build-up due to the closing of the fresh air dampers by a temperature controlled pneumatic mechanism.

5.4 Visual inspections of the duct internals showed contamination that would be expected for a building of this age. The levels of contamination found in the fresh air intake duct were above levels that we like to see in office buildings and damaged internal insulation was noted in the main air supply duct of air handling unit #2.

5.5 Assessment of the filter systems in place revealed that the presently installed polyester filters are removing less than 20% of respirable suspended dusts from the supply air and fall below our recommended standards for office buildings.

5.6 Airborne particle counts taken within the supply air ducts were all below the recommended level of 150,000 particles of 0.5 microns and larger per cubic foot of air, confirming that adequate air filtration is not occurring.

5.7 Measurement of weights of respirable matter were for the most part below our recommended level of 75 ug/m^3 and were, therefore, considered to be satisfactory.

5.8 Static pressure measurements made from the supply ductwork did not identify any gross imbalances or blockages.

5.9 Carbon dioxide measurements taken at this inspection to assess ventilation efficiency revealed that the building was receiving adequate fresh air with carbon dioxide levels below 800 ppm on the day of our inspection. The outside temperature ranged from 64°F to 78°F on this day. At temperatures below 60°F the pneumatic mechanism that operates the fresh air dampers causes the dampers to close. When this occurs the air handling units run on a much greater percentage of recycled air. We can thus envision carbon dioxide levels building up above this figure of 800 ppm during outside temperatures below 60°F.

5.10 Carbon monoxide levels measured throughout the building showed levels that tended to mirror outdoor readings with no levels which would give cause for concern.

5.11 Temperature and relative humidity readings taken throughout the occupied areas showed them to be within generally accepted comfort levels on the day of our inspection.

5.12 Gas sampling for a range of other potentially irritating gases such as ozone, sulphur dioxide, and high and low molecular weight hydrocarbons revealed no levels of these gases above the detection level of the method used, and therefore are of no concern at this time.

5.13 Analysis of sample wipes showed no harmful materials apart from the levels of organic matter found in the fresh air intake duct, which can serve as an indication of microbial growth.

5.14 Microbial surface sampling results showed a range of typical bacteria species which are common and generally harmless. A number of fungal species were also identified and of these, Penicillium, Aspergillus, and Cladosporium species are known to be allergens in sensitive individuals. These species were repeated throughout the air handling units and on the supply air diffusers.

5.15 Microbial air sampling results showed a similar range of species to that found from the microbial surface sampling.

5.16 A bulk sample taken was tested and was found to contain 40-45% asbestos material. However, this sample does not warrant a full asbestos survey for this building.

5.17 Sampling for volatile organic compounds found levels below the American Conference of Governmental Industrial Hygienists recommended levels for industrial areas. Maintaining proper ventilation rates at all times should prevent the build up of any compounds.

5.18 Testing for environmental tobacco smoke showed low levels of nicotine for discretionary smoking areas. Slightly elevated levels were found in the lunch room. These levels were not seen as a cause for concern and can be reduced by adding a dedicated exhaust for this area.

6.1 Overall the air handling units and their associated equipment were showing their age and were in need of some general cleaning and maintenance operations. The internal components and surfaces of both units should be cleaned. These operations should include repairing or removing the internal insulation within the units to prevent any further release of fibers into the air supply. The damaged internal insulation noted in the main air supply duct of air handling unit #2 should also be repaired. After cleaning the units they should be sprayed down with a safe, broad spectrum biocide. A suitable product would be Microban Institutional Spray available from Unsmoke Systems Inc., Homestead, Pennsylvania, or equivalent. We also suggest the use of chemical packs in the condensate trays of both units.

Additionally, the fresh air intake duct should be cleaned to remove any debris and accumulations. The fresh air intake should be raised to prevent the infiltration of such debris as leaves. Cleaning the air supply diffusers with a sanitizing agent is also recommended.

6.2 From an air quality standpoint, the presently installed polyester filters should be upgraded to more efficient filters -- pleated panel filters with ASHRAE Dust Spot Test efficiency ratings of 40% would be a good choice. Installing more efficient filters will also help to prevent the levels of contamination from building up in the supply air ducting. It should be noted if the present levels of contamination continue to increase within the ductwork, cleaning operations may be necessary in the future.

6.3 Because the pneumatic mechanisms that control the fresh air dampers will cause the fresh air dampers to close at temperatures below 60°F, we believe that indoor pollutant concentrations will increase when these dampers close and the system runs on a greater percentage of recycled air. In order to prevent the build-up of indoor airborne pollutants and gaseous pollutants such as carbon dioxide during colder temperatures, we recommend the installation of heat coils within the fresh air intake duct. The heating of the outside air to a temperature above 60°F before reaching the fresh air dampers' controlling mechanism will cause the dampers to remain open and allow the building to receive ample amounts of fresh air on a year round basis.

6.4 We recommend that the asbestos containing material found in the basement mechanical room be removed by a specialist contractor. Additionally, the hole in the fresh air duct that was noted should be sealed to prevent any infiltration of asbestos containing materials from the basement. The finding of this one item of asbestos containing material does not, of course, constitute a full asbestos survey and we recommend that such a survey be done and a risk assessment made of any asbestos containing materials identified.