

UPDATE

UCSF Mission Center Building Air Quality Improvement Program

April 25, 1994

Work on the \$1.9 million overhaul of Mission Center's ventilation system began in January and will continue until June 1995, UCSF Vice Chancellor Dorothy Bainton told building employees at a "town hall" meeting on April 15.

UCSF decided to move ahead with program after a series of comprehensive new studies found significant problems in providing adequate fresh air to all parts of the building.

At the April 15 meeting, Bainton and others overseeing the air quality improvement program provided updates on the repair and renovation of the ventilation system, the employee health survey, and the air quality evaluation.

Ventilation System Improvements

UCSF retained the mechanical engineering firm Fisher O'Connell Associates, Inc. of San Francisco, to identify problems and design a program to overhaul, repair, and replace parts of the Mission Center ventilation system.

- Crews are currently replacing all of the building's thermostats and inspecting all of the air distribution boxes the thermostats control. In many cases, the distribution boxes are being replaced because the dampers and other mechanical parts needed to direct the air no longer work.
- Some of the ducts that carry pressurized air to the distribution boxes also are being replaced. Much of the air pumped through the ducts never reached the distribution boxes because of leaks in the old tubing
- The next steps in the project will include a room-by-room evaluation of air movement, redistribution and rebalancing of air flow, improvements to wall baseboard heaters, and an overhaul of the air compressors that push the air through the building.

Engineers from Fisher O'Connell are working with various air filter suppliers to evaluate the charcoal filters installed last year in Mission Center's air intake vents. Because of the concentration of industrial and commercial uses in the Mission District, the filters appear to remain effective for shorter periods than normal. Different types of filters are being evaluated to find the most effective and to determine the best replacement schedule.

Employee Health Survey

A team of occupational health experts led by Robert Harrison, MD, UCSF associate clinical professor of medicine, reported the final results of a survey of Mission Center workers about their health concerns.

- A total of 454 UCSF employees, or 59 percent of those who work in the building, responded to the survey. A total of 193 people (43 percent) reported taking off an average of slightly more than seven days in the previous year as a result of illnesses which they believed to be caused or worsened by their work environment.

- Most of the problems reported involved symptoms associated with inadequate ventilation, including upper respiratory conditions and eye irritation.
- Lower respiratory irritation, such as chest tightness and wheezing, was reported by fewer than 15 percent of the employees. Harrison said this suggests that toxic contaminants within the building are not causing a high proportion of lower respiratory problems.
- An analysis of the results found no difference in employee symptoms among on any of the building's six floors or in any of the different areas served by the building's eight separate ventilation systems.
- In order to answer questions about the rate of miscarriages suffered by Mission Center employees, the health survey included questions concerning pregnancy. A total of 40 employees reported they were pregnant or had fathered a child over the previous 12 months, of which three ended in a spontaneous abortion. Harrison noted that this rate is well within the range expected for spontaneous abortions.

Air Quality Evaluation

UCSF contracted with Indoor Environmental Engineering of San Francisco to test Mission Center air samples for a wide range of possible air contaminants. Engineers used the most modern and accepted technology to conduct the tests but found no significant contaminants.

- More than a year ago, EH&S found a detectable contaminant in the building's air for the first time since they began taking air samples. A paint chemical called diisocyanate was measured at levels nearly 100 times below state safety standards. No air samples taken at Mission Center, including those in the most recent tests by the outside firm, have contained any kind of detectable contaminant, including diisocyanate.
- Because an auto body shop located next door to Mission Center appears to be the source of the paint odors, UCSF began negotiations with the body shop owners to develop a way to control the fumes. Two companies that sell painting booths designed to capture and remove fumes are preparing bids.
- Compounds for which air samples were tested include carbon dioxide, carbon monoxide, volatile organic compounds, formaldehyde, microbiological contaminants, total suspended particulates, silica, total suspended fibers, airborne metals, and isocyanates (including diisocyanates).
- The report concluded that several locations in the building do not receive enough fresh air under some circumstances, particularly during cold periods when less outside air is drawn into the building in order to maintain indoor temperatures. Inadequate ventilation in the building correlates with the two of the most frequently cited problems in the employee health survey — "stuffy, stale" air (reported by 58 percent of the respondents) and air temperatures that are "too hot" (reported by 53 percent).

Copies of the studies are available for review in the Mission Center Building manager's office.

MCB/940421/803959
Dorothy A. STINNETT
LPPI
Bx 0884 (m) MCB 506

APR 26 1994

Major overhaul of MCB's ventilation system begins next week

Vice Chancellor David J. Ramsay announced in early January plans to begin work as soon as possible on an overhaul and repair of the Mission Center Building's ventilation system.

Ramsay expects the project to begin within a week. The decision to move ahead with the overhaul was made after reviewing the results of comprehensive new studies of employee health concerns, air quality, and the mechanical condition of the ventilation systems in the building.

The new studies found no contaminants in the building's air and no clusters of complaints among workers in the building, but the results revealed significant problems in providing adequate fresh air to all parts of the building.

Background

MCB employees began complaining of odors and poor air quality more than 10 years ago before the building was acquired by UCSF. Soon after, the Environmental Health & Safety Office began a series of air quality surveys in an attempt to locate the source of any problem.

Early last year, EH&S found a detectable contaminant in the building's air for the first time since they began taking air samples. A paint chemical called diisocyanate was measured at levels nearly 100 times below state safety standards. Since then, no air samples taken at MCB have contained any kind of detectable contaminant, including diisocyanate.

Employee complaints about sore throats, dry eyes, and other health concerns have continued, and UCSF decided several months

ago to conduct an employee health survey and to obtain opinions from experts in air quality and ventilation systems in an attempt to resolve the situation.

Employee Health Survey

A team of occupational health experts led by Robert Harrison, associate clinical professor of medicine, surveyed MCB workers about their health concerns.

- A total of 439 people, or 56 percent of those who work in the building, responded to the survey. Researchers hope to increase the response rate through a reminder letter to employees who failed to answer.

- Most of the problems reported by MCB employees are symptoms associated with inadequate ventilation — dry and strained eyes (reported by 48 percent of those responding), sneezing (43 percent), stuffy nose or congestion (43 percent), fatigue (41 percent), sore or dry throat (30 percent), runny nose (30 percent), and headaches (28 percent).

- A preliminary analysis of the results found no concentration of employees with symptoms on any of the building's six floors. Most floors, however, are served by more than one of the building's eight separate ventilation systems, and researchers will next search for any concentrations of employees with symptoms in areas served by each ventilation system.

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Pay off your credit cards & other good ideas for the New Year

For those who are in the midst of turning over new leaves, Financial Planning's John Beeson has forwarded some ideas for a more financially secure future:

- **Pay off your credit cards.** The national average credit card finance charge is about 16%, so eliminating your credit card balance makes good financial sense. One source of funds may be your 403 (b) plan at UC.

- **Create an emergency cash reserve.** At least one and preferably two or three times your monthly living expenses should be set

aside in a savings account or money market fund in case of a small catastrophe.

- **Contribute to the 403 (b) plan.** This will reduce your taxable income (which reduces your taxes) and builds up funds for your retirement. All funds grow tax deferred until withdrawal.

- **Look for future articles on investment options and strategies.** Meanwhile, call 476-9256 for more information on the above or to arrange for personal financial planning counseling.

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- Charcoal filters installed in the building's air intake vents last year work adequately but may be insufficient to remove the odor of paint fumes from the auto body shop located next to Mission Center. The report recommended studying other types of filtration systems.

- The report concluded that several locations in the building do not receive enough fresh air under some circumstances, particularly during cold periods when less outside air is drawn into the building in order to maintain indoor temperatures.

- Inadequate ventilation in the building correlates with the two most frequently cited problems in the employee health survey — "stuffy,

respondents) and air temperatures that are "too hot" (reported by 37 percent).

Ventilation System Report

Fisher O'Connell Associates, Inc. of San Francisco analyzed the current ventilation systems at MCB and found a number of problems.

- Zone temperature controls are out of calibration or broken.

- Some fans are too small to move an adequate supply of air to certain parts of the building. The ventilation system provides only two-thirds of the air demand in some cases.
- Ducts are undersized, and considerable duct leakage is reported as a result of worn and inadequate joints.

- A variety of additional design problems and mechanical failures are identified as contributing sources of poor ventilation in the building.

Immediate repairs recommended to eliminate the stuffy air problem and ensure adequate air flow to all parts of the building are expected to cost between \$1.3 million and \$1.9 million. Work will begin in those areas of the building identified by engineers as the greatest source of problems.

Copies of the studies are available for MCB employees at \$15.

UCSF Mission Center Building Air Quality Improvement Program

January 6, 1994

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(more)

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February 11, 1994

To: All MCB Departments

Fr: Katy Irwin, Building Manager 

Re: Ventilation Improvement Project

Twelve recommendations were made by mechanical engineers for improved ventilation systems at Mission Center. The recommendations were divided into three phases; Chancellor Martin has authorized work to begin on Phase I. Phase I will entail the following:

- A. Repair VAV Box Controllers and Thermostats
- B. Improve Local Air Distribution
Reconfigure Problem Zones
Redistribute and Rebalance Airflows
- C. Improve Heating Control at Perimeter Radiators

Throughout the next twelve to sixteen weeks, workers from Scott Company and National Air Balance Company will be repairing ventilation controls and replacing thermostats. Terry Albonico and Art DeLeon will be the primary workers on the project, although others will also be working with them. Terry and Art will be in offices beginning at 7am each day. They will make every effort not to be disruptive but there may be some periodic noise or inconvenience.

Please do not hesitate to contact me if you have any questions or concerns.

cc: Remi Barron, FM

1993 Survey

TO: Fellow occupants of Mission Center Building

FROM: MCB Employee Health Committee

DATE: September 10, 1993

RE: Results of MCB Employee Health Questionnaire

Attached are the results of the MCB Employee Health Questionnaire to which you responded. As you can see in the cover letter, this information is also being sent to several UCSF representatives for their review. We have requested a public meeting to discuss these findings as well as current issues about air quality in our building. We look forward to your attendance and continued interest in working in a safe, healthy building.

TO: Chancellor Joseph Martin, MD, PhD
Roy Balzer, PhD, UCSF Environmental Health and Safety
Diane Liu, MD, Occupational and Environmental Medicine
Catherine Irwin, MCB Management Office
Sharon Schulte, Risk Management

FROM: MCB Employee Health Committee

RE: Results of MCB Employee Health Questionnaire

DATE: September 10, 1993

In May, 1993 an ad hoc employee health committee was formed in response to concerns about air quality problems and health symptoms experienced by fellow employees at the UCSF Mission Center Building. In June, on a volunteer basis, the committee developed and distributed a questionnaire to fellow occupants of MCB in an attempt to assess the nature and scope of perceived health problems. An attempt was made to distribute the questionnaire throughout the building; however, because of the limited time and access of the volunteer committee members some areas may not have been reached and some occupants may not have had an opportunity to provide comments. The total number of questionnaires distributed is unknown. One hundred and seventeen surveys were returned.

This is a summary of the questionnaire results. We ask that you review this information (a survey response matrix is attached to the material sent to Environmental Health and Safety). Following your review, we encourage you to conduct a public forum to be held at MCB to allow discussion of these findings.

It is clear to us from these responses that there is a population of MCB occupants who experience a variety of health symptoms with some consistency. It is significant to note that 113 people (97 percent of respondents) reported experiencing physical symptoms while in MCB. It is also noteworthy that 70 percent of respondents report that symptoms disappear or lessen when they leave the building (see question #70).

We hope that you consider the significance of these responses as you proceed with plans to evaluate the safety of the Mission Center Building as an appropriate work setting and assess ongoing engineering system improvements. As of this writing, some employees report that they continue to experience symptoms that necessitate the intermittent evacuation of the building in an attempt to breathe fresher air.

We look forward to your thoughtful consideration and timely response.

xc: Respondents to MCB Employee Health Questionnaire

SUMMARY: Mission Center Building Employee Health Questionnaire

(Sample questionnaire attached)

There were 117 respondents to this questionnaire, which was distributed on a volunteer basis by members of the MCB Employee Health Committee in June 1993 at various locations within the Mission Center Building. The total number of questionnaires distributed is unknown.

Responses were received from occupants of the following locations:

YMCA Day Care Center, 'CNA', and rooms 40, 120, 230, 232, 302, 304, 306/505 (employees were temporarily relocated to 505 because of air quality problems experienced in 306; some reported continued problems in 505 at the time of this questionnaire), 401, 407, 425, 500, 506, 520, 549, 600, 601, 630, and 654.

Respondents were asked to respond to individual symptom sections, prompted by the general question: "Have you or your child (for those parents of day care center children) experienced any of the following since coming to MCB?"

Mission Center Building Employee Health Questionnaire, June 1993

N=117

Categories	Respondents*	% of Total Respondents
Eye Symptoms	95	81%
Contacts	26	22%
Nasal Symptoms	80	68%
Headaches	75	64%
Throat	78	67%
Breathing	77	66%
Mouth	64	55%
Skin Problems	63	54%
Stomach	48	41%
Aches	50	43%
Flu-like	43	37%
Miscellaneous	92	79%
Allergies	55	47%
Symptoms Disappear	82	70%
Medicines	55	47%

*Respondents per category may have experienced more than one symptom in that category.

EYE SYMPTOMS Experienced by 95 respondents (81% of total questionnaire respondents) **261 aggregate total for symptom category**

1. Redness - Experienced by 45 respondents (38% of total questionnaire respondents)
2. Watering - Experienced by 33 respondents (28% of total questionnaire respondents)
3. Dryness - Experienced by 59 respondents (50% of total questionnaire respondents)
4. Itching/Burning - Experienced by 65 respondents (56% of total questionnaire respondents)

5. Puffiness - Experienced by 21 respondents (18% of total questionnaire respondents)
6. Blurred Vision - Experienced by 30 respondents (26% of total questionnaire respondents)
7. Other - Experienced by 8 respondents (7% of total questionnaire respondents)

EYE SYMPTOMS: COMMENTS

- ☐ Dryness/dust/itching
- ☐ Outer edge of eyes
- ☐ Eyes itch and burn quite a lot
- ☐ Blurred vision only recently since the paint fumes have been so bad
- ☐ Itching/burning and stabbing pain
- ☐ Sometimes the eyeball itself swells, sometimes just the surrounding tissue
- ☐ Light sensitivity
- ☐ Redness associated with sneezing
- ☐ Itching associated with air quality
- ☐ I have seen different doctors, they cannot conclude what my problem is; during weekends or after office hours, sometimes I feel just fine
- ☐ Usually when air flow is bad/non-existent
- ☐ Tender
- ☐ Sometimes causes a headache
- ☐ Shooting pains
- ☐ Frequent occurrences/ year-round
- ☐ I always have pink eyes
- ☐ Watering if I am not wearing my contact lenses
- ☐ Sometimes
- ☐ Dx w/dry eyes about 2 years ago
- ☐ Increased need to wear eyeglasses to avoid eye fatigue
- ☐ Have seen physician - conjunctivitis, corneal irritation; crusting of skin around eyelids
- ☐ Allergic conjunctivitis
- ☐ Symptoms were fairly severe while located in 306 but have abated since moving to 5th floor
- ☐ Itching/burning/redness the most
- ☐ 1990, developed a corneal erosion problem, cause unknown
- ☐ Very sensitive to light

CONTACT LENSES Experienced by 26 respondents (22% of total questionnaire respondents).
37 aggregate total for symptom category

8. Discomfort - Experienced by 21 respondents (18% of total questionnaire respondents)
9. Deposits/Filming - Experienced by 12 respondents (10% of total questionnaire respondents)
10. Other - Experienced by 4 respondents (3% of total questionnaire respondents)

CONTACT LENSES: COMMENTS

- ☐ Deposits seem more than ordinary
- ☐ Filming more often since Jan 93 to now
- ☐ Filming within weeks after receiving new pair
- ☐ Reduced wear time; corneal abrasion due to dry eye
- ☐ Only on left side/ changed solutions 2 times
- ☐ Somedays it is very dry and warm. The air can be stagnant on Mondays
- ☐ Itchy eyes and dryness
- ☐ Watering eyes
- ☐ Had to stop wearing
- ☐ Can't wear contacts in the building. Blurred vision after removing lenses
- ☐ Unable to wear in the building
- ☐ Dryness, burning, have to enzyme clean more often since working here full time
- ☐ Lenses get too dry, uncomfortable to wear

NASAL SYMPTOMS Experienced by 80 respondents (68% of total questionnaire respondents) **167 aggregate total for symptom category**

11. Nosebleeds - Experienced by 20 respondents (17% of total questionnaire respondents)
12. Congestion - Experienced by 50 respondents (43% of total questionnaire respondents)
13. Sinus Problems - Experienced by 46 respondents (39% of total questionnaire respondents)
14. Runny Nose - Experienced by 39 respondents (33% of total questionnaire respondents)
15. Other - Experienced by 12 respondents (10% of total questionnaire respondents)

NASAL SYMPTOMS: COMMENTS

- ☐ Sinus problems very frequently
- ☐ Very dry mucus membranes
- ☐ Sneezing a lot at work which is otherwise rare for me
- ☐ Blood when I blow my nose; runny nose continues all day long; I start to sneeze, but sometimes I can't
- ☐ Runny nose from when I get in in the AM 'til I leave
- ☐ Burning sensation, dry nostrils
- ☐ Problems with mucus that begin shortly after I began working at MCB
- ☐ Itching/burning of nostrils
- ☐ Runny nose almost constantly while in the building
- ☐ Two weeks after 3/24/93 exposure, developed severe sinusitis This was my first sinusitis. Problem is still present and now am being referred to a specialist. I don't know if condition was caused by exposure to fumes, but since I've never had this problem before, I am suspicious
- ☐ Several severe nosebleeds; other times have experienced more than normal nosebleeds; sores in my nose

- ☐ My nose will crack, very dry
- ☐ I have gone to Kaiser due to sores inside my nose due to dryness
- ☐ Never had these problems before I started working in this building in 1989
- ☐ Chronic sinusitis; sinus surgery as a result; multiple infections treated with antibiotics
- ☐ Itching nose; sneezing fits
- ☐ Only dry spots that bleed when wiping nose with tissue - scabs that break open; repeating sinus infections for 2 - 3 years, runny nose constantly
- ☐ Frequent occurrences/ year-round
- ☐ Sneezing
- ☐ Sinus problems - never had before in my life
- ☐ One sinus infection/ 3 episodes of sinusitis
- ☐ Often
- ☐ Sinus/nose dry up at first indication of paint fumes; then get runny after episode
- ☐ Develop breathing problems, dry blood from nose, stuffed up all the time/ especially the last couple of years. Lots of mucus from nose and at times, down to chest - developed bronchitis
- ☐ Congestion with the multiple environmental sensitivities this toxic exposure has developed into
- ☐ Occasional sinus problems, almost constant runny nose
- ☐ One year (89) I got very sick for 6-8 weeks

HEADACHES Experienced by 75 respondents (64% of total questionnaire respondents)
76 aggregate total for symptom category

16. Headaches - Experienced by 75 respondents (64% of total questionnaire respondents)

HEADACHES: COMMENTS

- ☐ Almost daily
- ☐ Constant
- ☐ Lots and lots
- ☐ More than I've ever experienced before
- ☐ Severe, lasting 3-4 days continuously
- ☐ When paint fumes entered the work area
- ☐ Increased dramatically
- ☐ Every week in the afternoon
- ☐ I can almost count on a headache everyday I am at work
- ☐ Migraines
- ☐ More frequent than ever
- ☐ Light headed/ Fatigue/ Difficult to concentrate
- ☐ Sometimes
- ☐ Mild
- ☐ About three times a week; take tylenol every 4 hours
- ☐ On Mondays
- ☐ Almost every day
- ☐ Sometimes at least two times a month

- ☐ Especially when I smell the paint; once out of the building I am fine
- ☐ A lot
- ☐ Mild to severe
- ☐ Intermittent
- ☐ Usually after 2 pm
- ☐ Caused by paint fumes, reported to bldg mgr.
- ☐ Migraines
- ☐ Late afternoon
- ☐ Sinus and tension headaches
- ☐ Severe headaches that subside upon leaving work
- ☐ Periodic when located on 3rd floor
- ☐ After major paint fumes
- ☐ Quite severe headaches shortly before I became quite ill in early April
- ☐ Late afternoons and mornings
- ☐ Sinus headache by the middle of the day

THROAT SYMPTOMS Experienced by 78 respondents (67% of total questionnaire respondents)

167 aggregate total for symptom category

- 17. Dry - Experienced by 47 respondents (40% of total questionnaire respondents)
- 18. Scratchy - Experienced by 40 respondents (34% of total questionnaire respondents)
- 19. Sore - Experienced by 43 respondents (37% of total questionnaire respondents)
- 20. Hoarseness - Experienced by 29 respondents (25% of total questionnaire respondents)
- 21. Other - Experienced by 8 respondents (7% of total questionnaire respondents)

THROAT SYMPTOMS: COMMENTS

- ☐ Sticky mucus buildup
- ☐ Drink lots of liquids (mostly water); need to clear throat often
- ☐ Tickle in back of throat
- ☐ For two weeks, visit my doctor for antibiotics
- ☐ Tightness; ache
- ☐ Hard swallowing
- ☐ Scorched feeling
- ☐ Drainage problems from sinus cause problem with throat and bronchials
- ☐ Very frequently
- ☐ Sore mostly at end of workday and hoarse throughout the workday
- ☐ Frequent occurrences/ year-round
- ☐ Secretion of much phlegm, post nasal drip
- ☐ Burning throat
- ☐ Periods of unexplained sore throats
- ☐ Inflammation

- ☐ This has been a noticeable ongoing condition, starting only in the office, gradually becoming more long lasting
- ☐ Extremely irritated, red-looking sore throat from early January until I left the building permanently in early April 93. The symptoms disappeared only during 9 day vacation away from MCB and renewed two days after I returned to work
- ☐ Almost constant thick mucus

BREATHING PROBLEMS Experienced by 77 respondents (66 % of total questionnaire respondents)

147 aggregate total for symptom category

- 22. Breathlessness - Experienced by 27 respondents (23% of total questionnaire respondents)
- 23. Wheezing - Experienced by 21 respondents (18% of total questionnaire respondents)
- 24. Coughing - Experienced by 40 respondents (34% of total questionnaire respondents)
- 25. Chest Tightness - Experienced by 43 respondents (37% of total questionnaire respondents)
- 26. Other - Experienced by 7 respondents (6% of total questionnaire respondents)
- 26a "Have you been diagnosed with asthma?" Experienced by 9 respondents (8% of total questionnaire respondents)

BREATHING PROBLEMS: COMMENTS

- ☐ Diagnosed with asthma about 8 years ago - no symptoms for the last 5 years
- ☐ As a child, I had sinus problems/allergy problems; some requiring hospitalization. Have not suffered in many years
- ☐ Was treated with antibiotics at least 4 times during the last two years for bronchitis
- ☐ Chest tightness and some pain on inhalation
- ☐ Stale air
- ☐ I think I experienced an asthma attack 2 months after beginning work here. Ever since then, I've experience many episodes of breathlessness.
- ☐ Shortness of breath
- ☐ Wheezing which is being prescribed with inhaler
- ☐ Dry cough
- ☐ Shortness of breath, sudden short spasmodic inhaling breaths (as if after crying).
- ☐ Coughing daily - year round; chest tightness infrequent
- ☐ Coughing for three weeks early this year
- ☐ Chest Tightness when smell of paint becomes very strong
- ☐ Especially when I smell the paint
- ☐ In the AM, when first get up
- ☐ Persisting cough, inability to take a deep breath without coughing
- ☐ Have had two bronchial spasm spells
- ☐ Methacholine challenge test was initially told I had Asthma - high sensitivity
- ☐ Periodic when located on 3rd floor
- ☐ Shortness of breath - when I occasionally gulp to get it in
- ☐ I become winded when climbing steps

- ☐ Pneumonia within a year after working full time
- ☐ Decreased pulmonary function up until about three weeks after I left building permanently
- ☐ Not able to take full complete breaths
- ☐ Coughing is one of my symptoms in this building

MOUTH SYMPTOMS Experienced by 64 respondents (55% of total questionnaire respondents)

74 aggregate total for symptom category

- 27. Unusual Tastes - Experienced by 18 respondents (15% of total questionnaire respondents)
- 28. Dryness/Thirst - Experienced by 54 respondents (46% of total questionnaire respondents)
- 29. Other - Experienced by 2 respondents (2% of total questionnaire respondents)

MOUTH SYMPTOMS: COMMENTS

- ☐ I feel very dehydrated frequently
- ☐ Very thirsty
- ☐ Metallic
- ☐ Throat constriction, difficulty in swallowing
- ☐ Daily
- ☐ Metallic taste in mouth upon breathing fumes
- ☐ Taste of chemical
- ☐ Tingling around mouth during paint fume episodes
- ☐ Metallic taste in mouth
- ☐ Chemical taste
- ☐ When I left the building permanently and began detoxifying, I developed metallic taste for awhile. When I revisited MCB for a "building status" meeting and spent 3 hours in MCB, I had a strange sort of chemical taste in my mouth by the time I left MCB.

SKIN PROBLEMS Experienced by 63 respondents (54% of total questionnaire respondents)

121 aggregate total for symptom category

- 30. Dryness - Experienced by 44 respondents (38% of total questionnaire respondents)
- 31. Rash - Experienced by 23 respondents (20% of total questionnaire respondents)
- 32. Flaking - Experienced by 11 respondents (9% of total questionnaire respondents)
- 33. Itching - Experienced by 37 respondents (32% of total questionnaire respondents)
- 34. Other - Experienced by 6 respondents (5% of total questionnaire respondents)

SKIN PROBLEMS: COMMENTS

- ☐ Welts on hands and arms, where skin is exposed
- ☐ Face blotching and red
- ☐ Need to use lotion both here and at home

- ☐ Red blotches
- ☐ Insect bites from carpet and irregular changing of garbage bags
- ☐ Itching all over the body
- ☐ About once a week, I break out in a small rash
- ☐ This never happened before I began working at MCB
- ☐ Rashes appear on face
- ☐ Sometimes, allergy in my hands
- ☐ Started over the past 6 months
- ☐ Rash and itching since 4/93 - diagnosed as rash from contact with some type of chemicals
- ☐ Sometimes on my face
- ☐ Burning
- ☐ Over the face and forehead area
- ☐ Rash - unidentifiable
- ☐ In elbow area. And cracking skin around irritated eye area
- ☐ Psoriasis
- ☐ On my back so bad that my scratching has caused pigmentation discoloration and roughness
- ☐ Very bad skin problems from early Jan until I left the building permanently April; I felt like a burn victim
- ☐ On face and scalp

STOMACH PROBLEMS Experienced by 48 respondents (41% of total questionnaire respondents)

87 aggregate total for symptom category

- 35. Indigestion - Experienced by 7 respondents (6% of total questionnaire respondents)
- 36. Nausea - Experienced by 36 respondents (31% of total questionnaire respondents)
- 37. Vomiting - Experienced by 6 respondents (5% of total questionnaire respondents)
- 38. Diarrhea - Experienced by 11 respondents (9% of total questionnaire respondents)
- 39. Constipation - Experienced by 6 respondents (5% of total questionnaire respondents)
- 40. Aches/Cramps - Experienced by 20 respondents (17% of total questionnaire respondents)
- 41. Other - Experienced by 1 respondent (1% of total questionnaire respondents)

STOMACH PROBLEMS: COMMENTS

- ☐ Many times when multi-fumes are around
- ☐ A few times, where associated with smells
- ☐ If no constipation, there is diarrhea; if no diarrhea, there is constipation; cramps arms and legs
- ☐ Slight; when diesel smells come from air conditioning, about twice a month
- ☐ Vomiting - I found it strange to experience these symptoms on Mondays and Tuesdays
- ☐ Nausea because of the smell
- ☐ Occasionally

- ☐ I notice that these symptoms have definitely increased in numbers of occurrences since I moved into the building. I have the same healthy dietary habits and normal bowel movements, otherwise.
- ☐ Occasionally when odor is bad; sometimes chemical smell, sometimes sewer like odor
- ☐ Nausea and occasional dizziness
- ☐ Vomiting - teachers at the daycare center told me there was a marked increase after Jan 93.
- ☐ Stomach pain becoming more common
- ☐ Every time I smell paint fumes; really strange reactions

ACHES AND PAINS Experienced by 50 respondents (43% of total questionnaire respondents)
73 aggregate total for symptom category

- 42. Backache - Experienced by 23 respondents (20% of total questionnaire respondents)
- 43. Muscle Ache - Experienced by 28 respondents (24% of total questionnaire respondents)
- 44. Joint Pain - Experienced by 20 respondents (17% of total questionnaire respondents)
- 45. Other - Experienced by 2 respondents (2% of total questionnaire respondents)

ACHES AND PAINS: COMMENTS

- ☐ Carpal tunnel/neck flare-up
- ☐ Neck pain
- ☐ Taking medication for muscle ache; ELAVIL
- ☐ Elbows
- ☐ I have been diagnosed with RA and this environment compounds my joint problems, I know
- ☐ On my shoulders and lower back
- ☐ Left area, check pain w/pain extending down left arm and back; occasional
- ☐ Occasional, related to ergonomics
- ☐ Neck and shoulders - had therapy; at base of skull, wore neck protector and scarves
- ☐ Knees, hips and lower back

FLU-LIKE SYMPTOMS Experienced by 43 respondents (37% of total questionnaire respondents)

68 aggregate total for symptom category

- 46. Fever - Experienced by 13 respondents (11% of total questionnaire respondents)
- 47. Chills - Experienced by 19 respondents (16% of total questionnaire respondents)
- 48. Weakness - Experienced by 32 respondents (27% of total questionnaire respondents)
- 49. Other - Experienced by 4 respondents (3% of total questionnaire respondents)

FLU-LIKE SYMPTOMS: COMMENTS

- ☐ Always feeling tired
- ☐ Sever weakness & irritability - especially during the days when painting fumes are stronger

- ☐ Tiredness, exhaustion
- ☐ And fatigue (mental and physical)
- ☐ Infrequent - although most occurrences were between Sept. and Feb.
- ☐ I had a lot of flu-like symptoms for 2 years when I first started working in this building (ed note: then went half time)
- ☐ I have had 3 stomach flus during the time period 6/92 - 4/93
- ☐ Warm at times
- ☐ Endless cycles from early Jan until April, with increasing severity; throughout my tenure in MCB, episodes of these symptoms were intermittent. Now, even small exposures to toxins makes me ill
- ☐ Chills all the time when there
- ☐ When I get these symptoms, I know I'm in trouble. I ask to lay down until it goes away. I can't stand sometimes for very long and I miss time from work. I go home sick and stay home until better.

MISCELLANEOUS SYMPTOMS Experienced by 92 respondents (79% of total questionnaire respondents)

430 aggregate for total symptom category

- 50. Anxiety - Experienced by 36 respondents (31% of total questionnaire respondents)
- 51. Irritability - Experienced by 44 respondents (38% of total questionnaire respondents)
- 52. Sleeplessness - Experienced by 21 respondents (18% of total questionnaire respondents)
- 53. Depression - Experienced by 17 respondents (15% of total questionnaire respondents)
- 54. Fatigue/Exhaustion - Experienced by 54 respondents (46% of total questionnaire respondents)
- 55. Feeling of Panic - Experienced by 9 respondents (8% of total questionnaire respondents)
- 56. Drowsiness - Experienced by 50 respondents (43% of total questionnaire respondents)
- 57. Faintness - Experienced by 14 respondents (12% of total questionnaire respondents)
- 58. Dizziness - Experienced by 44 respondents (38% of total questionnaire respondents)
- 59. Trouble Concentrating - Experienced by 30 respondents (26% of total respondents)
- 60. Menstrual Irregularities - Experienced by 10 respondents
- 61. A "High" Feeling - Experienced by 12 respondents (10% of total questionnaire respondents)
- 62. Memory Loss - Experienced by 16 respondents (14% of total questionnaire respondents)
- 63. Rapid Pulse - Experienced by 9 respondents (8% of total questionnaire respondents)
- 64. Heart Arrhythmia/Tachycardia - Experienced by 9 respondents (8% of total questionnaire respondents)
- 65. Chest Pain - Experienced by 19 respondents (16% of total questionnaire respondents)
- 66. Miscarriage - Experienced by 3 respondents
- 67. Ear Problems - Experienced by 23 respondents (20% of total questionnaire respondents)
- 68. Other - Experienced by 10 respondents (9% of total questionnaire respondents)

MISCELLANEOUS SYMPTOMS: COMMENTS

- ☐ Usually by Friday
- ☐ Lack of windows and fresh air make me unhappy and restless at times
- ☐ I was taken to Peninsula Hospital by ambulance 7/24/92
- ☐ Drowsiness in the afternoon
- ☐ Over the course of the day, I feel very fatigued
- ☐ Trouble concentrating at times because of the fatigue feeling
- ☐ Slight heart arrhythmia diagnosed since working here
- ☐ "Buzzing" feeling inside my skull - very strange feeling - on one of the mornings when the paint fumes were bad
- ☐ Anxiety and irritability both due to the knowledge that I may have been working in an unhealthy environment
- ☐ Dizziness with paint fumes
- ☐ Very often, it is so stuffy that I cannot stay awake
- ☐ Drowsiness in the afternoon
- ☐ Slight ear ache for a couple of months
- ☐ Drowsiness always during mid-day; relieved by fresh air outside
- ☐ Miscarriage 6/92
- ☐ Can't wait til it is 4:30PM so I can go home and rest
- ☐ Ear problems with fluid collection/allergic response
- ☐ Could be due to pregnancy
- ☐ Drowsiness especially in late afternoon when there is bad/no air circulation
- ☐ Ear problems and constant ear ache
- ☐ Loss of balance
- ☐ Increasingly, I experience a lack of ability to focus and stay focused
- ☐ Rapid pulse and hear arrhythmia infrequent - cut down on caffeine. Ear problems infrequent - occur with ENT irritations
- ☐ High feeling from paint fumes
- ☐ Infection of the left ear
- ☐ Irritability - usually never in this state
- ☐ Ear infection
- ☐ One inner ear infection
- ☐ Periods of extreme fatigue which are not characteristic of my general health
- ☐ Dizziness and trouble concentrating especially when breathing fumes
- ☐ Anxiety when feel sick in building
- ☐ Feel hopeless sometimes and scared about exposure
- ☐ Occasionally a wall of exhaustion hits
- ☐ Anxiety and irritability - only due to the time we have spent trying to solve this problem
- ☐ I'm HIV+ and have noted a quickened pace of immune suppression (T cells loss) since bad fumes began (Sep/Oct 92).
- ☐ Fatigue every afternoon
- ☐ Ear scaly rash
- ☐ Faintness when carpet was being installed on 3rd floor
- ☐ Fatigue frequently in afternoon

- ☐ Loose train of thought and individual words
- ☐ Due to roar from duct near my desk, jaw clenching - occlusion and periodontal problems.
- ☐ Quite severe fatigue; panic when I realized I was having cognitive problems; memory loss has not cleared up since leaving MCB
- ☐ Never felt so exhausted, so stressed out at a job
- ☐ Anxiety and irritability - I'm not sure what's causing it but I'm very "touchy" these days
- ☐ Fatigue a lot; heart arrhythmia - taken in ambulance
- ☐ Ear aches

ALLERGIES Experienced by 55 respondents (47% of total questionnaire respondents)
55 aggregate total for symptom category

69. Sensitivity to paints, solvents, cigarette smoke, or other chemicals? Experienced by 55 respondents (47% of total questionnaire respondents)

ALLERGIES: COMMENTS

- ☐ Sensitive to odors
- ☐ I am very sensitive to the smells, but don't think it results in an allergy
- ☐ Paints, solvents, cigarette smoke
- ☐ I have not pinpointed what my allergies are due to
- ☐ Dust, feathers, animal hair
- ☐ Sensitivity to smoke which causes coughing
- ☐ Because my sinuses are always dry
- ☐ Paint solvents
- ☐ It seems I'm sensitive to nail polish remover & cleaning fluids at home - a wall of exhaustion hits
- ☐ More sensitive to almost all smells
- ☐ I just realized olfactory sensitivity to diesel exhaust, perfumes, ammonia, paint(to point of nausea) is allergic reaction.
- ☐ I find I'm more sensitive to chemical/paint smells.
- ☐ I never had allergies until I became quite ill and had to stop working. After I detoxified, I developed extreme reactions to even small amounts of paint solvents, molded plastics, magic markers, etc.
- ☐ Lately

70. Do any of the above symptoms disappear or lessen when you or your child leave the building? Answered "yes" by 82 respondents (70% of total questionnaire respondents)

SYMPTOMS DISAPPEAR OR LESSEN AFTER LEAVING THE BUILDING:

- ☐ When I leave here and get to the campus, my head is clearing up
- ☐ Yes, the constant "thirsty" feeling goes away and doesn't occur on the weekend
- ☐ Yes, headaches go away
- ☐ Yes, I only sneeze at work mostly

- ☐ Dehydration lessens after I leave, but I think our air comes from another source so I can't necessarily attribute these problems to the air quality problem here
- ☐ Yes, I feel better after a few hours out of the building; on the weekends, I feel like a different person
- ☐ Within 30 - 60 minutes after leaving, I feel more alert and my throat seems less sore
- ☐ Yes, nasal and allergy type
- ☐ One hour after arriving at home all symptoms subside; they return as soon as I enter the building
- ☐ I had no ear, drowsiness, or wheezing problems before starting here
- ☐ Yes, less or none
- ☐ Headaches usually go away as does dryness of mouth and throat
- ☐ Yes
- ☐ Yes, about 30 minutes to an hour after I leave the building, the fatigue feeling goes away
- ☐ Sore throat and hoarseness disappear
- ☐ During weekends, symptoms usually disappear. Sometimes even I walk outside of the building makes me feel better.
- ☐ With the exception of arrhythmia, all of the symptoms have been directly related to the paint fumes we have had in the past few months
- ☐ Does not disappear; watering eyes increase or decrease when entering or leaving the building
- ☐ All of the symptoms have disappeared since I stopped working in the building
- ☐ These symptoms begin when in the building and can often smell fumes at same time. Symptoms (except sinusitis) disappear after leaving - although may persist for a few hours.
- ☐ Yes, when we have more than a week-end off
- ☐ Symptoms appear after 2-4 hours in the building and disappear immediately upon exit
- ☐ My energy level increases dramatically and allergies disappear
- ☐ Yes - sinus problems improve, feel more energetic
- ☐ My nausea goes away immediately
- ☐ I only experience the drowsiness here, also dizziness
- ☐ Yes, I feel better when I'm not in this building. But the effect of it all is lasting. Over the past 4 years, I have become a miserable sinus-allergy sufferer - chronic condition.
- ☐ All sinus and allergic reactions clear when out of the building
- ☐ Allergy symptoms lessen and headaches subside
- ☐ I noticed all these symptoms began when I started working here; I am not prone to headaches
- ☐ Eye irritation and dizziness symptoms lessen when I leave the building
- ☐ When I was on a 2 week vacation last year, all symptoms went away
- ☐ Yes, my sinus problem leaves too!
- ☐ When I go outside, I feel better
- ☐ My sinuses seem to clear up a bit when I leave the building
- ☐ Usually notice less sniffing and more awareness when leaving building
- ☐ Most of them
- ☐ Yes!!
- ☐ Some disappear after a few days; ear problem have had for months
- ☐ Definitely lessen over weekends; especially long ones
- ☐ Yes, the ear, eye, nose and throat problems and headaches
- ☐ Not consistently

- ☐ Yes, my nose is congested
- ☐ Yes, I feel better, much better when I am out of the building
- ☐ I do not have these problems when I am not in the building
- ☐ Yes, I can breathe well and my headache disappears
- ☐ Within one hour, all symptoms are gone
- ☐ Yes, I just feel comfortable outside
- ☐ Yes, I can concentrate better as well as breathe easier
- ☐ Yes
- ☐ Sometimes, if I am outside in the air
- ☐ I do not get this rash any other place than here; when I leave here, the rash goes away in 2 or 3 hours
- ☐ Just stepping outside and getting fresh air revitalizes you
- ☐ These symptoms become very evident when I am at work
- ☐ Breathing problems and headaches disappear a few hours after leaving the building
- ☐ Most lessen on weekends
- ☐ The symptoms checked do not occur when doing similar work in another setting
- ☐ Yes, after being out of building, breathing becomes better, more energy
- ☐ Yes, weekends always feel better
- ☐ Once outside of the building, symptoms seem to disappear
- ☐ Yes
- ☐ Yes, burning eyes, nasal stuffiness, mild headaches, and general fatigue all usually disappear after leaving the building. We need air!! Windows that open!
- ☐ Yes, the weekend is always better
- ☐ Yes, eye problems and running nose
- ☐ Headache, sinus, itching eyes clear up after leaving the building for 2+ hours
- ☐ Yes, asthma, skin sensitivity, nasal congestion!
- ☐ Yes! Eye problems, cough and headache subside, fatigue persists into the evening
- ☐ The eye symptoms linger a bit, always a dry feeling, better on weekend. Fatigue persists a few hours after I leave. Nose better as soon as I leave building, other symptoms better.
- ☐ Yes, within 30 minutes of leaving the building I am symptom free
- ☐ Yes, all symptoms go away after leaving the building
- ☐ Most symptoms occur during active paint fume episodes and diminish after fresh air outside
- ☐ Since moving to 5th floor, all symptoms have lessened for dissipated
- ☐ Most go away but takes the weekend
- ☐ All symptoms lessen when I leave the building, however, breathing problems are taking longer and longer to clear up.
- ☐ When I leave for more than 5 days, symptoms tend to lessen and feeling of tired and stuffed nose and bleed(dry blood) doesn't exist
- ☐ They used to all disappear. Now throat, eye problems, allergies, mental & jaw problems continue
- ☐ The breathlessness does
- ☐ Not immediately, only after a period of time in which I recover; reappear when I return
- ☐ I left approximately two years ago; symptoms disappeared Daughter pulled from daycare in May, symptoms disappeared
- ☐ Yes, and they return when I come back
- ☐ Since out of building April 93, I feel a lot better. Headaches, fatigue, and breathing much better

- ☐ Yes, all listed
- ☐ Yes, all symptoms clear in 1 to 4 hours after leaving

71. Since coming to MCB, have you or your child been prescribed medications or do you take over-the-counter medications to prevent or treat any of the above symptoms? Answered "yes" by 55 respondents (47% of total questionnaire respondents)

List of Medications Taken:

Contact lens drops, Visine, eye lubricants, Bromufed, Seldane, Aspirin, Advil, Motrin, Excedrin, Azmacort, Nafazair, Cortisone cream, Ventolin, Kolonopin, Prozac, Beconase, Antihistamines, Actifed, Robitussen, Bronchaid, Bendaryl, Lozenges, Vancenase, Paramin, Eardrops, Entax-LA, Bronchaid, Theocrin, Airobid, Hydrocortizone, Nasalide, Sudafed, Muro 128, Butabital, Augmentin.

OTHER COMMENTS:

- ☐ I seem to be more susceptible to irritability since I work here.
- ☐ Recently, on vacation, it just hit me that I wasn't experiencing headaches, nosebleeds, and nasal congestions. I had never experienced any of these symptoms prior to working in this building.
- ☐ Thank you for looking into this.
- ☐ This survey was a very good idea. Thanks for thinking of it.
- ☐ We've (HISD 401) never noticed any illness or symptom aggravated specifically by this building. I truly believe many of these symptoms people complain of would exist in another setting and/or may have nothing to do with MCB!
- ☐ At times I can't breathe very well because my nose gets congested.
- ☐ When I became quite ill, my doctor tried to clear up the symptoms with antibiotics, neither made a difference. I didn't get well until I left the building permanently and I still have fatigue, cognitive difficulties, and recently - multiple sensitivities.

INDOOR AIR QUALITY
MISSION CENTER BUILDING
AIR QUALITY SURVEY

1991 Survey

I. BACKGROUND

At the request of Katy Irwin, Building Manager, Mission Center Building, the office of Environmental Health and Safety performed an air quality survey of the Mission Center Building (MCB). This study is a followup to a previous study conducted in July 1991. The purpose of this study was to gather further information on reactions to the indoor environment from building occupants prior to conducting a mechanical investigation of the heating, ventilating, and air conditioning system.

II. DESCRIPTION OF ENVIRONMENT

The Mission Center Building is located at 1855 Folsom Street. The building consists of six floors which house various UCSF administrative offices, as well as laboratory space. The building is situated in a low to moderate industrial section, south of Market Street. The Mission Center Building is heated with fin tube radiators along the perimeter of each floor. Cooling, ventilation, and additional heating for the building are provided by eight individual forced-air HVAC systems. Each system is provided with its own temperature controls. The energy plant which serves these systems is located in the northwest mechanical room on the fourth floor. Descriptions of the systems are as follows:

Multi-zone system MZ-1

A Trane multi-zone unit, located in the mechanical penthouse, provides heating, ventilation and air conditioning for the VIACOM studio on the sixth (6) floor. This system is a 14,000 CFM, 5 zone, constant air volume HVAC system with economizer cycle controls, presumably providing approximately 17 air changes per hour for the space. Hot and cold deck temperatures of the multizone unit is maintained by the heating hot water and the chilled water generated from the energy plant of the building.

System S-5

Air conditioning for the northwest portions of the first, fourth, fifth and sixth floors of the building is provided by system S-5 located in the northwest mechanical room on the fourth floor. This system is a field erected, variable air volume system with economizer cycle controls. Supply air distribution of the system is via insulated, high velocity, oval shaped, steel ductwork associated with variable air volume induction boxes, low pressure steel ductwork at downstream of the induction boxes and ceiling mounted diffusers. Return air of the system is collected by the return/exhaust fan via oval shaped, steel ductwork and is either returned to the system or

expelled to the atmosphere.[Economizer Cycle]. The system is a variable air volume system with chilled water cooling only, and hot water reheat coils are provided at the induction boxes installed on the sixth floor.

System S-10

System S-10 is located in the southeast mechanical room in the fourth floor. This system is similar to system S-5 above except that the system is serving the southeast portion of the first, fourth, fifth and sixth floors of the building.

System SF-1

This system is housed in the northwest fan room on the third floor and is similar to system S-5 above except that the system is provided with zone VAV Boxes with reheat coils in lieu of induction boxes, and fan-width controls in lieu of inlet vane controls.

Animal holding room system S-21

System S-21 is located in the northwest mechanical room on the second floor. This system is 100% outdoor air, constant air volume, dual duct, heating, ventilating and air conditioning (HVAC) system.

Laboratory HV system S-22

This system is located at the same mechanical room as system S-21. The system is a 100% outdoor air, variable air volume, heating and ventilating system.

Cell analysis system AH-1

System AH-1 is located in the mechanical room on the south end of the second floor. This system is a constant air volume heating, ventilating and air conditioning system with economizer controls

Cell analysis system AH-2

This system is located at the same mechanical room as system AH-1 and is similar to AH-1 except 100% outdoor air in lieu of economizer cycle.

III. METHODS

Building health questionnaires were given to Katy Irwin and distributed to all building occupants to complete. The results were recorded and are presented in Table I.

IV. RESULTS

Office Health Questionnaire-462 Respondents

The most frequent health complaints and building comfort complaints are listed in Table I. The symptoms reported most frequently were stuffy stagnant air movement, followed by air temperature too hot/cold, eye burning/itching, headaches, noise from the ventilation system, congestion/sinus, throat dryness/scratchiness, and drowsiness. Most respondents reported smelling paint and food odors periodically. The complete summary of the MCB health questionnaire are listed in Table II.

TABLE I
HEALTH AND BUILDING COMFORT COMPLAINTS
HIGHEST FREQUENCY

1. Health Complaints

<i>Eye Symptoms:</i>	<i># Respondents</i>
<i>redness</i>	<i>94</i>
<i>burning/itching</i>	<i>125</i>
<i>Contact Lenses:</i>	
<i>discomfort</i>	<i>45</i>
<i>deposits/filming</i>	<i>27</i>
<i>Nasal Symptoms:</i>	
<i>congestion</i>	<i>108</i>
<i>sinus problems</i>	<i>95</i>
<i>Throat Symptoms:</i>	
<i>dryness</i>	<i>99</i>
<i>scratchiness</i>	<i>86</i>

Breathing Problems:

<i>coughing</i>	81
<i>chest tightness</i>	39

Mouth Symptoms:

<i>unusual tastes</i>	14
<i>dryness/thirst</i>	103

Skin Problems:

<i>dryness</i>	41
<i>rash</i>	30

Stomach Trouble:

<i>indigestion</i>	34
<i>nausea</i>	31

Aches and Pains:

<i>headache</i>	119
<i>backache</i>	60

Flu Like Symptoms

<i>chills</i>	46
<i>weakness</i>	47

Stress Symptoms:

<i>anxiety</i>	55
<i>exhaustion</i>	48

General Complaints:

<i>drowsiness</i>	101
<i>headache</i>	92
<i>lethargy/lack of energy</i>	95

2. *Building Comfort Complaints*

Noise from: *# Respondents*

ventilation system 112

Air Movement:

drafty 97

stuffy/stagnant 211

Air Temperature/ Humidity:

too hot 170

too cold 145

Odors:

food odors 82

other odors 66

Lighting:

too dim 49

glare or flicker 56

Work Area:

cleanliness 51

other 50

Other:

privacy 66

closed-in feeling 80

TABLE II
SUMMARY OF MCB HEALTH QUESTIONNAIRE

1. *Health Complaints*

Eye Symptoms: *# Respondents*

a.	redness	94
b.	burning/itching	125
c.	dryness	82
d.	watering	62
e.	puffiness	76
f.	blurred vision	72
g.	other	3

Contact Lenses:

a.	discomfort	45
b.	deposits/filming	27
c.	other	4

Nasal Symptoms:

nosebleeds	26
congestion	108
sinus problems	95
runny nose	87
other	24

Throat Symptoms:

dryness	99
scratchiness	86
soreness	73
other	8

Breathing Problems:

breathlessness	28
wheezing	39
coughing	81
chest tightness	39

TABLE II CONT.

<i>Mouth Symptoms:</i>	<i># Respondents</i>
<i>unusual tastes</i>	14
<i>dryness/thirst</i>	103
<i>other</i>	0
<i>Skin Problems:</i>	
<i>dryness</i>	41
<i>rash</i>	30
<i>flaking</i>	22
<i>itching</i>	77
<i>other</i>	2
<i>Stomach Trouble:</i>	
<i>indigestion</i>	34
<i>nausea</i>	31
<i>vomiting</i>	4
<i>diarrhea</i>	19
<i>constipation</i>	10
<i>aches/cramps</i>	28
<i>other</i>	2
<i>Aches and Pains:</i>	
<i>headache</i>	119
<i>backache</i>	60
<i>muscle ache</i>	19
<i>joint pain</i>	49
<i>other</i>	0
<i>Flu Like Symptoms</i>	
<i>fever</i>	28
<i>chills</i>	46
<i>weakness</i>	47
<i>other</i>	0

TABLE II CONT.

<i>Stress Symptoms:</i>	<i># Respondents</i>
<i>anxiety</i>	55
<i>irritability</i>	37
<i>sleeplessness</i>	46
<i>exhaustion</i>	48
<i>depression</i>	44
<i>feeling of panic</i>	20
<i>other</i>	1

General Complaints:

<i>drowsiness</i>	101
<i>faintness</i>	20
<i>dizziness</i>	46
<i>trouble</i>	
<i>concentrating</i>	62
<i>headache</i>	92
<i>lethargy/lack of</i>	
<i>energy</i>	95
<i>menstrual cycle</i>	
<i>irregularity</i>	11

2. *Building Comfort Complaints*

<i>Noise from:</i>	<i># Respondents</i>
<i>ventilation system</i>	112
<i>office equipment</i>	46
<i>other</i>	24

Air Movement:

<i>drafty</i>	97
<i>stuffy/stagnant</i>	211
<i>other</i>	15

TABLE II CONT.

Air Temperature/ Humidity: # Respondents

<i>too hot</i>	<i>170</i>
<i>too cold</i>	<i>145</i>
<i>too damp</i>	<i>18</i>
<i>too dry</i>	<i>84</i>
<i>other</i>	<i>12</i>

Odors:

<i>food odors</i>	<i>82</i>
<i>tobacco smoke</i>	<i>25</i>
<i>body odors</i>	<i>23</i>
<i>other odors</i>	<i>66</i>

Lighting:

<i>too bright</i>	<i>32</i>
<i>too dim</i>	<i>49</i>
<i>glare or flicker</i>	<i>56</i>
<i>other</i>	<i>15</i>

Work Area:

<i>decor</i>	<i>46</i>
<i>partitions</i>	<i>31</i>
<i>neatness/ cleanliness</i>	<i>51</i>
<i>other</i>	<i>50</i>

Other:

<i>privacy</i>	<i>66</i>
<i>view</i>	<i>49</i>
<i>distractions</i>	<i>57</i>
<i>closed-in feeling</i>	<i>80</i>
<i>other</i>	<i>15</i>

V. CONCLUSIONS

The majority of the respondents to the building health questionnaire reported headaches, fatigue/drowsiness, and stuffy hot air. Building comfort complaints were found to be the most significant.

A significant number of building occupants indicated that paint fumes and food odors occur periodically.

VI. RECOMMENDATIONS

1. The HVAC system should be maintained and operated to provide at least the outdoor air ventilation rate (based on actual occupancy) required by the applicable building code, mechanical code, or ventilation and indoor air quality code in effect at the time the permit covering the building HVAC system was issued. Therefore, it is recommended that HVAC systems SF-1, S-5, S-10, and S-22 be evaluated for the following:

- A. Total air measurements, supply and exhaust for each system.*
- B. Determination of fresh air quantities (%) for each system, minimum and maximum.*
- C. Supply air quantities delivered to each floor.*
- D. Return air quantities from each floor.*
- E. Quantities of air from each supply diffuser on each floor.*
- F. Air changes per hour for each area/room.*
- G. One line diagrams or drawings illustrating each of the above.*
- H. Identification of deficiencies if applicable.*

In addition, the above systems should be evaluated to current ASHRAE standards (1989).

2. Evaluate the HVAC systems air filtration efficiency by the ASHRAE atmospheric dust spot test, ASHRAE 52-76.

3. Departmental managers shall insure that indoor air quality problems or indoor air quality complaints from employees are documented and reviewed with affected employees to assist in correction of identified unsafe conditions or practices.

Report Prepared By:
Woody Hill
Woody Hill
Sr. Industrial Hygienist
OHRS

Report Reviewed By:
Woody Hill for
Eugene Lau
Program Manager
OHRS

October 22, 1992

DS-
pls keep!
copy for file

Academic Affairs
University of California, San Francisco

April 9, 1993

TO: MCB Unit Managers
FROM: David J. Ramsay
Senior Vice Chancellor

Enclosed for your information is the MCB Air Quality Status Report. We will review its contents and answer your questions at our upcoming meeting next week (April 15 at 3pm in MCB-125).

UNIVERSITY OF CALIFORNIA

SAN FRANCISCO

MISSION CENTER BUILDING
AIR QUALITY STATUS REPORT

April 9, 1993

I. BACKGROUND

The Mission Center Building is located at 1855 Folsom Street between 14th and 15th Streets in San Francisco's Mission district. The six-story structure was constructed in 1927 as a warehouse building. In addition to the 291,000 gross-square-foot structure, the three-acre property includes a parking lot for 257 cars.

In 1976, the building was acquired from the Owens Illinois Glass Company by Far West Laboratories for office use in educational program development. In 1977, UCSF acquired a 49% interest in the building comprising the second, third, and fourth floors of the building. In 1989, UCSF acquired the remaining interest in the building and renamed it the Mission Center Building. Currently UCSF occupies approximately 82% of the building with administrative office uses and some research laboratories. Approximately 9% of the building remains leased to outside tenants whose occupancy pre-dates UCSF's acquisition in 1989. Approximately 9% of the building currently is vacant.

Owing to the incremental conversion of the building from warehouse to office building and the varied ownership of the building during the past twenty years, the mechanical and other utility systems in the building have been installed and modified in a piecemeal rather than comprehensive planned manner. As a result, the current heating, ventilating, and air conditioning (HVAC) systems in the building are a complex network of ducts, fans, and mechanical rooms. Ten independent systems currently exist in the building.

Complaints about air quality in the building date back to 1982. Complaints historically have addressed the amount of "fresh" air, stuffiness, too hot, too cold, paint smells, gas vapors and food odors.

Certain aged systems have not been performing up to design standards. Air balancing, maintenance, and in some cases repair has been recommended and undertaken. One study completed in 1991 estimated that a complete overhaul of the mechanical systems in the building could cost as much as \$3 million.

During the past six months complaints about air quality have increased, especially with regard to concerns about health-related symptoms which may be attributed to air quality. In particular, complaints have addressed the presence of paint vapors in the northwest portions of the building served by systems with air intakes located on the north side of the building. As a result, a new series of air quality studies has been undertaken.

This report focuses on the current round of investigations.

II. AIR QUALITY STANDARDS IN THE WORKPLACE

Many potential sources of indoor air pollution can be found in any building (e.g. carpet adhesives, pressed wood products, maintenance and cleaning chemicals, perfumes, cigarette smoke). The primary cause of indoor air quality problems usually is the release of gases from these sources. Inadequate ventilation can increase indoor pollutant levels by not providing sufficient outside air to dilute these irritants and by not eliminating the pollutants from the building. In the Mission Center Building (MCB), the principal air quality problem originates on the outside of the building, where paint vapors enter two or more of the ventilating systems.

There are no existing standards which address indoor air quality in an office setting. Agencies such as the U.S. Environmental Protection Agency, the National Institute for Occupational Safety and Health, and the federal Occupational Health and Safety set standards for various purposes, but none address indoor air quality in an office setting. For the MCB indoor air quality issue, Cal/OSHA and Bay Area Air Quality Management District (BAAQMD) are the most pertinent agencies.

Occupational Health and Safety Administration

Employees are protected at their workplace by Occupational Safety and Health Administration (OSHA) standards. OSHA has standards for many chemicals, and exceeding the standards constitutes a violation of the law. The federal OSHA regulates workers in States that do not have an OSHA program; in California, Cal/OSHA has the enforcement power.

Cal/OSHA standards, which were originally adopted to protect workers who are healthy males working in an industrial setting, are unlikely to be exceeded in an office setting. Cal/OSHA does have a building ventilation standard of five cubic feet per minute (5 cfm), but the regulations focus primarily on maintenance issues.

Bay Area Air Quality Management District

The Bay Area Quality Management District (BAAQMD) controls the emission of volatile organic compounds (VOC) to the atmosphere from the paint finishing of motor vehicles by

1. Limiting the amount of VOC's that can be formulated into paints, and
2. Limiting the amount of paint that may be used by a particular shop.

The first control is applied to the manufacturer of paints; the latter is generally a condition of a permit issued to the paint shop by the BAAQMD. Inspections are conducted regularly to ensure compliance. An inspection includes an examination of records to verify that proper paints have been used in proper amounts and an examination of the conditions under which the paint is used and stored. The BAAQMD does not regulate the use of spray booths or the spraying of paints outside paint booths.

If further enforcement from the BAAQMD is desired, the option to file an odor complaint remains. An unannounced inspection will be conducted to verify the complaint. Generally, five complaints from five different individuals are needed before the District will take action under the Public Nuisance provisions of the Safety Code (Section 41700). Please see Section V.4 on page 8, for further information regarding the BAAQMD.

III. AIR QUALITY TEST RESULTS

The Office of Environmental Health and Safety (EHS) has conducted a number of indoor air quality surveys at the Mission Center Building. The following summary includes surveys within the last three years. All of the reports referenced below are available for review in the EHS Office and MCB Building Management Office.

June 1990

This survey was conducted in response to employee concerns relating to poor air quality on the fourth floor (Accounting Dept.) of MCB. Office health questionnaires were distributed to accounting personnel to ascertain types of air quality problems noted by employees and the prevalence of their symptoms. Based on the results of the questionnaire, air sampling was conducted throughout the fourth floor. Air sampling was conducted for organic chemicals commonly found in paint formulations such as benzene, xylene, toluene, and ethylbenzene. In addition, sampling for formaldehyde, carbon monoxide, carbon dioxide, and particulates was conducted. The results of this survey indicated that all environmental measurements conducted during that time period were all well below current Cal/OSHA standards for allowable exposures (200 - 100,000,000 times lower than workplace standards). The survey did indicate that the ventilation system serving this floor was supplying air at rates below design values and would require balancing. However, balancing was not undertaken pending further engineering evaluations.

August 1991

This survey of the fourth floor was a follow-up to the previous survey (June 1990). Due to continued concerns relating to paint vapors and the ventilation system, air monitoring for organic chemicals, formaldehyde, and biological agents was conducted. In addition, the ventilation system serving the fourth floor was inspected. The air sampling results indicated that organic and formaldehyde vapors were well below Cal/OSHA limits. The ventilation system serving this floor again was found to be unbalanced and providing air below design values, as noted in the earlier study.

November 1992

The third survey was conducted in response to indoor air quality concerns arising from paint

vapors from the north-west occupants of the third and fifth floors. In order to assess the concerns of all MCB occupants, building health questionnaires were distributed to all building occupants. Out of 950 questionnaires distributed, 462 individuals responded. The most frequent complaint was about stuffy, hot air. Approximately 17% of those returning surveys indicated that paint vapors and food odors occur periodically. This survey indicated that most were experiencing some level of discomfort, including a number of health-related symptoms.

Following the results of this survey, material safety data sheets (MSDS) were collected from Alioto's Garage and Body Shop to determine what products they are using. A review of these data sheets indicated that Alioto's was using several polyurethane based paints which contain volatile organic chemicals (i.e. xylene, toluene, methyl ethyl ketone, alcohols) and hexamethylene diisocyanate. Based on the information, another air quality survey was planned.

January - March 1993

Air sampling for hexamethylene diisocyanate was conducted on the third and fifth floors of the MCB between 8 am and 5 pm in January 1993. The sampling was repeated on the third floor in March 1993. Results are shown on the tables that follow.

Hexamethylene diisocyanate - January 11-15, 1993

Sample No.	Employee/ Location	Cal/ OSHA PEL (ppb)*	Results ppb
001	Rm. 308	5.00	0.030
002	Rm. 308	5.00	0.029
003	Rm. 308	5.00	0.025
004	Rm. 308	5.00	0.025
005	Rm. 566	5.00	0.024
006	Rm.308	5.00	0.055
007	Rm. 308	5.00	0.055
008	Rm.566	5.00	0.053
009	Rm.308	5.00	0.050
010	Rm. 308	5.00	0.050

* ppb - Parts per billion

Hexamethylene Diisocyanate - March 1-5, 1993

Sample No.	Employee/ Location	Cal/ OSHA PEL (ppb) *	Results ppb
001	Rm. 308	5.00	0.018
002	Rm. 308	5.00	<0.017
003	Rm. 308	5.00	<0.017
004	Rm. 308	5.00	<0.017
005	Rm. 308	5.00	0.023
006	Air Intake 3rd.	5.00	<0.017
007	Air Intake 3rd	5.00	<0.017
008	Air Intake 3rd	5.00	<0.017
009	Air Intake 3rd	5.00	<0.017
010	Air Intake 3rd	5.00	0.031

Room 308 (Medical Center Marketing) is located on the north west side of MCB. The room contains mechanical heating, ventilation, and air conditioning equipment. No windows are located in the room. Room 566 (Real Estate) also is located on the northwest side of the building. The area is maintained by mechanical ventilation. No operable windows are located on the fifth floor.

Conclusions of January - March, 1993 Test Results

Airborne samples collected during both time periods were well below the current Cal/OSHA permissible exposure limit of 5.00 (ppb) parts per billion.

Samples collected during January 11-15, 1993, indicate the highest concentration to be 0.055 ppb, much lower than the permissible exposure limit.

All except three of the samples collected during March 1-5, 1993 were found to be non-detectable. The highest concentration of 0.031, also was much lower than the permissible exposure limit.

However, the air sampling results only reflect the conditions at the time of sampling. Factors such as the weather, air currents, reduced chemicals in use at the source, etc. affect the sampling and test results.

All samples analyzed to date indicate that all pollutants tested below the Cal/OSHA permissible exposure levels. Nonetheless, concerns persist about the intrusion of paint vapors into the building ventilation system.

To ensure all health and safety precautions are taken, additional air sampling evaluations are planned.

IV. HEALTH EFFECTS

Indoor air pollutants can elicit health effects that vary the full range from being life-threatening or debilitating to being simply annoying or unnoticed. Some indoor air contaminants may be present at levels that are too low to cause any health effects in certain populations, yet high enough to pose serious health problems in more sensitive populations. Several factors must be considered when assessing indoor air pollutants and their health effects. The following describes and gives examples for each pollutant category.

Particles. Indoor air pollutants classified as particles are solids or liquid substances light enough to be suspended in air. Examples are biological contaminants. These are tiny particles that are alive, were once alive, or are part of something that is or once was alive (e.g., molds, insect parts, pollen, animal dander). These contaminants can cause health effects such as allergic reactions, Legionnaire's disease, and pneumonitis. Symptoms range from eye, nose, and/or throat irritation. Sensory detection of these pollutants can be visual (wet or damp materials, standing water, insect excreta, etc.), or one can sometimes detect a moldy smell.

Gases. Gases are individual atoms or molecules that spread evenly in air. Certain gases are odorless (carbon monoxide), whereas others produce odors (e.g., materials containing petroleum-based solvents such as paints, thinners, and adhesives). Examples of indoor air contaminants that are gases include carbon monoxide, formaldehyde, and organic gasses.

Formaldehyde exposure has been associated with cancer and possibly allergy. Exposure to this gas can elicit symptoms such as eye, nose and throat irritation, upper respiratory tract irritation, fatigue and skin rash. Some of its sources include insulation, particle board and plywood, environmental tobacco smoke, and fabrics. It is colorless, and can sometimes give off a sharp, pungent odor.

Organic gases (volatile organic compounds such as toluene and benzene) elicit health effects such as irritation of the eye, nose, and throat, and damage to the nervous system, liver and kidney. Some organic gases are suspected or known to cause cancer. Exposure to these gases elicits a variety of symptoms such as fatigue, weakness, and loss of coordination or memory. Examples of organic gases include isocyanates generally, and hexamethylene diisocyanate (HDI), in particular.

Hexamethylene diisocyanates (HDI's), which are commonly called polyurethanes, enter into the composition of most industrial products by that name. Isocyanates are irritating to the skin and the mucous membranes, the skin conditions ranging from localized itching to more or less widespread eczema. Eye tearing is often found; conjunctivitis is rare. The most common and most serious troubles, however, are those affecting the respiratory system. The majority of the literature mentions nasal drainage, sore throat and asthmatic manifestations, which range from minor difficulty in breathing to acute attacks. There are many types of isocyanates. Hexamethylene diisocyanate was typically identified in the Material Safety Data Sheets provided by Alioto's.

There is little to no data addressing the chronic effects of repeated low level exposures (levels below the Cal/OSHA recommended permissible exposure limit of 5 parts per billion) to hexamethylene diisocyanate.

V. PLANS FOR ACTION

The Chancellor's Office, the Medical Center, and the School of Medicine all recognize the need to act without delay to take all reasonable steps to prevent the entry of isocyanates and other organic vapors into the Mission Center Building. It is also true that engineering solutions to this problem are likely to require lengthy and costly modifications to MCB itself or to the source of the emissions. The following actions are underway to work to the ultimate solution of this problem:

1. Environmental Health and Safety has undertaken more extensive study of all of the air intakes and the ten different ventilation systems serving MCB to assess more fully the extent to which isocyanates and other organic vapors can be detected within MCB. Additional air samples were collected between March 31 and April 8, 1993. The sampling included both short-term intervals when exposure to paint fumes appears to be most intense and longer intervals that cover the work day. Testing included off-hours samples and samples of exterior areas as well.

Analysis of the samples should be completed and results made available within the month. The results also will be considered in relation to air samples in comparable office buildings. Because the previous samples were taken in areas with the highest reported concentration of paint fumes, it is not anticipated that the samples will exceed the permissible limits for the materials tested. Nonetheless, the additional sampling may help to identify whether there are other problem areas.

2. The Facilities Management staff and consulting engineers are evaluating the effectiveness of using charcoal filters to filter out vapors from entering the ventilation system. This evaluation must weigh the filtering capacity of the charcoal against the extent to which the filters would further reduce the air flow through the current ventilation systems. A pilot filter was installed on the ventilation system serving the third floor on March 22, 1993, with limited success. Other filters will be evaluated and installed until the most appropriate balance of filtering and air flow is achieved. Use of charcoal filters will be an interim measure until other control measures can be put in place. The extent to which filters will be part of the permanent solution also is under consideration.
3. There may be some temporary relocation of offices within MCB if it is determined that those relocations would decrease exposure to the highest concentrations of paint vapors.
4. EHS has contacted the Bay Area Air Quality Management District (BAAQMD) to review the permit of the body shop adjacent to NCB. It appears that the body shop has met all BAAQMD permit requirements. The remaining option with this agency is to file an odor complaint; this approach is being evaluated for future action.
5. Vice Chancellor Bruce Spaulding (Advancement and Planning) and representatives from EHS and Community Relations met with the owners of the Alioto's body shop to explore potential solutions that could prevent paint vapor from exiting the body shop or entering the air intakes for MCB. The owners agreed to allow UCSF representatives to conduct on-site air quality tests and to evaluate potential solutions. For example, increasing the auto body shop's stack height and providing a booster fan might make it possible to disperse the vapors to safe dilution levels before they reach any of the MCB air intakes, or any other buildings in the neighborhood. EHS representatives subsequently returned to Alioto's, met with the workers and discussed the spray painting operation. Facilities Management and engineering consultants will be meeting shortly with Alioto's to

proceed with engineering analysis.

6. The campus is updating prior studies of the MCB ventilation systems and undertaking new engineering studies of the air intake system to define the time frames and costs for permanent modifications to the MCB ventilation system. If it is not possible to reduce the emissions at their source before they enter MCB, this information will be available so that decisions on the MCB infrastructure can be made expeditiously.

VI. WHAT THE EMPLOYEE CAN DO

Employees who need to obtain medical care can do so through their group health insurance plan. Employees who think their condition may be work-related should file a workers' compensation claim through their department. If the claim is approved, medical costs will be reimbursed by workers' compensation.

Group Health Insurance Plan Benefits

Employees who elect to use their group health insurance plan and have questions about their coverage should call their health insurance carrier first. Other general information questions about employee benefits may be directed to the UCSF Employee Benefits Office at 476-1400.

Workers' Compensation

Employees are eligible to file for workers' compensation if they have experienced any symptoms which they think are work-related and have resulted in the need for medical care or in lost time from work due to medical inability to work. An employee may file for workers' compensation whether or not he or she has been treated by his or her personal physician. If the claim is approved, medical costs will be reimbursed by the UC Regents' Workers' Compensation program.

Should the employee elect to file a workers' compensation claim, the first thing the employee should do is notify his or her supervisor. Supervisor or employee questions regarding the workers' compensation process, and the necessary forms to complete, can be directed to Nick Plezbert of the UCSF Risk Management Department at 476-1759.

Notice to Supervisor of Time Away from Work

The employee should follow regular departmental policies and procedures in notifying his or her supervisor of any time away from work due to medical appointments or medical inability to work. The supervisor may request from the employee written verification of any

time away from work. The supervisor can answer questions regarding policies and procedures in the employee's department. Supervisors wishing clarification of University policies and procedures may call the Labor and Employee Relations Division at 476-3905.

Other Resources for Employees

Questions regarding this report or issues related to the air quality of the building to Woody Hill of EHS at 6-0880. All studies of MCB air quality are available for review by employees in the MCB Building Management Office.

Individual employees are encouraged to discuss any of their concerns about air quality with their supervisors. Supervisors will work with individual staff members to assure that appropriate actions are taken in their cases. The campus will provide additional status reports on MCB air quality, and will continue to inform employees as reports are received and actions are taken.

A meeting to discuss the contents of this report will be convened by Vice Chancellor David Ramsay (Academic Affairs) with MCB unit managers on Thursday, April 15, 1993 at 3 pm in MCB-125. Subsequent briefings open to all staff are being scheduled to follow the April 15th meeting.

RESOURCES FOR ANSWERING QUESTIONS

The following parties may be contacted regarding questions related to the contents of this report:

MCB Building Management Office Contact: Katy Irwin	476-0434
UCSF Environmental Health and Safety Office Contact: Woody Hill	476-0880
UCSF Facilities Management Contact: Gary Nelson	476-6829
UCSF Benefits Office Employee health benefits	476-1400
UCSF Risk Management Contact: Nick Plezbert Workers' compensation process Receives and processes injury reports	476-1759
Applied Risk Management Contact: Bobbie Baca Coordination and authorization of medical care Status of workers' compensation claims Payment of workers' compensation benefits	255-0127
State of California Office of Benefit Assistance Questions regarding workers' compensation	1-800-736-7401
State of California Information and Assistance Officer Questions regarding workers' compensation	557-1901

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513 Parnassus Avenue Room S101
San Francisco, CA 94143-0462
(415) 476-2557
FAX (415) 665-8668

Carol Fox, News Director
Source: Bill Gordon (415) 476-2557

FOR IMMEDIATE RELEASE

April 15, 1993

UC SAN FRANCISCO INITIATES PROGRAM TO IMPROVE
AIR QUALITY IN MISSION CENTER BUILDING

In response to recent tests which found very low levels of a paint chemical in air samples taken from UC San Francisco's Mission Center Building, UCSF today (April 15) initiated an air quality improvement program.

Air samples taken earlier this year at Mission Center found the presence of Diisocyanate, a paint chemical associated with respiratory and other health problems. Although measured at levels nearly 100 times below state safety standards, some Mission Center employees have reported health problems consistent with exposure to the compound, including fatigue and eye, nose and throat irritation.

The Mission Center Building air intake system appears to be drawing the contaminant into the building from an automobile body and paint shop that adjoins the building property.

Work began today on a detailed engineering plan to install new air filtration systems and to overhaul Mission Center's ventilation system. Selection of a mechanical contractor to perform the work will be made within a few days, UCSF Senior Vice Chancellor David J. Ramsay, DM, told employees.

In addition, UCSF representatives continue to meet with the owners of Alioto's Garage & Body Shop, which adjoins the Mission Center Building site, to explore the possibility of installing a new exhaust duct system to serve the garage paint shop. UCSF administrators propose to install an exhaust system designed to direct paint fumes above the roof of Mission Center and prevent them from entering the building's air intakes, but several legal issues first must be negotiated with the body shop owners.

If an agreement can be reached quickly, construction of the exhaust duct system could begin by the first week in June and be completed by early August.

Work which began today on the Mission Center Building ventilation system will be completed in three phases. The schedule is the following:

- Replace the main air filtration system on the third and fourth floors with a dual system consisting of a bag filter and a charcoal filter designed to remove paint fumes. Installation of the combination system, expected to eliminate 95 percent of particulates, is scheduled to begin the first week of May and to be completed by mid-June.
- Replace the remaining air filtration systems in the building with similar dual systems. Installation is scheduled to begin the week of May 23 and to be completed by mid-July.
- Measure and improve air flow after installation of the new filter systems is complete. Specifications for the "tune up," which may involve replacement of fans or motors as necessary, will be completed in mid-August with work beginning immediately thereafter.

UCSF is continuing to sample and test the air for a variety of compounds, but subsequent tests have turned up no significant contaminants. Results of the tests will be posted and UCSF officials will meet regularly with employees to keep them informed of the latest information. In the meantime, Mission Center employees who feel unwell are being told to leave the building.

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TO: All AHP Staff:

From Joanna Pinaldi

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UCSF

University of California, San Francisco . . . A Health Sciences Campus

Office of the Senior Vice Chancellor,
Academic Affairs
Room 115-S
San Francisco, California 94143-0400
Tel: (415) 476-1881
Fax: (415) 476-0816

April 16, 1993

TO: All MCB Employees

FROM: David J. Ramsay *DJR*
Senior Vice Chancellor

General meetings have been scheduled at different dates and times to give all employees working at MCB an opportunity to get updated information and ask questions about what is being done to solve the air quality problems at Mission Center Building. I and representatives from Occupational Health, Environmental Health & Safety, Labor Relations, Facilities Management, Employee Health, Employee Benefits, and Risk Management will be present at these briefings.

Wednesday, April 21, 10:00 a.m., Room 125

Wednesday, April 28, 12:00 noon, Room 125

Wednesday, May 5, 2:00 p.m., Room 125

Due to the limited conference room capacity, I would suggest you let your department manager know which meeting you are planning to attend so he/she can notify my office of the number of employees attending the different meetings.

March 17, 1993

TO: All MCB Employees

FR: Roy Balzer, EH&S

In response to concerns expressed by several of you about odors and air quality in the Mission Center Building, the Environmental Health & Safety office conducted an air sampling and testing program in an attempt to trace the source of any problems and develop alternatives to eliminate or reduce them.

Preliminary results of the tests show the presence of paint chemicals at levels well below state standards in the air supply to MCB. Results of the tests are being studied by a committee made up of MCB occupants and campus members. The committee received a draft copy of the report on Tuesday and will meet later this week to evaluate our options and make immediate recommendations for corrections.

We will share the test results and recommendations with you as soon as the report is complete. Copies of the final report will be distributed to all employees at informational meetings in each department where EH&S experts will discuss the findings and answer any questions you have. The meetings are being planned for the week of March 29.

We understand your concern and want to be sure you get the most accurate and complete information. Thanks for your patience.

**INDOOR AIR QUALITY
MISSION CENTER BUILDING
AIR QUALITY SURVEY**

I. BACKGROUND

At the request of Katy Irwin, Building Manager, Mission Center Building, the office of Environmental Health and Safety performed an air quality survey of the Mission Center Building (MCB). This study is a followup to a previous study conducted in July 1991. The purpose of this study was to gather further information on reactions to the indoor environment from building occupants prior to conducting a mechanical investigation of the heating, ventilating, and air conditioning system.

II. DESCRIPTION OF ENVIRONMENT

The Mission Center Building is located at 1855 Folsom Street. The building consists of six floors which house various UCSF administrative offices, as well as laboratory space. The building is situated in a low to moderate industrial section, south of Market Street. The Mission Center Building is heated with fin tube radiators along the perimeter of each floor. Cooling, ventilation, and additional heating for the building are provided by eight individual forced-air HVAC systems. Each system is provided with its own temperature controls. The energy plant which serves these systems is located in the northwest mechanical room on the fourth floor. Descriptions of the systems are as follows:

Multi-zone system MZ-1

A Trane multi-zone unit, located in the mechanical penthouse, provides heating, ventilation and air conditioning for the VIACOM studio on the sixth (6) floor. This system is a 14,000 CFM, 5 zone, constant air volume HVAC system with economizer cycle controls, presumably providing approximately 17 air changes per hour for the space. Hot and cold deck temperatures of the multizone unit is maintained by the heating hot water and the chilled water generated from the energy plant of the building.

System S-5

Air conditioning for the northwest portions of the first, fourth, fifth and sixth floors of the building is provided by system S-5 located in the northwest mechanical room on the fourth floor. This system is a field erected, variable air volume system with economizer cycle controls. Supply air distribution of the system is via insulated, high velocity, oval shaped, steel ductwork associated with variable air volume induction boxes, low pressure steel ductwork at downstream of the induction boxes and ceiling mounted diffusers. Return air of the system is collected by the return/exhaust fan via oval shaped, steel ductwork and is either returned to the system or

expelled to the atmosphere. [Economizer Cycle]. The system is a variable air volume system with chilled water cooling only, and hot water reheat coils are provided at the induction boxes installed on the sixth floor.

System S-10

System S-10 is located in the southeast mechanical room in the fourth floor. This system is similar to system S-5 above except that the system is serving the southeast portion of the first, fourth, fifth and sixth floors of the building.

System SF-1

This system is housed in the northwest fan room on the third floor and is similar to system S-5 above except that the system is provided with zone VAV Boxes with reheat coils in lieu of induction boxes, and fan-width controls in lieu of inlet vane controls.

Animal holding room system S-21

System S-21 is located in the northwest mechanical room on the second floor. This system is 100% outdoor air, constant air volume, dual duct, heating, ventilating and air conditioning (HVAC) system.

Laboratory HV system S-22

This system is located at the same mechanical room as system S-21. The system is a 100% outdoor air, variable air volume, heating and ventilating system.

Cell analysis system AH-1

System AH-1 is located in the mechanical room on the south end of the second floor. This system is a constant air volume heating, ventilating and air conditioning system with economizer controls

Cell analysis system AH-2

This system is located at the same mechanical room as system AH-1 and is similar to AH-1 except 100% outdoor air in lieu of economizer cycle.

III. METHODS

Building health questionnaires were given to Katy Irwin and distributed to all building occupants to complete. The results were recorded and are presented in Table I.

IV. RESULTS

Office Health Questionnaire-462 Respondents

The most frequent health complaints and building comfort complaints are listed in Table I. The symptoms reported most frequently were stuffy stagnant air movement, followed by air temperature too hot/cold, eye burning/itching, headaches, noise from the ventilation system, congestion/sinus, throat dryness/scratchiness, and drowsiness. Most respondents reported smelling paint and food odors periodically. The complete summary of the MCB health questionnaire are listed in Table II.

TABLE I
HEALTH AND BUILDING COMFORT COMPLAINTS
HIGHEST FREQUENCY

1. Health Complaints

<i>Eye Symptoms:</i>	<i># Respondents</i>
<i>redness</i>	<i>94</i>
<i>burning/itching</i>	<i>125</i>
<i>Contact Lenses:</i>	
<i>discomfort</i>	<i>45</i>
<i>deposits/filming</i>	<i>27</i>
<i>Nasal Symptoms:</i>	
<i>congestion</i>	<i>108</i>
<i>sinus problems</i>	<i>95</i>
<i>Throat Symptoms:</i>	
<i>dryness</i>	<i>99</i>
<i>scratchiness</i>	<i>86</i>

Breathing Problems:

<i>coughing</i>	81
<i>chest tightness</i>	39

Mouth Symptoms:

<i>unusual tastes</i>	14
<i>dryness/thirst</i>	103

Skin Problems:

<i>dryness</i>	41
<i>rash</i>	30

Stomach Trouble:

<i>indigestion</i>	34
<i>nausea</i>	31

Aches and Pains:

<i>headache</i>	119
<i>backache</i>	60

Flu Like Symptoms

<i>chills</i>	46
<i>weakness</i>	47

Stress Symptoms:

<i>anxiety</i>	55
<i>exhaustion</i>	48

General Complaints:

<i>drowsiness</i>	101
<i>headache</i>	92
<i>lethargy/lack of energy</i>	95

2. *Building Comfort Complaints*

Noise from: *# Respondents*

ventilation system *112*

Air Movement:

drafty *97*

stuffy/stagnant *211*

Air Temperature/ Humidity:

too hot *170*

too cold *145*

Odors:

food odors *82*

other odors *66*

Lighting:

too dim *49*

glare or flicker *56*

Work Area:

cleanliness *51*

other *50*

Other:

privacy *66*

closed-in feeling *80*

TABLE II
SUMMARY OF MCB HEALTH QUESTIONNAIRE

1. Health Complaints

Eye Symptoms: *# Respondents*

a.	redness	94
b.	burning/itching	125
c.	dryness	82
d.	watering	62
e.	puffiness	76
f.	blurred vision	72
g.	other	3

Contact Lenses:

a.	discomfort	45
b.	deposits/filming	27
c.	other	4

Nasal Symptoms:

nosebleeds	26
congestion	108
sinus problems	95
runny nose	87
other	24

Throat Symptoms:

dryness	99
scratchiness	86
soreness	73
other	8

Breathing Problems:

breathlessness	28
wheezing	39
coughing	81
chest tightness	39

TABLE II CONT.

<i>Mouth Symptoms:</i>	<i># Respondents</i>
<i>unusual tastes</i>	14
<i>dryness/thirst</i>	103
<i>other</i>	0
<i>Skin Problems:</i>	
<i>dryness</i>	41
<i>rash</i>	30
<i>flaking</i>	22
<i>itching</i>	77
<i>other</i>	2
<i>Stomach Trouble:</i>	
<i>indigestion</i>	34
<i>nausea</i>	31
<i>vomiting</i>	4
<i>diarrhea</i>	19
<i>constipation</i>	10
<i>aches/cramps</i>	28
<i>other</i>	2
<i>Aches and Pains:</i>	
<i>headache</i>	119
<i>backache</i>	60
<i>muscle ache</i>	19
<i>joint pain</i>	49
<i>other</i>	0
<i>Flu Like Symptoms</i>	
<i>fever</i>	28
<i>chills</i>	46
<i>weakness</i>	47
<i>other</i>	0

TABLE II CONT.

Stress Symptoms: *# Respondents*

<i>anxiety</i>	55
<i>irritability</i>	37
<i>sleeplessness</i>	46
<i>exhaustion</i>	48
<i>depression</i>	44
<i>feeling of panic</i>	20
<i>other</i>	1

General Complaints:

<i>drowsiness</i>	101
<i>faintness</i>	20
<i>dizziness</i>	46
<i>trouble</i>	
<i>concentrating</i>	62
<i>headache</i>	92
<i>lethargy/lack of</i>	
<i>energy</i>	95
<i>menstrual cycle</i>	
<i>irregularity</i>	11

2. *Building Comfort Complaints*

Noise from: *# Respondents*

<i>ventilation system</i>	112
<i>office equipment</i>	46
<i>other</i>	24

Air Movement:

<i>drafty</i>	97
<i>stuffy/stagnant</i>	211
<i>other</i>	15

TABLE II CONT.

Air Temperature/ Humidity: *# Respondents*

<i>too hot</i>	<i>170</i>
<i>too cold</i>	<i>145</i>
<i>too damp</i>	<i>18</i>
<i>too dry</i>	<i>84</i>
<i>other</i>	<i>12</i>

Odors:

<i>food odors</i>	<i>82</i>
<i>tobacco smoke</i>	<i>25</i>
<i>body odors</i>	<i>23</i>
<i>other odors</i>	<i>66</i>

Lighting:

<i>too bright</i>	<i>32</i>
<i>too dim</i>	<i>49</i>
<i>glare or flicker</i>	<i>56</i>
<i>other</i>	<i>15</i>

Work Area:

<i>decor</i>	<i>46</i>
<i>partitions</i>	<i>31</i>
<i>neatness/</i>	
<i>cleanliness</i>	<i>51</i>
<i>other</i>	<i>50</i>

Other:

<i>privacy</i>	<i>66</i>
<i>view</i>	<i>49</i>
<i>distractions</i>	<i>57</i>
<i>closed-in feeling</i>	<i>80</i>
<i>other</i>	<i>15</i>

V. CONCLUSIONS

The majority of the respondents to the building health questionnaire reported headaches, fatigue/drowsiness, and stuffy hot air. Building comfort complaints were found to be the most significant.

A significant number of building occupants indicated that paint fumes and food odors occur periodically.

VI. RECOMMENDATIONS

1. The HVAC system should be maintained and operated to provide at least the outdoor air ventilation rate (based on actual occupancy) required by the applicable building code, mechanical code, or ventilation and indoor air quality code in effect at the time the permit covering the building HVAC system was issued. Therefore, it is recommended that HVAC systems SF-1, S-5, S-10, and S-22 be evaluated for the following:

- A. Total air measurements, supply and exhaust for each system.*
- B. Determination of fresh air quantities (%) for each system, minimum and maximum.*
- C. Supply air quantities delivered to each floor.*
- D. Return air quantities from each floor.*
- E. Quantities of air from each supply diffuser on each floor.*
- F. Air changes per hour for each area/room.*
- G. One line diagrams or drawings illustrating each of the above.*
- H. Identification of deficiencies if applicable.*

In addition, the above systems should be evaluated to current ASHRAE standards (1989).

2. Evaluate the HVAC systems air filtration efficiency by the ASHRAE atmospheric dust spot test, ASHRAE 52-76.

3. Departmental managers shall insure that indoor air quality problems or indoor air quality complaints from employees are documented and reviewed with affected employees to assist in correction of identified unsafe conditions or practices.

Report Prepared By:

Woody Hill
Woody Hill

Sr. Industrial Hygienist
OHRS

Report Reviewed By:

Woody Hill for
Eugene Lau

Program Manager
OHRS

October 22, 1992

San Francisco Chronicle

BAY AREA

AND CALIFORNIA

EDITORIALS

PAGE A14

PANORAMA

PAGE A15

Chemical Blamed for UCSF Health Complaints

By Louis Freedberg
Chronicle Staff Writer

After 10 years of health complaints at a Mission District building owned by the University of California at San Francisco, new tests have revealed that chemical fumes have been leaking into the building, probably causing a range of health problems in hundreds of employees.

In a just-completed report, the university has concluded that health problems — including eye, nose and throat irritation and fatigue — were caused by diisocyanate, a paint chemical that was used at Alioto's Garage and Body

Fumes from garage next door leaked into Mission District building

Shop next to UCSF's Mission Center, an office building at 1855 Folsom Street in San Francisco's Mission District.

Fumes from the garage apparently entered the ventilation system of the building, where almost 850 university employees work.

University officials will meet with employees at the building Thursday to discuss their findings and possible remedies. In the meantime, the university has told employees who feel "unwell" that

they can leave the building at any time.

"I think we have some problems with people in the building obviously having some ailment with difficulty in breathing and so on," said Dr. David Ramsay, vice chancellor of academic affairs. "But most of the complaints really did not become acute until the last two or three months. I don't think the immediate problem is a 10-year-old problem."

A survey of Mission Center workers found that a majority of the almost 500 responding com-

plained of headaches, fatigue or drowsiness, and stuffy hot air.

However, Ramsay said, it is not known how many employee sick days during the past 10 years are directly related to the building's bad air.

According to university officials, previous attempts to trace the problem found no significant contamination of the air. They said that the amounts found during the most recent air sampling — 0.055 parts per billion — was 100 times

below the safety standards set by the California Occupational Health and Safety Administration.

They said that the available literature provides little information on the effects of the long-term exposure to low levels of the compound.

So far, Ramsay said, none of the workers has apparently become seriously ill.

"I hope we can come to a reasonable short-term solution this week and work out the long-term

remedies later," said Ramsay. "The problem in terms of the fumes being pulled in is relative new. But we are going to do what we have to to make sure our employees are in a safe environment."

UCSF has contacted the Bay Area Air Quality Management District to review the permits of the auto shop. The university said that its review of records indicates that the paint shop complies with air quality regulations, but the owners said they would cooperate with UCSF to find a solution to the problem.

The owner of the garage could not be reached for comment yesterday.

Anti-Smoking Bill Ignites Criticism

Health groups say tobacco industry would benefit from uniform law

By Greg Lucas
Chronicle Sacramento Bureau

Sacramento

A key Assembly committee chairman said yesterday that he will introduce a tough anti-smoking bill, but his proposal was immediately denounced by health groups as a tobacco industry smoke screen designed to curtail the power of local governments to regulate smoking.

In a virtual rerun of one of 1991's most hotly debated special-interest bills, Assemblyman Curtis Tucker Jr. said that he will introduce a measure to create a uniform state law on smoking that local governments cannot pre-empt with tougher standards. The measure would limit smoking in restaurants, theaters, shopping malls and other public places.

Manufacturers Of Nail Polish Named in Suit



October 26, 1993

To: All MCB Occupants
Fr: Dr. David Ramsay
In Re: MCB Air Quality Issues

Filtration Systems

Inspections and studies are ongoing to determine sources and explanations for ongoing odors within Mission Center. Please continue to keep logs of any odors smelled within MCB including type of odor, date, and time; observations of outside weather conditions would also be relevant. These logs may be sent to Katy Irwin at Box 0831.

Testing & Analysis

An indoor air quality engineering firm, Indoor Environmental Engineering (IEE), has been asked to assist with coordination of the engineering and environmental testing analyses. IEE works with building owners and design professional on IAQ diagnosis and mitigation as well as directs State and Federal research projects regarding indoor air quality. IEE's role is to conduct additional tests within MCB as well as make recommendations for mitigation of air quality complaints.

Environmental Health Survey

An occupational health survey is being prepared by Marion Gillen, RN, and Bob Harrison, MD of UCSF's Division of Occupational and Environmental Health. The questionnaire is being developed based on similar surveys done nationwide. A draft of the survey is currently being reviewed and will be ready for pilot testing among twelve MCB occupants in early November.

Cleaning of HVAC Systems

All vents, air diffusers, and parts of air ducts on floors one through six are in the process of being vacuumed and cleaned. All work is being performed after 5pm, Monday through Friday. Departments will be notified regarding ventilation shutdowns and access to specific areas as the work progresses.

Further Updates

A meeting to provide further information and new updates will be scheduled in mid-November after the Environmental Health Survey has been distributed to MCB occupants.

Academic Affairs
University of California, San Francisco

April 6, 1993

TO: All MCB Employees
FROM: David J. Ramsay
Senior Vice Chancellor

DR

I am writing to let you know that Chancellor Krevans has asked me to take responsibility for developing a plan to deal with the current air quality problems at the Mission Center Building.

As you already know, Environmental Health & Safety has conducted an air sampling and testing program attempting to trace the source of any problem and to develop alternatives to eliminate or mitigate them. Other staff have been gathering background on the history of this problem and the measures which have been tried to date.

Next week, I will convene a meeting to begin the process of discussing the reports which will be distributed on April 9th. On Thursday, April 15th at 3pm, I and representatives from Environmental Health & Safety, Labor Relations, Facilities Management, Employee Health, Employee Benefits, and Risk Management will meet with all MCB unit managers and an employee from each unit in MCB Room 125. A series of general briefings open to all staff are being scheduled to follow the April 15 briefing.

We appreciate the patience of our MCB staff as we attempt to determine the proper course of action.

March 17, 1993

TO: All MCB Employees

FR: Roy Balzer, EH&S

In response to concerns expressed by several of you about odors and air quality in the Mission Center Building, the Environmental Health & Safety office conducted an air sampling and testing program in an attempt to trace the source of any problems and develop alternatives to eliminate or reduce them.

Preliminary results of the tests show the presence of paint chemicals at levels well below state standards in the air supply to MCB. Results of the tests are being studied by a committee made up of MCB occupants and campus members. The committee received a draft copy of the report on Tuesday and will meet later this week to evaluate our options and make immediate recommendations for corrections.

We will share the test results and recommendations with you as soon as the report is complete. Copies of the final report will be distributed to all employees at informational meetings in each department where EH&S experts will discuss the findings and answer any questions you have. The meetings are being planned for the week of March 29.

We understand your concern and want to be sure you get the most accurate and complete information. Thanks for your patience.

DS-
Did this go out to
all AHP employees?
If not, pls distribute.
j

Air Quality Meeting at MCB/AHP.

JR - FY I: My notes - we should keep a file of this for staff info.

1-19-00

NAME

DEPARTMENT

Jane Warner

Eileen Lloyd

Eugene LAU

Jim Chung

MEREDITH JACOBSON

DAVE GREGO

Michael Keleman

Jim Dilley

LPPI Administration

EH&S

EH&S

EH&S

LPPI

FM

FM

AHP

EH

- 92-94 EH&S just 80K on EPA expect to come in re: air measurements, etc.

FM

- 5-6 mos life safety project; making stairway - balancing systems was

- windows should be always closed.

- Alioto - end of Nov. Alioto added an add'l guy booth, the exhaust duct was aimed at us.

- around Xmas time - Alioto changed direction - and hence

— was apologetic, etc. He turned it around.

— Aliotti's is operating in their legal right —

no job —

— Pre-filters — dust, etc. particulate matter. / 95% effective

— Charcoal filters — \$200 2x/yr. — to A.
— for again matter. /

— FM will ask that disto's will agree to notify us

— Response Plan — for when/if this happens again

— direct, immediate response by FM; then

— air intake fumes are hi —

The supervisor
Personal.
Pager / Prompt response

Keep a log of AQ incidents.

Have a ^{mobile} filter available to staff.

Make reference material avail.

Have brief staff presentation re: H&O Process.

Next

For

Don Campbell will be responsible for UCB.

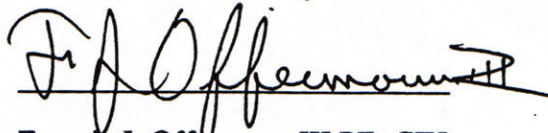
**UCSF
MISSION CENTER BUILDING
INDOOR AIR QUALITY
EVALUATION**

Final Report

Prepared by:

**Indoor Environmental Engineering
San Francisco, CA
(415) 567-7700**

Authorized by:

A handwritten signature in black ink, appearing to read 'Francis J. Offermann III', written over a horizontal line.

**Francis J. Offermann III PE, CIH
President**

February, 1994

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EXECUTIVE SUMMARY

Employees experiencing physical discomforts while working at the UCSF Mission Center Building (MCB) have expressed concern regarding the quality of the air in the building. Complaints about the air quality in the building date back to 1981. Complaints historically have included lack of "fresh air", stuffiness, too hot, too cold, paint smells, gas vapors, and food odors. During the past year complaints about air quality in the building have increased. In particular, complaints have centered around the presence of paint vapors in the northwest portions.

To address these concerns regarding the quality of air at MCB, Indoor Environmental Engineering was retained by the UCSF Environmental Health and Safety staff to conduct a comprehensive assessment of the air quality at MCB. The following are the five objectives of our indoor air quality study:

- inspect the building for potential sources of indoor air contaminants
- characterize the gaseous and particulate air and surface contaminants at selected indoor locations in a comprehensive fashion and compare to indoor air quality guidelines for office spaces.
- measure the ventilation system air circulation rates and outside air delivery rates and compare to recommended minimum ventilation rate guidelines for office spaces.
- assess the efficiency of the charcoal filters installed in the building ventilation system to remove volatile organic compounds and diisocyanates.
- outline mitigation actions necessary to improve the indoor air quality where required.

The indoor sources we identified during our investigation include the usual sources associated with office spaces: people, paper products, printing equipment, and office furnishings. Site 1, Room 116, had a liquid toner copy machine which produces a significant amount of organic contaminants. Pollutant sources in the outside air of the Mission Center Building include most notably the auto body shop next door across the alley on the north side of the building. According to UCSF Environmental Health and Safety staff, this body shop uses polyurethane based paints which contain diisocyanates.

Our measurements of ventilation rates indicate that the air circulation rates do not meet the recommended air circulation rate or outside air delivery rate guidelines at three of the four office spaces inspected under one or more operating conditions. In addition there is no purge cycle (e.g. 100% outside air) for clearing out air contaminants which may have built up during the night time when the ventilation systems are not operating. Also the thermostat VAV controls appear to be stuck in 5 of the 9 VAV boxes inspected. This lack of control will cause for unacceptably large swings in air temperature with changing thermal loads of people, lighting and equipment.

The indoor concentrations of air contaminants measured at four different indoor locations on October 20, 1993 were all below both recommended irritant guidelines and occupational health guidelines except for total volatile organic compounds at Site 1, Room 116 on the first floor. The concentration of total volatile organic compounds at Site 1 was $1502 \mu\text{g}/\text{m}^3$ which is below occupational health guidelines (i.e. OSHA) but above the recommended irritant guideline of $1000 \mu\text{g}/\text{m}^3$. The source of volatile organic compounds was traced to a liquid process photo copy machine in that area. We also noted that the outside air at MCB has relatively high concentrations of total volatile organic compounds which appear to be caused by the auto body shop next door.

Since the ventilation systems were operating with a maximum percentage of outside air during the period when we sampled for air contaminants, we prepared projections of the indoor contaminant concentrations for periods when the ventilation systems operate at the minimum outside air percentage. The projected indoor concentrations of total volatile organic compounds and formaldehyde exceeded the recommended irritation guidelines at Sites 1 and 3. While these concentrations substantially exceeded the recommended irritant guidelines (i.e. by factors of 2-3) the projected indoor concentrations were still substantially below recommended occupational health guidelines (e.g. OSHA). The projected indoor concentrations of carbon dioxide exceeded the recommended comfort guide of 1000 ppm at each of the four study sites.

We note that while the indoor concentration of HDI measured in each of the office locations were measured to be below recommended guidelines we believe that under favorable wind conditions and with heavy auto painting activity that the indoor concentration may approach the irritation guideline. Also, given the extreme irritation associated with exposure to this

compound, the 0.5 ppb (e.g. 1/10th of the ACGIH TLV) irritation guideline, may not be sufficient to protect sensitive individuals.

The contaminant removal efficiency of the charcoal filters was observed to be generally low with the average removal efficiency of 40% for eleven compounds. This contaminant removal efficiency is typical of this type of filter which is a light duty filter not intended for applications where high removal efficiencies (e.g. >90%) are required. Thus it appears that the filters selected for mitigating the paint fumes have insufficient material to insure the contaminant removal efficiency necessary to keep the concentrations below the odor detection threshold during episodic periods of high concentrations of paint fume contaminants.

In summary, there are a number of locations in the building which are receiving either not enough supply air and/or not enough outside air under certain operating conditions. This finding is consistent with the occupant survey conducted by the UCSF Environmental Health and Safety where 46% of the building occupants reported experiencing "stuffy stagnant" air. This condition of not enough ventilation air may also explain why 37% of the occupants report air temperatures "too hot". These were the two highest symptom prevalence rates reported by the building occupants. To remedy these complaints the building ventilation system needs to be balanced to meet the maximum projected occupancies in each area. This lack of ventilation in portions of the building is a violation of Cal-OSHA 5142 and should be addressed as soon as possible.

The lack of adequate ventilation during cold periods when the building is operating with a minimum amount of outside air combined with indoor sources of volatile organic compounds and formaldehyde produce elevated indoor concentrations which can cause many of the physical discomforts being experienced by employees at MCB including the four highest health complaints documented in two health and comfort surveys: headache, burning itching eyes, congestion, and dryness of throat or mouth.

The proximity of the auto body paint shop next to MCB is both a source of volatile organic compounds and diisocyanates in the building air. The low efficiency charcoal filters currently installed in the building air handlers have neither sufficient efficiency, nor capacity, to preclude paint odors from entering the indoor space.

The following are our recommendations to improve the indoor air quality at the UCSF MCB:

- 1.) Adjust the ventilation supply air flow rate in each area to vary between 0.5 and 1.5 cfm/ft² according to the maximum anticipated heat load. This means installing minimum stops on all VAV boxes such as those at Site 4 on the sixth floor. Installation of re-heat coils may also be required at each VAV box to insure thermal comfort during low load conditions. A building wide survey of maximum and minimum heat loads from people, lighting, and equipment will be required to do this task.
- 2.) Set the outside air economizer controls to provide a minimum delivery of outside air of 1.0 air change per hour or 20 cfm per occupant, whichever is greater, to each occupied portion of the building at all times. Currently the minimum outside air percentage is 7.5% in SF-10 and 31% in SF-5. The optimal percent outside air percentage from indoor air quality and energy perspectives should be selected based upon a complete building air balance report and occupancy count according to ASHRAE 62-1989 (i.e. see critical zone analysis as described in ASHRAE 62-89 Section 6.1.3.1.). In any newly renovated spaces, a minimum of 3 ach of outside air should be maintained until the odors and/or irritation associated with the new building materials have dissipated.
- 3.) Calibrate each thermostat and check for correct operation of temperature control actuators (e.g. VAV box dampers). Verify operation and system responsiveness by measuring the temperature and air flow rates of the supply air on full heating and full cooling thermostat settings. Repair sticky valves and dampers as necessary. This repair work should be done prior to any re-balancing work. Also the location of thermostats should be checked to see that they are not divorced from the loads they are controlling (e.g. located in a different room).
- 4.) Continue to pursue mitigation methods for eliminating paint fumes from entering the building. The most sure means of accomplishing this is to stop the painting activities at the adjacent auto body shop. If this is not possible, then a combination of improving the dispersion of exhausted paint fumes from the auto body shop with installation of higher efficiency activated charcoal filters should be able to eliminate most of the paint fumes from entering the building at concentrations above the odor threshold. The dispersion of paint fumes may be improved if they are centrally collected into an exhaust duct which discharges the fumes above the wake of MCB (e.g. 1/3 the building height). Effective

filtration of the fumes can only be accomplished with a packed bed charcoal filter. A pilot study of such a system should be conducted to select the appropriate media and amount of media.

5.) Consider re-locating the wet process copy machine located in Room 116 to an enclosed room with an exhaust air system in order to prevent circulation of the contaminants generated from the copier. Adjust the exhaust air flow rate to 0.5 cfm/ft² and adjust the flow rate of supply air to maintain a negative pressure in this room.

6.) Set the ventilation system operating schedule for a minimum of three air changes of outside air through the space before occupants enter the building to purge the building of the contaminant build up during the shut down period. Also schedule the building ventilation system to operate at 100% outside air during all janitorial cleaning operations (e.g. carpet cleaning, floor waxing etc.) in the building. Continue ventilation to the building for a minimum of three outside air changes following the cleaning work.

7.) Institute a pro-active indoor air quality plan as described in Appendix A, Contaminant Control Guidelines for Building Renovations, for all building renovation work. With respect to carpet installations, select low emitting products and install carpet with the appropriate amount of ventilation as described in the guidelines.

8.) Upon completion of the on-going occupant survey, review the data and conduct an indoor air quality diagnostic study of each area with unacceptably high occupant symptom prevalence rates.

BACKGROUND

Employees experiencing physical discomforts while working at the UCSF Mission Center Building (MCB) have expressed concern regarding the quality of the air in the building. Complaints about the air quality in the building date back to 1981. Complaints historically have included lack of "fresh air", stuffiness, too hot, too cold, paint smells, gas vapors, and food odors. During the past year complaints about air quality in the building have increased. In particular, complaints have centered around the presence of paint vapors in the northwest portions.

According to facilities management, there are approximately 50 workman's compensation cases pending, where employees are claiming injury from the exposure to air contaminants in the building. In the past two years there have been two health and comfort questionnaires conducted amongst the building employees. There have also been three indoor air quality studies conducted by the UCSF Environmental Health and Safety staff in the past three years.

The following is a summary of the two health and comfort surveys and the three indoor air quality studies conducted to date at MCB.

Health and Comfort Surveys. In April, 1992 the office of Environmental Health and Safety administered a confidential health and comfort questionnaire to the building employees. The questionnaire contained 61 health related questions and 28 comfort related questions. Of the approximate 900 employees working at MCB, 462 responded.

The following is a summary of the symptoms reported by 20% or more of the 462 occupants responding to the survey.

Health Complaints.

<u>Symptom Description</u>	<u>Percent of 462 Respondents Reporting Symptom</u>
----------------------------	---

Eye Symptoms

• redness	20
• burning itching	27

Nasal Symptoms

• congestion	23
• sinus problems	21

<u>Throat Symptoms</u>	
• dryness	21
<u>Mouth Symptoms</u>	
• dryness/thirst	22
<u>Aches and Pains</u>	
• headache	26
<u>General Complaints</u>	
• drowsiness	22
• lethargy/lack of energy	21
<u>Building Comfort Complaints.</u>	
<u>Noise</u>	
• noise from ventilation system	24
<u>Air Movement</u>	
• drafty	21
• stuffy/stagnant	46
<u>Air Temperature/Humidity</u>	
• too hot	37
• too cold	31
<u>Odors</u>	
• food and other odors	32

In June, 1993 an ad hoc employee health committee was formed in response to concerns about air quality problems and health symptoms experienced by employees at the UCSF Mission Center Building. The survey contained a total of 70 questions regarding physical symptoms. There were no questions in this survey regarding building comfort such as air temperature or air movement. The total number of questionnaires distributed is not known other than not all areas were reached. A total of 117 employees completed the questionnaire.

The following is a summary of the symptoms reported by 20% or more of the 117 occupants responding to the survey.

Health Complaints.

<u>Symptom Description</u>	<u>Percent of 117 Respondents Reporting Symptom</u>
<u>Eye Symptoms</u>	
• redness	38
• watering	28
• dryness	50
• burning itching	56
• blurred vision	26
<u>Nasal Symptoms</u>	
• congestion	43
• sinus problems	39
• runny nose	33
<u>Throat Symptoms</u>	
• dryness	40
• scratchy	34
• sore	37
• hoarseness	25
<u>Breathing Problems</u>	
• breathlessness	23
• coughing	34
• chest tightness	37
<u>Mouth Symptoms</u>	
• dryness/thirst	46
<u>Skin Problems</u>	
• dryness	38
• itching	32
<u>Stomach Problems</u>	
• nausea	31
<u>Aches and Pains</u>	
• headache	64
• backache	20
• muscle ache	24
<u>Flu-Like Symptoms</u>	
• weakness	27

Miscellaneous Symptoms

• anxiety	31
• irritability	38
• fatigue/exhaustion	46
• drowsiness	43
• dizziness	38
• trouble concentrating	26
• ear problems	20

Sensitivity to Paints, Solvents, Tobacco Smoke
and Other Chemicals 47

Symptoms Disappear or Lessen
When Not in Building 70

We note that the Environmental Health & Safety survey did not contain any information regarding the location of the complaints. The survey administered by the Environmental Health and Safety staff had a 51% response rate and the survey administered by the employees had a 13% response rate. These low response rates preclude drawing conclusions regarding the satisfaction of the entire building population. A response rate in excess of 80% is required to draw such conclusions. Both surveys do however provide a good description of the symptoms being experienced by the building occupants who responded.

The UCSF Environmental Health and Safety survey conducted in April, 1992 contained nine physical symptoms with prevalence percentages higher than 20% while the UCSF June, 1993 employee survey contained 31 physical symptoms with prevalence percentages higher than 20%. In addition to reporting three times as many symptoms with prevalence percentages higher than 20%, the employee survey had symptom prevalence percentages roughly twice as high as those discovered in the survey administered one year earlier by the Environmental Health and Safety staff. The higher number of symptoms reported and the higher symptom prevalence percentages observed in the employee study may be a combination of the lower overall building occupant response rate and a higher response rate from those occupants experiencing symptoms in the building.

In each of the two surveys the four highest health complaints were:

- headache
- burning itching eyes
- congestion
- dryness of throat or mouth

The UCSF Employee Health Services staff is currently conducting a more detailed health and comfort study amongst the occupants of the building. This study will attempt to get a higher occupant response rate and will also gather information regarding the location of the complaints. Analysis of this data will provide an important basis of all future air quality diagnostic and mitigation efforts at MCB.

It is noteworthy that 70% of the individuals claiming to experience symptoms while working at MCB report that their symptoms disappear or lessen when they leave the building. This fact is consistent with there being some causative agent in the building.

Indoor Air Quality Studies. In June, 1990 the office of Employee Health Services conducted an indoor air quality study on the fourth floor in the Accounting Department. This study was prompted by employee complaints of poor air quality and paint fume odors. Air sampling was conducted for organic compounds commonly found in paint as well as for formaldehyde, carbon dioxide, carbon monoxide, and particulates. All measurements of contaminant concentrations were observed to be between 200 or more times lower than current Cal/OSHA standards. The study also reported that the delivery of ventilation air to the fourth floor was below design values and that balancing would be required. Balancing of the ventilation system was delayed pending further engineering evaluations.

In August, 1991 a follow up indoor air quality study on the fourth floor in the Accounting Department was conducted by the office of Environmental Health and Safety. The air contaminant concentrations were again found to be well below Cal/OSHA limits and the ventilation rates were still below design values.

In January 11-15, 1993 and March 1-5, 1993 the office of Employee Health Services conducted measurements of hexamethylene diisocyanates (HDI) on the third and fifth floors. This was done in response to complaints of paint fumes from employees working on these two floors, and the discovery that the neighboring paint shop was using polyurethane paints, which contain HDI, a highly irritating compound. Ten samples were collected during the period of January 11-15, 1993 between 8 AM and 5 PM. Eight were collected in Room 308, which is served by ventilation system SF-1, and two were collected in Room 566, which is served by ventilation system SF-5. The indoor concentrations ranged from 0.025 ppm to 0.050 ppm in Room 308 and in Room 566 the indoor concentrations ranged from 0.024 to 0.053 ppm. Another ten samples were collected during the period of March 1-5, 1993 between 8 AM and 5 PM. Five were collected in

Room 308, which is served by ventilation system SF-1, and five were collected from the outside air intake of ventilation system SF-1. Another five were also collected in Room 566 which is served by ventilation system SF-5. The indoor concentrations ranged from below the detection limit of 0.017 ppm to 0.023 ppm in Room 308 and at the outside air intake of SF-1 the concentrations ranged from below the detection limit of 0.017 ppm to 0.031 ppm.

The report noted that the HDI concentrations only reflect the conditions at the time of sampling and factors such as wind speed and direction and painting activity can significantly affect the concentrations of HDI in the building.

STUDY OBJECTIVES

The following are the five objectives of our indoor air quality study:

- inspect the building for potential sources of indoor air contaminants
- characterize the gaseous and particulate air and surface contaminants at selected indoor locations in a comprehensive fashion and compare to indoor air quality guidelines for office spaces.
- measure the ventilation system air circulation rates and outside air delivery rates and compare to recommended minimum ventilation rate guidelines for office spaces.
- assess the efficiency of the charcoal filters installed in the building ventilation system to remove volatile organic compounds and diisocyanates.
- outline mitigation actions necessary to improve the indoor air quality where required.

STUDY APPROACH

This study was designed to provide a detailed characterization of the air and surface contaminants in the building and the performance of the building ventilation system. This study was not designed to diagnose the cause of the complaints in the building. Such a diagnostic study would require a detailed description of the nature and location of the complaints. As discussed earlier, the health and comfort surveys conducted to date at MCB

lack sufficient information regarding location of the complaints to establish a basis for a focused diagnostic study. Currently a health and comfort survey which is designed to provide both a higher response rate as well as information regarding the location of the complaints in the building is being developed. Information from this survey will provide a basis for any further diagnostic studies designed to determine the causes of the employee complaints and design effective mitigation.

In the mean time it was decided that a detailed characterization study would still provide important information regarding the indoor environment at MCB. We focused our characterization efforts on four indoor locations. The four indoor locations were selected to include a known complaint and a non-complaint area from the zones served by air handlers SF-5 and SF-10 which, are two of the largest air handlers serving the building. In addition, air handler SF-5 has an outside air inlet located on the north side of the building in close proximity to an auto body shop while SF-10 has an outside air inlet on the south east corner of the building farther away from the auto body shop.

The selection of the complaint and non complaint areas in each ventilation zone were done based upon the knowledge of the Facilities Management staff who regularly receive complaints regarding the air quality in the building. Based upon this information the following four study sites were selected.

<u>Site ID</u>	<u>Location</u>	<u>Room ID</u>	<u>Air Handler</u>	<u>Occupant Complaint Status</u>
1	First Floor, SE	116	SF-10	Non-complaint area *
2	Fifth Floor, N	549	SF-5	Non-complaint area *
3	Fifth Floor, SE	505A	SF-10	Complaint area
4	Sixth Floor, NW	630	SF-5	Complaint area

* We note that the selection of the complaint and non-complaint areas was not based upon a formal survey of complaints but upon the knowledge of the Facility Management staff. During the course of our study we learned there were employees in each of the two selected non-complaint areas who have or are currently experiencing symptoms. In Room 116 one

individual experiences headaches and in Room 549 several individuals experienced paint fumes.

Our comprehensive indoor air quality characterization conducted at each of the four MCB study sites included each of the following four elements:

- Contaminant Source Inspection
- Ventilation System Inspection
- Contaminant Measurements
- Data Interpretation

The following is a brief description of each step.

Contaminant Source Inspection. This step involves a walk through of the building and the building ventilation system during which one collects a detailed inventory of potential sources of contaminants. Sources of contaminants may arise from indoor sources such as off gassing of new materials installed during a building renovation, outdoor sources such as motor vehicle exhaust from parking garages and loading docks, and from underground sources such as trichloroethylene from contaminated underground soil and water. A contaminant source inspection of the building ventilation system should include a description of any sources of contaminants which may be entrained into the outside air inlet (e.g. sewer vents or fume hood exhausts) and any standing water or visible micro biological contaminants (e.g. slime or mold) in the cooling coil condensate drip pan. Also the cooling coil drain should be checked to see if it is properly trapped. In addition the prior use of the building should be investigated to determine if there is any potential of exposure to contaminants associated with the previous use.

Ventilation System Inspection. The operation of the building ventilation system is an important variable determining the concentrations of all indoor air contaminants. Thus it is important that the operation of the building ventilation system be thoroughly understood. Air contaminant measurements made in a building without consideration for the amount of outside air being delivered into the building during the time of the contaminant measurements are prone to false negatives and preclude a diagnosis of the cause of elevated concentrations and development of an effective mitigation plan. The indoor concentration of contaminants with indoor sources is inversely proportional to the outside air exchange rate.

Since the outside air exchange rate in buildings with economizer controls may vary from as little as 5% during hot or cold weather to 100% during mild weather conditions the indoor concentration contaminants may be expected to vary by as much as a factor of twenty.

Contaminant Measurements. Sampling and analytical protocols should be selected to provide the necessary analytical sensitivity. The EPA published in 1990 a "Compendium of Methods for the Determination of Air Pollutants in Indoor Air" which describes methods for measuring building air exchange rates and nine different classes of pollutants at concentrations commonly encountered in indoor air. ASTM Committee D-22 on Sampling and Analysis of Atmospheres has also published a number of recommended sampling and analytical methods specifically for indoor air.

Data Interpretation. During this step the sick building investigator considers results of the investigation in context with applicable ventilation and contaminant standards. The ventilation standard in the United States which defines the minimum standard of care is ASHRAE Standard 62-1989 "Ventilation for Acceptable Indoor Air Quality". This standard prescribes minimum supply rates of outside air on a cubic feet per minute (cfm) basis per occupant or square foot of building space depending upon the type of space. The standard currently recommends a minimum of 20 cfm/occupant for office spaces. ASHRAE 62-1989 also contains a number of tables summarizing United States, Canadian, European and Japanese standards for indoor air contaminants in residences, offices and other non-industrial environments. There is also a European document, "Ventilation Requirements in Buildings" which contains a number of contaminant exposure guidelines.

Our comprehensive set of indoor air contaminant and ventilation rate measurements were collected on October 20, 1993. We collected additional ventilation rate data on October 21, 1993.

On October 22, 1993 we collected data on the concentrations of volatile organic compounds upstream and downstream of the charcoal filters installed into air handler SF-5. At this time we also collected a set of screening measurements (e.g. $\pm 35\%$ uncertainty) for diisocyanates from each of the four main study locations as well as at the outside air inlets of both SF-5 and SF-10 air handlers.

Finally, on each of four consecutive days between November 2, 1993 and November 5, 1993 we returned to the building and collected air samples to determine more accurately the

concentrations of hexamethylene diisocyanates, which had been identified, during the previous screening measurements, as being present in the building air. We collected samples at each of the four indoor locations, and at the outside air inlets of both SF-5 and SF-10 air handlers. We also collected samples upstream and downstream of the charcoal filters installed into air handler SF-5, in the rear loading dock area, and at each of three additional indoor locations (i.e. Room 130L-Daycare, Room 300, and Room 411). The protocol decided upon and followed was to use these measurements to analyze the concentration of hexamethylene diisocyanates in the air at the outside air inlets of both SF-5 and SF-10 and based upon these analyses, determine the concentrations in the complete sample set for the day with highest outdoor concentration. The purpose of this analysis scheme was to minimize the substantial analytical costs associated with this compound.

BUILDING AND HVAC DESCRIPTION

The following is a description of the Mission Center Building and the various ventilation systems.

Building Description. The UCSF Mission Center Building is located at 1855 Folsom Street between 14th and 15th Streets in San Francisco's Mission district. The building is a six story structure constructed in 1927 as a warehouse building. In 1976, the building was acquired from the Owens Illinois Glass Company by Far West Laboratories for office use in educational development. In 1977, UCSF acquired a 49% interest in the building comprising the second, third, and fourth floors of the building. In 1989, UCSF acquired the remaining interest in the building and renamed it the Mission Center Building. Currently UCSF occupies approximately 82% of the building primarily for use as administrative office space with some research laboratories on the second floor. Approximately 9% of the building is leased to outside tenants and 9% remains vacant.

Ventilation system Description. MCB is heated with fin tube hot water radiators along the perimeter of each floor. Cooling, ventilation air, and additional heating are provided eight separate ventilation systems each with their own temperature controls. The energy plant which serves each of these systems is located in the northwest mechanical room on the fourth floor. The systems serving the four study locations are SF-5 and SF-10. The following is a brief description of both of these systems.

SF-5 provides air conditioning for the northwest portions of the first, fourth, fifth, and sixth floors and is located in the northwest mechanical room on the fourth floor. Supply air for the building is distributed via high velocity, oval shaped, steel ducts to variable air volume (VAV) boxes. The majority of the VAV boxes on first, fourth, fifth, and sixth floors are induction type VAV boxes. With this type of VAV box, as the cooling requirements are reduced in a space, the thermostat causes an actuator on the box to throttle the conditioned air from the supply fan into a high velocity jet while at the same time opening up an induction air damper. The net effect is that a relatively constant supply air flow rate is delivered to the ceiling diffusers (if controls are properly adjusted) while allowing for variable amounts of primary cooling air. At Site 4 on the sixth floor the VAV boxes are non-induction type boxes which only throttle the supply of primary cooling air in response to changes in the space cooling requirements. SF-5 also utilizes controls which vary the amount of outside air entering the primary supply air of the air handler according to the outside air temperature and building cooling needs. Return air is collected by the return/exhaust fan via oval shaped steel ductwork and depending upon the configuration of the controls is either recirculated to the building or exhausted to the outdoors. The system is equipped with cooling coils at the main air handler and with hot water re-heat coils at the induction VAV boxes installed on the sixth floor. Air filtration is provided by a combination of low efficiency pre-filters followed by high efficiency bag filters followed by low efficiency activated charcoal filters. The amount of outside air being delivered to the individual offices depends on the percentage of outside air in the supply air stream (which is adjusted at the air handler) and the amount of supply air being delivered to the area (which is controlled by the VAV boxes and room thermostats).

SF-10 is located in the southeast mechanical room on the fourth floor and is similar to system SF-5 except that the system serves the southeast portion of the first, fourth, fifth, and sixth floors.

Both of these ventilation systems are controlled largely in a manual mode. The ventilation systems are turned on at 6 AM and off at 7 PM. The building is manually configured into a morning warm up mode with outside air dampers in their minimum open position. When the chillers are needed to provide cooling to the building they are manually turned on by the building engineer. There is no purge cycle (e.g. 100% outside air) for clearing out air contaminants which may have built up during the night time when the ventilation systems are not operating.

MEASUREMENT METHODS

The following is a detailed description of the individual analyses made during our investigation of the UCSF Mission Center Building.

HVAC Measurements

We inspected the two ventilation systems serving the four study areas, SF-5 and SF-10, and measured the air circulation rates and outside air ventilation rates. At each study location we measured the delivery of supply air from each diffuser in using a calibrated airflow hood and thermal anemometer. Since these ventilation systems are both variable air volume systems and the supply air flow rate is determined by the building load we measured the supply air flow rates at the "as is" flow rates encountered during our investigation, as well as, at the minimum and maximum supply air flow rates. The minimum and maximum supply air flow rates were measured by setting the room thermostat to full heating (85 °F) and full cooling (55 °F) respectively.

The measured flowrates of supply air are used to calculate the following parameters that describe the performance of the ventilation system; the air circulation rate (cfm/ft²), the outside air flowrate per person and the outside air changes per hour.

To determine the outside air percentage in the supply air we used a sulfur hexafluoride tracer gas technique. Sulfur hexafluoride, is a colorless, odorless, non-reactive, harmless gas that is normally not present in outside air, thereby making it an excellent tracer for building ventilation studies. We injected tracer gas into the supply air of the building in the parts per billion range. We used a gas chromatograph equipped with a sensitive electron capture detector to measure the tracer gas concentrations. The accuracy of this measurement technique is approximately 5% outside air in the supply air. By making measurements of the concentration of tracer gas in the supply, return and outside air, we are able determine the actual outside air percentage in the supply air. We made outside air percentage measurements when the outside air dampers were in both their maximum and minimum settings.

We also used checked the set-points for the temperature sensors which control the opening and closing of the outside air dampers by immersing the sensors in a water bath while

adjusting the bath temperature and observing the action of the outside air and return air dampers.

Since the induction VAV boxes located at Sites 1, 2, and 3 are designed to mix room air with the primary supply air from the air handlers we conducted a second set of tracer gas samples simultaneously from the air entering and leaving each box. The percentage of outside air in the supply air being delivered to the office space was then calculated as the product of the percentage of outside air in the primary supply air of the air handler and the percentage of primary supply air in the supply air being delivered from the induction VAV boxes.

Building Occupancy

To determine the minimum delivery of outside air and supply air per occupant, we were required to know what were the maximum occupancy of the individual areas. To do this we counted the total number of work stations in each study area.

Building Area and Volume

Area and volume measurements were measured on site.

Air Contaminant Measurements

Carbon Dioxide. We measured the concentration of carbon dioxide using a real time portable non-dispersive infra-red (NDIR) analyzer (EPA Method IP-3A). The instrument , a Fugio CO₂ monitor # ZFP5YA21, was calibrated once before and once after each set of measurements using certified calibration gases.

Carbon monoxide. We measured the concentration of carbon monoxide using a real time portable electrochemical analyzer (EPA Method IP-3C). The instrument, a Drager 190 Detector, was calibrated once before and once after each set of measurements using certified calibration gases.

Volatile Organic Compounds. We determined the concentrations of total and individual volatile organic compounds (VOCs) by sampling a known amount of air over a pair of solid phase multi-sorbent samplers. One sample was thermally desorbed into a gas

chromatograph with a mass spectrometer (GC/MS) according to EPA Method IP-1B for individual VOCs. The second sample was thermally desorbed into a gas chromatograph with a flame ionization detector for total VOCs (TVOC).

Formaldehyde. We measured the concentration of formaldehyde using solid sorbent cartridge samplers impregnated with dinitrophenylhydrazine (DNPH) according to EPA Method IP-6A. The samplers were extracted and analyzed using high performance gas chromatography (HPLC).

Microbiological Contaminants. We measured the concentration of airborne viable microbiological contaminants using an inertial impactor loaded with the appropriate agar media for fungi and bacteria. Concentrations are reported as colony forming units per cubic meter of air for both fungi and bacteria.

Total Suspended Particles. We measured the concentration of total suspended particles using 37 mm high efficiency PVC filters which were analyzed gravimetrically using an electronic microbalance.

Silica. We determined the concentration of silica dust using a 37 mm high efficiency PVC filters which were analyzed using X-ray diffraction according to NIOSH Method 7500.

Total Suspended Fibers. We measured the concentration of total suspended fibers using 25 mm high efficiency MCE filters which were analyzed using a phase contrast microscope according to NIOSH Method 7400.

Airborne Metals. We measured the concentration of airborne metals using 25 mm high efficiency MCE filters which were analyzed using ICP atomic emission spectroscopy according to NIOSH Method 7300.

Diisocyanates. We initially conducted a set of screening measurements for hexamethylene diisocyanates (HDI), toluene-2,4-diisocyanate (TDI), and methylene biphenyl isocyanate (MDI) using a colorimetric technique. Subsequently we measured the concentration of HDI using specially coated 37 mm high efficiency glass fiber filters which were analyzed using HPLC UV spectroscopy according to OSHA Method 42. In addition to measuring the concentrations at the four study sites and the outside air inlets of SF-5 and SF-10, we also measured the concentrations at two more office locations, the child care center on the first

floor, a location in the shipping dock area, and upstream and downstream of the charcoal filters of SF-5. We collected samples for four consecutive days at each location over a 6-8 hour period. We also collected and analyzed samples from the air in the alley way between the auto body shop and the Mission Center Building on two occasions, November 11 and 12, 1993.

Temperature and Humidity. Using a Solomat MPM 500e Multifunctional Environmental Instrument we measured temperature with a fast response platinum resistance thermistor and humidity with a thin film capacitive humidity sensor. Sensors were calibrated before and after to NBS traceable standards.

RESULTS

Contaminant Source Inspection

The indoor sources we identified during our investigation include the usual sources associated with office spaces; people, paper products, printing equipment, and office furnishings. Laser printers and fax machines are located in office locations throughout the building. Site 1, Room 116, had a liquid toner copy machine. This type of copy machine uses a liquid toner which is known to produce a substantial amount of volatile organic compounds as part of the copying process. Other copy machines which use dry toner cartridges are also known to generate volatile organic compound but at a much lower rate. Site 4, Room 630 is the Publications Department and contains a number of solvent based adhesives used to prepare manuscripts.

Pollutant sources in the outside air of the Mission Center Building include, most notably, the auto body shop next door across the alley on the north side of the building. Which, according to UCSF Environmental Health and Safety staff, uses polyurethane based paints containing diisocyanates.

The building HVAC system was inspected for cleanliness and was found to be acceptable as, the filters were not loaded during our investigation.

We note that the odor of paint fumes from the adjacent auto body shop was apparent in the outside air in the alley separating the body shop from the Mission Center building as well as in the outside air inlets of both SF-5 and SF-10. The odor of paint fumes could also be

detected at times in the office air and coming from the ventilation system supply air diffusers.

We also note that during our measurements on October 20-22, 1993 there was a roofing operation going on in the neighborhood and the fumes from the roofing operation were apparent at times in the outside air inlets of the building ventilation system and at indoor locations. This source of odors and contaminants is expected to be a short term source which will dissipate upon completion of the roofing operation.

At the air handlers we detected the odor of both paint and roofing fumes upstream and downstream of the charcoal filters.

HVAC Inspection

Supply Air Delivery Rates. We measured the total delivery of supply air to each of the four indoor measurement locations. The following is a summary of the supply air flow rate measurements we made at each of the VAV boxes serving the four measurement sites. We conducted measurements under the "as is" flow rates encountered during our inspection and under full heating and full cooling conditions.

Site 1. Induction VAV Box Serving South Two Diffusers

Controls:	Inoperable
As Is Condition:	Induction damper open 2 inches (100%)
	Supply air flow rates: 250 cfm east diffuser, 250 cfm west diffuser

Site 1. Induction VAV Box Serving North Three Diffusers

Controls:	Inoperable
As Is Condition:	Induction damper open 2 inches (100%)
	Supply air flow rates: 210 cfm east diffuser, 195 cfm center diffuser, 230 cfm west diffuser

Site 2. Induction VAV Box Serving East Two Diffusers

Controls: Inoperable
As Is Condition: Induction damper open 1/2 inches (25%)
Supply air flow rates: 330 cfm west diffuser, 340 cfm east diffuser

Site 2. Induction VAV Box Serving West Two Diffusers

Controls: Operational
As Is Condition: Induction damper open 0 inches (0%)
Supply air flow rates: 310 cfm west diffuser, 290 cfm east diffuser
Full Heating Condition: Induction damper open 1/2 inches (25%)
Supply air flow rates: 300 cfm west diffuser, 280 cfm east diffuser
Full Cooling Condition: Induction damper open 0 inches (25%)
Supply air flow rates: 310 cfm west diffuser, 290 cfm east diffuser

Site 3. Induction VAV Box Serving West Diffuser

Controls: Operational
As Is Condition: Induction damper open 0 inches (0%)
Supply air flow rates: 550 cfm west diffuser,
Full Heating Condition: Induction damper open 2 inches (100%)
Supply air flow rates: 685 cfm west diffuser
Full Cooling Condition: Induction damper open 0 inches (100%)
Supply air flow rates: 550 cfm west diffuser

Site 3. Induction VAV Box Serving East Diffuser

Controls: Inoperable
As Is Condition: Induction damper open 1/8 inches (6%)
Supply air flow rates: 730 cfm east diffuser,

Site 4. Non-Induction VAV Box Serving West Two Diffusers

Controls: Operable
As Is Condition: No induction damper
Supply air flow rate: 220 cfm north diffuser, 220 cfm south diffuser
Full Heating Condition: No induction damper
Supply air flow rates: 0 cfm north diffuser, 0 cfm south diffuser
Full Cooling Condition: No induction damper
Supply air flow rate: 220 cfm north diffuser, 220 cfm south diffuser

Site 4. Non-Induction VAV Box Serving North East Four Diffusers

Controls: Operable
As Is Condition: No induction damper
Supply air flow rates (west to east, cfm): 340, 380, 430, 400
Full Heating Condition: No induction damper
Supply air flow rates (west to east, cfm): 0, 0, 0, 0
Full Cooling Condition: No induction damper
Supply air flow rates (west to east, cfm): 340, 380, 430, 400

Site 4. Non-Induction VAV Box Serving South East Three Diffusers

Controls: Inoperable
As Is Condition: No induction damper
Supply air flow rates (west to east, cfm): 0, 0, 0

Air Circulation Rates. The results of our measurements of air circulation rates are summarized for each of the four measurement locations in Table 1. The total quantity of air per square foot being supplied to the four office areas ranged from no measurable supply air flow rate at Site 4 under full heating conditions to 2.3 cfm/ft² at Site 3 also under full heating conditions. We note that the thermostats did not change the damper positions at five of the nine VAV boxes inspected when we adjusted the temperature set point from 55 °F to 85 °F. These inoperable VAV boxes include both the VAV boxes serving Site 1, one of the two VAV boxes serving Site 2, one of the two VAV boxes serving Site 3, and one of the three VAV boxes serving Site 4.

For office spaces Indoor Environmental Engineering recommends a supply air (outside air + recirculated air) circulation rate between 0.5 cfm/ft² and 1.5 cfm/ft². Air circulation rates less than 0.5 cfm/ft² are subject to air mixing problems (e.g. stagnant air zones) and air circulation rates greater than 1.5 cfm/ft² are subject to draft problems. There are no OSHA guidelines for supply air circulation rates.

At Site 1 the air circulation rates remained constant at 1.6 cfm/ft² with no change in the VAV box damper controllers in response to adjustments to the room thermostat. At Site 2 the air circulation rates also remained constant at 1.1 cfm/ft². At Site 3 the air circulation rates ranged from 2.0 cfm/ft² in the "as is" VAV box supply air flow rate condition to 2.3 cfm/ft² under full heating conditions. The air circulation rates at Sites 1 and 3 exceed the maximum recommended rates and are prone to causing draft. We note in areas with high thermal loads, such as at Site 3 where there is a high density of computers draft from the very high air circulation rate may be avoided through proper selection, positioning, and adjustment of air diffusers, return air inlets and air temperatures.

At Site 4 the air circulation rate falls below recommended minimum guidelines when the thermostat is calling for full heat. This space has conventional VAV boxes with no induction air. Apparently there is no minimum stop on these VAV boxes to prevent them from reducing the air flow rate below recommended minimum air circulation rate guidelines under heating conditions.

Thus, the air circulation rates do not meet the recommended air circulation rate guidelines at three of the four office spaces inspected under one or more operating conditions.

Outside Air Percentage Measurements. In order to determine the amount of outside air being delivered to the building we measured the percent outside air contained in the supply air of each system using a tracer gas technique, with the outside air dampers in both maximum and minimum outside air percentage positions. We determined that the outside air percentages in system SF-5 ranged from 31% at the minimum setting to 82% at the maximum setting. We determined that the outside air percentages in system SF-10 ranged from 7.5% at the minimum setting to 77% at the maximum setting.

The controls for the outside air percentages of both SF-5 and SF-10 are not outside air economizer control packages. An outside air economizer control package can vary the percentage of outside air according to the outside air temperature and the heating/cooling

needs of the building. The controls are designed to provide "free cooling" when the outside air temperature is less than indoors and the building requires cooling. Typically the controls are set up to provide a maximum amount of outside air when the outside air temperature is between 55 °F and 75 °F. Above 75 °F the controls reduce the percent outside air to a minimum percentage and as temperatures fall below 55 °F the controls reduce the outside air percentage to maintain a desired discharge air temperature (i.e. typically 55 °F).

The controls for the outside air percentage of both SF-5 and SF-10 are designed to run at the maximum outside air percentage except under morning warm up conditions and during cold weather periods. Oddly the controls are not set up to close the outside air dampers to their minimum position when outdoor temperatures exceed indoor temperatures. To check the operation of the sensors and controls we immersed the sensors into a temperature bath and varied the temperature from 90 °F to 35 °F. We observed that the outside air dampers remained in their maximum outside air percentage position at 90 °F and did not move to their minimum outside air percentage until temperatures were reduced to between 45 °F to 47 °F for SF-5 and to between 38 °F to 40 °F for SF-10. According to the building engineer, on December 17, 1993 the outdoor temperature was 43 °F and most of the HVAC systems had been either automatically or manually put into their minimum outside air percentage damper position to keep the building warm.

To determine the percent of primary supply air being delivered by the induction VAV boxes serving Sites 1, 2, and 3 we also used a tracer gas technique. The following is a summary of the supply air flow rate measurements we made at each of the VAV boxes serving the four measurement sites. We conducted measurements under the "as is" flow rates we encountered during our inspection and under full heating and full cooling conditions.

Site 1. Induction VAV Box Serving South Two Diffusers

Controls:	Inoperable
As Is Condition:	Induction damper open 2 inches (100%)
	Percent primary supply air: 62%

Site 1. Induction VAV Box Serving North Three Diffusers

Controls:	Inoperable
As Is Condition:	Induction damper open 2 inches (100%)
	Percent primary supply air: 62%

Site 2. Induction VAV Box Serving East Two Diffusers

Controls: Inoperable
As Is Condition: Induction damper open 1/2 inches (25%)
Percent primary supply air: 61%

Site 2. Induction VAV Box Serving West Two Diffusers

Controls: Operational
As Is Condition: Induction damper open 0 inches (0%)
Percent primary supply air: 51%
Full Heating Condition: Induction damper open 1/2 inches (25%)
Percent primary supply air: 81%
Full Cooling Condition: Induction damper open 0 inches (0%)
Percent primary supply air: 51%

Site 3. Induction VAV Box Serving West Diffuser

Controls: Operational
As Is Condition: Induction damper open 0 inches (0%)
Percent primary supply air: 46%
Full Heating Condition: Induction damper open 2 inches (100%)
Percent primary supply air: 50%
Full Cooling Condition: Induction damper open 0 inches (100%)
Percent primary supply air: 46%

Site 3. Induction VAV Box Serving East Diffuser

Controls: Inoperable
As Is Condition: Induction damper open 1/8 inches (6%)
Percent primary supply air: 38%

Site 4. Non-Induction VAV Box Serving West Two Diffusers

Controls: Operable
As Is Condition: No induction damper
Percent primary supply air: 100%
Full Heating Condition: No induction damper
Percent primary supply air: 100%
Full Cooling Condition: No induction damper
Percent primary supply air: 100%

Site 4. Non-Induction VAV Box Serving North East Four Diffusers

Controls: Operable
As Is Condition: No induction damper
Percent primary supply air: 100%
Full Heating Condition: No induction damper
Percent primary supply air: 100%
Full Cooling Condition: No induction damper
Percent primary supply air: 100%

Site 4. Non-Induction VAV Box Serving South East Three Diffusers

Controls: Inoperable
As Is Condition: No induction damper
Percent primary supply air: 100%

We calculated the overall percentage of outside air in the supply air being delivered to each office space as the product of the percentage of outside air in the primary supply air of the air handler and the percentage of primary supply air in the supply air being delivered from the induction VAV boxes.

Outside Air Ventilation Rates. We calculated the amount of outside air being delivered to each space as the product of the calculated percentage of outside air in the supply air being delivered to the space and the measured flow rate of supply air. The results of our measurements are summarized in Table 1. We calculated the outside air ventilation rates per person based upon the reported maximum occupants for that space. We calculated rates for both the full heating and the "as is" supply air flow rates encountered during our investigation, and for minimum and maximum outside air percentages in the primary supply air.

The outside air flow rates ranged from a minimum of 0 cfm/occupant at Site 4 under full heating conditions to 136 cfm/occupant at Site 4 under the "as is" supply air flow rate conditions with a maximum outside air percentage in the primary supply air.

The minimum outside ventilation rate recommended by the American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE Standard 62-1989, "Ventilation for Acceptable Indoor Air Quality", see Appendix B) for office spaces is 20 cubic feet per minute (cfm) of outside air per occupant. Under Section 5142, "Minimum Building

Ventilation Rates," of the California Occupational Safety and Health Administration's (CAL-OSHA, see Appendix B) General Industry Safety Orders, all buildings must be operated to "provide at least the quantity of outside air required by the State Building Standards Code" in effect at the time the building permit was issued.

With respect to the ASHRAE minimum recommended outside air flow rates of 20 cfm/person, the ventilation systems do not meet the recommended minimum rates in three of the four measurement areas under one or more operating conditions.

At Sites 1 and 3 the outside air ventilation rates per person fall below the recommended minimum guidelines for both the "as is" and full heating VAV box air flow rate conditions when the main air handler is operating with a minimum percentage of outside air. The low 7.5% minimum outside air percentage in SF-10 appears to be too low to meet the requirements for these areas. At Site 4 the outside air ventilation rate per person falls below the recommended minimum guidelines for the full heating VAV box air flow rate condition with either minimum or maximum percentages of outside air. The minimum supply air flow rate of the VAV box serving this location reduces the supply air flow rate to zero under full heating conditions.

We also calculated the minimum outside air exchange rate in air changes per hour (ach) for each space based upon the measured supply air flow rates and outside air percentages. The outside air exchange rates ranged from a minimum of 0 ach at Site 4 under full heating conditions to 4.2 ach at Site 3 under the full heating supply air flow rate conditions and maximum outside air percentage in the primary supply air.

The requirement of outside air on a per person basis is to control people related pollution (e.g. bio-effluents, odors, bacteria etc.). A minimum of one air change per hour is recommended to control indoor contaminants coming from sources other than people such as building materials and equipment. The California Energy Commission Title 24 energy code recommends a minimum of 0.15 cfm/ft² of outside air to control contaminants generated from building materials and furnishings. Assuming a 10 foot ceiling height this translates into 0.9 air changes per hour of outside air. Again, we recommend a minimum of 1.0 air changes per hour of outside air to control contaminants released from non-occupant related sources.

Thus, the minimum outside air exchange rates do not meet the recommended minimum guideline of 1.0 ach in three of the four measurement areas under one or more operating conditions.

At Sites 1 and 3 the outside air exchange rates fall below the recommended minimum guidelines for both the "as is" and full heating VAV box air flow rate conditions when the main air handler is operating with a minimum percentage of outside air. The low 7.5% minimum outside air percentage appears to be too low for Sites 1 and 3. At Site 4 the outside air exchange rate falls below the recommended minimum guidelines for the full heating VAV box air flow rate condition under either minimum or maximum outside air percentage conditions. The minimum supply air flow rate of the VAV box serving this location reduces the supply air flow rate to zero under full heating conditions.

Thus three out of the four areas inspected do not meet the recommended minimum outside air ventilation rate guidelines on either an outside air per person basis or an outside air exchange rate basis under one or more conditions.

We note that minimum outside air ventilation rates we calculated for the outside air economizer dampers in their minimum position occurs during morning warm up periods and during cold weather periods. In temperate climates like San Francisco the ventilation system operates on high percentages of outside air for many of the days of the year, but there is a significant number of days where the economizers would close to their minimum settings and these minimum outside air guidelines would not be met. For system SF-5, which goes into a minimum outside air percentage when the outdoor air temperature drops below 45 °F to 47 °F, this corresponds to approximately 56 hours per year. For system SF-10 which goes into a minimum outside air percentage when the outdoor air temperature drops below 38 °F to 40 °F this corresponds to approximately 10 hours per year. In addition to these hours there are the hours associated with morning warm up when the outside air temperature is warmer than the above set points but the building requires heat. According to the building engineers, the building holds heat well and the morning warm up period with the outside air dampers closed to their minimum position typically lasts for no more than 15 minutes. Of course on cold days, the position of the outside air damper remains in it's minimum position the entire day.

Air Contaminant Measurements

We conducted a comprehensive set of indoor air contaminants known to cause occupant discomfort at each of the four measurement locations.

We measured the indoor and outdoor concentrations of total volatile organic compounds, individual organic compounds, formaldehyde, total suspended particles, total suspended fibers, silica dust, total airborne fibers, airborne metals, total airborne viable fungi and bacteria, carbon dioxide, carbon monoxide, temperature, and humidity between 10:00 AM and 5:00 PM on October 20, 1993. On October 22, 1993 we measured the concentration of diisocyanates between 10:00 AM and 5:00 PM using a colormetric screening technique (e.g. $\pm 35\%$ uncertainty). On November 2-5, 1993 we returned and measured the concentrations of hexamethylene diisocyanates (HDI) which were identified as being present in the indoor air by the screening technique employed during the October 22, 1993 measurements.

We measured the concentrations of indoor air contaminants at breathing height of each of the four indoor measurement sites. We also simultaneously measured the contaminant concentrations in the outside air at the outside air inlets of air handlers SF-5 and SF-10. The locations of our sampling sites are depicted in Figures 1-5. The contaminant concentrations at each measurement location are summarized in Table 2. During our air contaminant measurements the ventilation systems were operating at their maximum percentage of outside air.

The following is a discussion of the results of these measurements:

Total Volatile Organic Compounds. The indoor concentrations of total volatile organic compounds in the office areas ranged from $308 \mu\text{g}/\text{m}^3$ at Site 4 to $1502 \mu\text{g}/\text{m}^3$ at Site 1. The outdoor concentration of total volatile organic compounds was measured to be $338 \mu\text{g}/\text{m}^3$ at the outside air inlet of SF-5 and $425 \mu\text{g}/\text{m}^3$ at the outside air inlet of SF-10.

The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for the volatile organic compounds typically found in building materials range from $375,000 \mu\text{g}/\text{m}^3$ to $1,050,000 \mu\text{g}/\text{m}^3$. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for non industrial spaces is $1000 \mu\text{g}/\text{m}^3$ for total volatile organic

compounds. This guideline was established by IEE to minimize eye, nose, and throat irritation in environments with sensitive occupants.

Thus the indoor concentrations of total volatile organic compounds measured in each of the four office locations were below the recommended irritation and OSHA guidelines except at Site 1 where the indoor concentrations were below OSHA guidelines but were above the irritant guideline of $1000 \mu\text{g}/\text{m}^3$. We note that the concentrations of total volatile organic compounds were significantly elevated in the outdoor air entering both SF-5 and SF-10 outside air inlets. Typically outdoor air concentrations in urban environments range between 100 and $200 \mu\text{g}/\text{m}^3$. Thus the concentration of $338 \mu\text{g}/\text{m}^3$ measured at the outside air inlet for SF-5 and the concentration of $425 \mu\text{g}/\text{m}^3$ measured at the outside air inlet for SF-10 are significantly elevated over those concentrations typically encountered in an urban environment with no strong nearby outdoor sources. The auto body paint shop is the most likely source of these elevated outdoor concentrations.

Formaldehyde. The indoor concentrations of formaldehyde in the office areas ranged from $12 \mu\text{g}/\text{m}^3$ at Site 4 to $16 \mu\text{g}/\text{m}^3$ at Site 1. Outdoor concentrations at both the SF-5 and SF-10 outside air inlet were $8 \mu\text{g}/\text{m}^3$.

The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for formaldehyde is $920 \mu\text{g}/\text{m}^3$. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces is $60 \mu\text{g}/\text{m}^3$ for formaldehyde. This guideline was established by IEE to minimize eye, nose, and throat irritation in environments with sensitive occupants. The California Air Resources Board also recommends a formaldehyde guideline $60 \mu\text{g}/\text{m}^3$ for residences.

Thus the indoor concentrations of formaldehyde measured in each of the four office locations were below the recommended irritation and OSHA guidelines. We note that the concentrations of formaldehyde were significantly elevated in the outdoor air entering both SF-5 and SF-10 outside air inlets. Typically outdoor air concentrations in urban environments range between 1 and $5 \mu\text{g}/\text{m}^3$. Thus the concentration of $8 \mu\text{g}/\text{m}^3$ measured at the outside air inlet for SF-5 and SF-10 are significantly elevated over those concentrations typically encountered in an urban environment with no strong nearby outdoor sources. The auto body paint shop may be a potential source of these elevated outdoor concentrations.

Total Suspended Particles. The indoor concentrations of total suspended particles ranged from 2 $\mu\text{g}/\text{m}^3$ at Site 3 to 12 $\mu\text{g}/\text{m}^3$ at Site 1. The concentration of total suspended particulate matter measured in the outside air inlet of SF-5 was 42 $\mu\text{g}/\text{m}^3$ and in the outside air inlet of SF-10 was 19 $\mu\text{g}/\text{m}^3$.

The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for nuisance dust is 10,000 $\mu\text{g}/\text{m}^3$. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces is 50 $\mu\text{g}/\text{m}^3$. This is also the Federal EPA NAAQS Standard for inhalable suspended particles (i.e. PM_{10} standard). We note that we sampled for total suspended particles and not for inhalable (i.e. PM_{10}) or respirable (i.e. $\text{PM}_{2.5}$). Since the majority of particles are of inhalable size in indoor environments, we believe our use of a total suspended particle data together with exposure criteria for inhalable size particles is appropriate and provides a conservative analysis of the indoor exposure to particulate matter.

Thus, the indoor concentration of total suspended particles measured in each of the four office locations were below recommended guidelines.

Silica Dust. The indoor concentrations of airborne silica dust were below our detection limit of 2 $\mu\text{g}/\text{m}^3$ at each of the four indoor measurement sites. The concentration of airborne silica dust measured in the outside air inlets of SF-5 and SF-10 were also below our detection limit of 2 $\mu\text{g}/\text{m}^3$.

The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for nuisance dust is 100 $\mu\text{g}/\text{m}^3$. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces as recommended by ASHRAE 62-1989 is 1/10th of the ACGIH TLV occupational health guideline of 100 $\mu\text{g}/\text{m}^3$ or 10 $\mu\text{g}/\text{m}^3$.

Since the majority of particles are of inhalable size in indoor environments, we believe our use of a total suspended silica dust together with exposure criteria for inhalable size silica dust is appropriate and provides a conservative analysis of the indoor exposure to silica dust.

Thus, the indoor concentration of total suspended particles measured in each of the four office locations were below recommended guidelines.

Total Airborne Fibers. The indoor concentrations of total airborne fibers ranged from 0.002 fibers/cc at Site 3 to 0.004 fibers/cc at Sites 2 and 4. Indoor airborne fibers typically include those generated by carpets, fabrics, and paper based materials. The concentration of total airborne fibers measured in the outside air inlets of both SF-5 and SF-10 was 0.001 fibers/cc.

There are no occupational health guidelines for exposure to total suspended fibers. The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for asbestos range from 0.2 to 2.0 fibers/cc. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces is 0.010 fibers/cc. This is also the EPA recommended clearance criteria for asbestos abatement projects in non-industrial buildings.

Thus, the indoor concentration of total suspended fibers measured in each of the four office locations were below recommended guidelines.

Carbon Dioxide. The concentrations of CO₂ measured at each measurement site ranged from 475 ppm at Sites 1 and 3 to 530 ppm at Site 4. The outdoor concentrations was between 400 and 450 ppm.

The recommended maximum indoor concentration is 1000 ppm (ASHRAE 62-1989). This guideline was established to prevent odor and comfort problems resulting from people generated contaminants in occupied spaces. Measurement of indoor carbon dioxide provides an indication of the people pollution that is present in a space. People produce carbon dioxide through respiration and the only way carbon dioxide is removed from the building is by ventilation with outside air. The concentration of carbon dioxide is always higher indoors than outdoors in an occupied building with the difference being proportional to the number of people in the building and the amount of outside air entering the building. The low indoor concentrations of carbon dioxide are consistent with the low occupancy and high percentage of outside air in the ventilation system during our measurements.

Thus the indoor concentrations of CO₂ measured in each of the four office locations were below recommended comfort guidelines.

Carbon Monoxide. The indoor concentrations of CO we observed in the office locations and in the outside air were all below our 2 ppm detection limit. The concentration typically found in outside air in urban areas may range from 1 ppm to 5 ppm. The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for CO is 35 parts per million (ppm) for an eight hour exposure. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces is 9 ppm (ASHRAE 62-1989). This guideline was established for protection of sensitive occupants in enclosed spaces. This is also the Federal EPA NAAQS Standard for carbon monoxide.

Thus the indoor concentrations of CO measured in each of the four office locations were below recommended guidelines.

Temperature and Humidity. The indoor air temperatures were between 73 °F and 75 °F at Site 1, 75 °F and 76 °F at Sites 2 and 3, and 74 °F and 76 °F at Site 4. The indoor relative humidity was between 48% and 54% at Site 1, 45% and 50% at Site 2, 43% and 53% at Site 3, and 45% and 57% at Site 4. The recommended air temperature and relative humidity comfort range for office buildings is 70 °F - 75 °F and 30% - 60% RH (ASHRAE Standard 55-1993). The outside temperature was between 71°F -76 °F and the relative humidity was between 40% to 57%.

Thus the relative humidities were within the recommended comfort guidelines at each of the four office sites, however, the indoor air temperatures were near the upper end of the comfort range at Site 1 and exceeded the maximum recommended temperature of 75 °F at Sites 2, 3, and 4.

Additional Contaminant Sampling

In addition to the comprehensive contaminant sampling conducted at each of the four study sites we measured the concentrations individual volatile organic compounds, diisocyanates, airborne metals and airborne viable microbiological contaminants at each of the four study sites and at the outside air inlets of SF-5 and SF-10. We also measured the concentrations of individual volatile organic compounds upstream and downstream of the charcoal filter to

evaluate the effectiveness with which the charcoal filter is removing organic contaminants from the ventilation system supply air. Finally we collected samples of surface dust from workstations at each of the four study sites and analyzed them for fibers and metals. The following summarizes the results of these measurements.

Individual Volatile Organic Compounds. The purpose of these analyses was to determine what the concentrations of the individual organic compounds were in the building and at the outside air inlet. Eleven of the most abundant compounds have been quantitated and are summarized in Table 3. The complete chromatograms of each of our analyses are included in Figures 6 through 11.

The concentrations of the eleven compounds we quantitated in Table 3 ranged from 0.5 $\mu\text{g}/\text{m}^3$ for naphthalene at Sites 2 and 3 to 52 $\mu\text{g}/\text{m}^3$ for acetone at Site 2.

The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for the volatile organic compounds measured ranged from 3200 $\mu\text{g}/\text{m}^3$ for benzene to 1,900,000 $\mu\text{g}/\text{m}^3$ for 1,1,1 trichloroethane. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces as recommended by ASHRAE 62-1989 is 1/10th of the occupational health guidelines.

Thus the indoor concentrations of individual VOCs measured in each of the four office locations were below recommended guidelines.

The elevated concentrations of total volatile organic compounds measured at Site 1 were dominated by a mixture of C₁₀-C₁₁ isoparaffinic hydrocarbons (Isopars) as can be seen clearly in the chromatogram for this site depicted in Figure 6. The composition of this mixture closely matches the composition of a commercially manufactured solvent with the tradename of Isopar G (Exxon Corp). Isopar G is primarily used as a solvent in the liquid dispersant of wet process copiers. As noted in our contaminant source inspection there is a liquid toner copy present in the office area. There are no specific guidelines for isoparaffinic hydrocarbons. The OSHA permissible exposure level for petroleum distillates is 1,600,000 $\mu\text{g}/\text{m}^3$.

We note that our analyses of these compounds indicates contamination of both the building ventilation air and indoor air from the paint fumes generated adjacent auto body shop.

According to a recent study (Journal of the American Industrial Hygiene Association, Vol. 54, November, 1993), the principle organic compounds in the breathing zone of workers spraying isocyanate containing polyurethane paints include toluene, ethyl acetate, butyl acetate and methyl isobutyl ketone. The lacquer odor associated with the paint fumes is attributable to toluene which is a very aromatic compound with an odor threshold of approximately $6000 \mu\text{g}/\text{m}^3$.

The concentrations of toluene in the outdoor air, while below recommended health and irritant guidelines, were significantly elevated. The most likely source of this compound in the outdoor air is the adjacent auto body shop. Typically outdoor concentrations of toluene are between $1 \mu\text{g}/\text{m}^3$ and $15 \mu\text{g}/\text{m}^3$. The concentrations of toluene in the outside air of the UCSF Mission Center Building ranged from $31 \mu\text{g}/\text{m}^3$ at the outside air inlet of SF-5 to $36 \mu\text{g}/\text{m}^3$ at the outside air inlet of SF-10. The indoor concentrations of toluene in the building were slightly less than these outdoor concentrations perhaps reflecting the removal being accomplished by the charcoal filters.

Butyl acetate, which is a compound more uniquely associated with auto body spray paint fumes, was significantly elevated at the SF-10 outside air inlet. The concentration at the SF-10 outside air inlet was $12 \mu\text{g}/\text{m}^3$ and typically the indoor and outdoor air concentrations of this compound are less than $1 \mu\text{g}/\text{m}^3$. The concentration at the SF-5 outside air inlet was lower, $2.1 \mu\text{g}/\text{m}^3$, despite being closer to the auto body shop. These results are consistent with the north-west wind direction observed during our measurements. As can be seen in Figure 3, a northwest wind direction will cause the paint fumes to disperse more in the direction of SF-10 than SF-5. The wind rose in Figure 3 indicates that in the San Francisco Bay area the predominant wind directions are: 21.5 % of the time from west north west, 18.7 % from the west, and 14.2 % of the time from the north west. Thus 54.4 % of the time the wind blows in a direction conducive to transporting the paint fumes generated by the adjacent auto body shop to locations where the building ventilation systems can pick up these fumes and transport them into the building.

Diisocyanates. We initially conducted a set of screening measurements for hexamethylene diisocyanates (HDI), toluene-2,4-diisocyanate (TDI), and methylene biphenyl isocyanate (MDI) using a colorimetric technique. The results of this screening indicated no detectable concentrations of TDI or MDI but did disclose a detectable concentration of HDI in the outside air inlets of SF-5 and SF-10 as well at locations in the building. Since this

technique is not designed to provide quantifiable concentrations we decided to conduct a series of measurements using a highly sensitive HPLC technique to quantify the indoor concentrations of HDI. We collected samples from each of the four indoor study sites, the outside air inlets of SF-5 and SF-10, and three additional indoor locations. The three additional indoor locations were :

Site 9: First Floor, Room 130L, day care center.

Site 10: Third floor, Room 300, office

Site 11: Fourth floor, Room 411, office

These additional sampling sites are depicted on the floor plans in Figures 1-5.

We collected samples from each location during four consecutive days, November 2-5, 1993. During these measurements we recorded our observations of paint odors and those obtained from the building occupants. We first analyzed the samples collected at the two outside air inlet locations for each of the four measurement days. The concentrations determined by these analyses were all below our detection limit of 0.013 ppb. Since the paint odor was most frequently reported on November 5, 1993 we decided to analyze the samples collected at each of the indoor locations. The results of these analyses are depicted in Table 4. Again the concentrations were all below our detection limit of 0.013 ppb.

We also collected and analyzed samples from the air in the alley way between the auto body shop and the Mission Center Building on two occasions, November 11 and 12, 1993. The samples were collected over an 8-hour period. The time weighted concentration in the outdoor air on these two dates were less than our detection limit of 0.013 ppb on November 11, 1993 and 0.174 ppb on November 12, 1993. Thus it appears from this analyses that paint fumes are contaminating the air on UCSF property. We would anticipate that the concentrations of HDI in the building may reach this level or higher under favorable wind conditions and with heavy auto painting activity.

The Permissible Exposure Limits (PEL) established by the Occupational Safety and Health Administration (OSHA) for HDI is 5 ppb. Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces as recommended by ASHRAE 62-1989 is 1/10th of the ACGIH LTV occupational health guideline of 5 ppb or 0.5 ppb.

Thus, the indoor concentration of HDI measured in each of the office locations were below recommended guidelines. Given the extreme irritation associated with exposure to this compound, the 1/10th of the ACGIH LTV occupational health guideline may not be sufficient to protect sensitive individuals.

Airborne Metals. The indoor concentrations of airborne metals were below our detection limit for each of the 23 metals analyzed for at each of the four indoor measurement sites. The concentration of airborne metals measured in the outside air inlets of SF-5 and SF-10 were also below our detection limits. The results are summarized in table 5.

Since OSHA limits are established for the protection of industrial workers exposed to single substances, a more appropriate guideline for residential and office spaces as recommended by ASHRAE 62-1989 is 1/10th of the ACGIH LTV occupational health guideline.

Thus, the indoor concentration of airborne metals measured at each of the four office locations were below recommended guidelines.

Total Airborne Viable Fungi. The indoor concentrations of total airborne viable fungi ranged from < 9 colony forming units per cubic meter of air (CFU/m³) at Site 1 to 150 CFU/m³ at Site 4. The corresponding outdoor concentration was measured to be 1263 CFU/m³ at the SF-10 outside air inlet and 1175 CFU/m³ at the SF-5 outside air inlet. These results are summarized in Table 6.

There are no recommended indoor health or irritant guidelines for exposure to airborne fungal spores, however, since the indoor concentration in the absence of an indoor source is typically less than the outdoor concentration, we recommend that the indoor concentration of viable fungal spores be maintained at a concentration which is lower than that outdoors both on a total CFU basis and on a CFU/genus basis. This is easily achievable if adequate ventilation with air filtration is provided and there are no indoor moisture problems.

The predominant genus in each of these samples were *cladosporium* and *penicillium* and each of these were higher outdoors than indoors.

Thus the concentration of airborne fungi measured in each of the four office locations were below recommended guidelines on both a total and genus by genus basis.

We note that the concentrations of airborne viable fungi may vary substantially with time in a building (e.g. hour-to-hour, day-to-day, and month-to-month). Thus it is important to not interpret a few negative air measurements (i.e. concentrations less indoors than outdoors) as proof positive that an indoor fungal contamination problem does not exist. The negative airborne viable fungi concentrations observed in this building are consistent with our limited visual inspection of the building which did not identify any indoor sources of fungal growth or building moisture problems.

Total Airborne Viable Bacteria. indoor concentrations of total airborne viable bacteria ranged from 9 colony forming units per cubic meter of air (CFU/m³) at Site 1 to 26 CFU/m³ at Site 4. The outdoor concentration of total airborne viable bacteria was measured to be 26 CFU/m³ at the SF-5 outside air inlet and 79 CFU/m³ at the SF-10 outside air inlet. The bacteria isolated were approximately equal proportions of gram negative and gram positive cocci, gram positive rods, and non-coliform gram negative rods. No particular colony type was predominating. The numbers isolated and colony types represent what is typically encountered in normal bacterial air flora. These results are summarized in Table 6.

There are no recommended indoor health or irritant guidelines for exposure to airborne bacteria. Indoor concentrations of total airborne viable bacteria in occupied buildings are usually higher than the corresponding outdoor concentrations because people are sources of bacteria. Airborne viable bacteria concentrations in buildings typically range from 12-1201 CFU/m³ with a mean of 124 CFU/m³ in high-rise office buildings to 35-2957 CFU/m³ with a mean of 655 CFU/m³ in home environments to 24-18,432 CFU/m³ with a mean of 919 CFU/m³ in school classrooms.

Thus the concentration of airborne viable bacteria measured in each of the four office locations were below the outdoor concentration and below the mean concentration typically found in high-rise office buildings.

Charcoal Filter Contaminant Removal Efficiency. The purpose of these measurements was to determine the effectiveness of the charcoal filters for removing organic compounds and in particular the organic compounds causing the paint odors in the building. On October 22, 1993 we collected a pair of samples, one upstream and one downstream of the charcoal

filters installed on air handler SF-5. The samples were collected over an approximate 5 hour period during the day. Eleven of the most abundant compounds have been quantitated and are summarized in Table 7. The complete chromatograms of each of our analyses are included in Figures 12 and 13. Table 7 also includes a calculation of the contaminant removal efficiency for total volatile organic compounds and for each of the eleven quantitated individual volatile organic compounds.

The contaminant removal efficiency was observed to be 17% for total volatile organic compounds and ranged from 22% for tetrachloroethene to 78% for acetone. The average removal efficiency for the eleven compounds is 40%.

This contaminant removal efficiency is typical of this type of filter which is a light duty filter not intended for applications where high removal efficiencies (e.g. >90%) are required. We also note that the face velocity of air at the filter bank of air handler SF-5 is approximately 900 feet per minute (fpm) which is almost twice the manufacturer's recommended maximum face velocity of 500 fpm. This high air velocity reduces the contact time that the air has with the activated charcoal and thus limits the ability of the charcoal to adsorb the contaminants.

Surface Contaminant Measurements. We measured the concentrations of surface dusts we collected from the desktops at each of the four study areas. We analyzed the dust samples by phase contrast microscopy for fibers and fiberglass and by ICP for metals. The dusts at each of the four sites contained some carpet fibers but no measurable amounts of glass fibers. The concentrations of metals consisted of primarily aluminum, barium, copper, iron, manganese, and zinc. These metals are commonly encountered in indoor and outdoor surface dusts. There was no detectable amounts of the following metals: beryllium (i.e. < 16 mg/kg), cadmium (i.e. < 160 mg/kg), cobalt (i.e. < 310 mg/kg), molybdenum (i.e. < 630 mg/kg), selenium (i.e. < 3100 mg/kg), silver (i.e. < 160 mg/kg), thallium (i.e. < 3100 mg/kg), tin (i.e. < 1600 mg/kg), tungsten (i.e. < 3100 mg/kg), or vanadium (i.e. < 160 mg/kg).

SUMMARY AND DISCUSSION

The following summarizes our findings with respect to our contaminant source inspection and measurements of ventilation and air contaminant concentrations.

Contaminant Source Inspection. The indoor sources we identified during our investigation include the usual sources associated with office spaces: people, paper products, printing equipment, and office furnishings. Laser printers and fax machines are located in office locations throughout the building. Site 1, Room 116, had a liquid toner copy machine. This type of copy machine uses a liquid toner which is known to produce a substantial amount of volatile organic compounds as part of the copying process. Other copy machines which use dry toner cartridges are also known to generate volatile organic compounds but at a much lesser rate. Site 4, Room 630 is the Publications Department and contains a number of solvent based adhesives used to prepare manuscripts.

Pollutant sources in the outside air of the Mission Center Building include most notably the auto body shop next door across the alley on the north side of the building. According to UCSF Environmental Health staff, this body shop uses polyurethane based paints which contain diisocyanates.

The building HVAC system was inspected and was found to be in acceptable cleanliness, the filters were not loaded during our inspection.

We note that the odor of paint fumes from the adjacent auto body shop was apparent in the outside air in the alley separating the body shop from the Mission Center building as well as in the outside air inlets of both SF-5 and SF-10. The odor of paint fumes could also be detected at times in the office air and coming from the ventilation system supply air diffusers. Up at the air handlers we could detect the odor of both paint and roofing fumes upstream and downstream of the charcoal filters.

Ventilation Measurements. Our measurements of ventilation rates indicate that the air circulation rates do not meet the recommended air circulation rate guidelines at three of the four office spaces inspected under one or more operating conditions. Our measurements of the delivery of outside air indicate that in three of the four areas ventilation rates do not meet the recommended minimum outside air ventilation rate guidelines on either an outside air per person basis or an outside air exchange rate basis under one or more conditions. There

is no purge cycle (e.g. 100% outside air) for clearing out air contaminants which may have built up during the night time when the ventilation systems are not operating. Also the thermostat VAV controls appear to be stuck in 5 of the 9 VAV boxes inspected. This lack of control will cause for unacceptably large swings in air temperature with changing thermal loads of people, lighting and equipment.

We compared our measurements of supply air flow rates in areas served by SF-5 and SF-10 with those acquired by JET Associates (HVAC Test Report, UCSF Mission Center Building, Air Quality Project #2044, August 24, 1993). We compared the results of measurements made on 10 supply air diffusers made at full cooling and full heating for a total of twenty comparisons. On SF-10 we compared a total of 12 measurements and found the measurements made by JET Associates to be on average 28% higher than ours with a standard deviation of 18%. On SF-5 we compared a total of 8 measurements and found the measurements made by JET Associates to be on average 1% lower than ours with a standard deviation of 22%.

An inquiry which we made to the building engineers suggests a possible cause for the higher air flow rates between the two different set of measurements made on diffusers connected to SF-10. According to the building engineer the measurements made by JET Associates were made with the inlet vanes on the supply fans of both SF-5 and SF-10 fully open for maximum supply air flow rates while the measurements we made were in the normally operating position. For SF-5 the normal operating position is reportedly 90% while for SF-10 the normal operating position is reportedly 50%. Thus we would expect the measurements made by JET Associates on supply diffusers from SF-10 to be significantly higher than our measurements.

Contaminant Measurements. The indoor concentrations of air contaminants measured at four different indoor locations on October 20, 1993 were all below both recommended irritant guidelines and occupational health guidelines except for total volatile organic compounds at Site 1, Room 116 on the first floor. The concentration of total volatile organic compounds at Site 1 was $1502 \mu\text{g}/\text{m}^3$ which is below occupational health guidelines (i.e. OSHA) but above the recommended irritant guideline of $1000 \mu\text{g}/\text{m}^3$. The source of volatile organic compounds was traced to a liquid process photo copy machine in that area.

We also noted that the outside air at MCB has relatively high concentrations of total volatile organic compounds which appear to be caused by the auto body shop next door.

The surface dust samples we collected from work stations at each study site contained no signs of contamination with fiberglass and a typical composition of metals.

Since the ventilation systems were operating with a maximum percentage of outside air during the period which we sampled for air contaminants we decided to prepare projections of the indoor contaminant concentrations for periods when the ventilation systems operate at the minimum outside air percentage. As noted previously these ventilation systems are designed to operate at minimum outside air percentage only when the outside air temperature falls below 40-45 °F. These temperatures occur in San Francisco during the day time hours an average of between 10 and 56 hours a year. Thus, there is a small but significant amount of time during which the building ventilation systems operate with a minimum amount of outside air. In addition to these daytime hours there are times in the early morning during the morning warm-up cycle when the ventilation systems operate with a minimum amount of outside air. According to the building engineers this is typically 15 minutes (e.g. 6:00 AM to 6:15 AM).

We projected the indoor concentrations of total volatile organic compounds, formaldehyde and carbon dioxide for each of the four study sites using a multi-zone mass balance model and assuming a constant indoor generation rate of contaminants. We assumed a contaminant removal effectiveness associated with the activated carbon filters of 17% for total volatile organic compounds (as measured during this study) and 0% for formaldehyde and carbon dioxide. We also assumed an average return air concentration equal to the average of the concentrations measured at the two sites served by each air handler except for total volatile organic compounds at Sites 1 and 3 where we assumed that the average return air concentration for SF-10 was equal to the concentration at Site 3. The purpose of this assumption was to avoid using the very elevated concentration of total volatile organic compounds measured at Site 1 as a determinant of the return air concentration since we felt that it is unlikely that there are many other areas connected to SF-10 with such a high indoor source of volatile organic compounds (i.e. we did not see any other liquid toner printing equipment in the building). If the actual return air concentrations are significantly lower or higher than what we have assumed here than our indoor concentration projections will be correspondingly lower or higher.

The results of our indoor contaminant concentration projections are summarized in Table 8. The projected indoor concentrations of total volatile organic compounds and formaldehyde exceeded the recommended irritation guidelines at Sites 1 and 3. While these concentrations substantially exceeded the recommended irritant guidelines (i.e. by factors of 2-3) the projected indoor concentrations were still substantially below recommended occupational health guidelines (e.g. OSHA). The projected indoor concentrations of carbon dioxide exceeded the recommended comfort guide of 1000 ppm at each of the four study sites.

We note that while the indoor concentration of HDI measured in each of the office locations were measured to be below recommended guidelines we believe that under favorable wind conditions and with heavy auto painting activity we anticipate that the indoor concentration may approach the irritation guideline. Also, given the extreme irritation associated with exposure to this compound, the 0.5 ppb (e.g. 1/10th of the ACGIH TLV) irritation guideline, may not be sufficient to protect sensitive individuals. We note that on November 22, 1993 we observed concentrations of 0.174 ppb in the alley separating the auto body shop from MCB.

Charcoal Filter Contaminant Removal Efficiency. The contaminant removal efficiency was observed to be 17% for total volatile organic compounds and ranged from 22% for tetrachloroethene to 78% for acetone. The average removal efficiency for the eleven compounds is 40%.

This contaminant removal efficiency is typical of this type of filter which is a light duty filter not intended for applications where high removal efficiencies (e.g. >90%) are required. We also note that the face velocity of air at the filter bank of air handler SF-5 is approximately 900 feet per minute (fpm) which is almost twice the manufacturer's recommended maximum face velocity of 500 fpm. This high air velocity reduces the contact time that the air has with the activated charcoal and thus limits the ability of the charcoal to adsorb the contaminants.

The odor threshold of toluene is approximately 5,000 to 10,000 $\mu\text{g}/\text{m}^3$. Since the odor of paint fumes, which is presumed to be dominated by toluene, episodically appears at the outside air inlet of both SF-5 and SF-10 we can surmise that the concentrations upstream of the charcoal filter vary substantially from concentrations below the detection limit to concentrations above the detection limit. The time weighted average concentration of toluene upstream of the charcoal filter was 32 $\mu\text{g}/\text{m}^3$ on the day of our test. Since during

our test we occasionally could smell paint fumes upstream of the filters we may assume that although the time weighted concentration is only $32 \mu\text{g}/\text{m}^3$ that periodically the concentration upstream of the filters exceeds 5,000 to 10,000 $\mu\text{g}/\text{m}^3$. The episodic nature of the paint odors is consistent with the fact that cars are not painted continuously at the shop and that wind directions favorable to the transport of the fumes to the building ventilation system air inlets must coincide with painting in the auto body shop. Considering that the filter efficiency for toluene is only approximately 30%, if the concentration of the paint fumes upstream of the filter exceeds the odor threshold by more than 30%, then there will be a perceptible odor in the ventilation air downstream of the filter. During our test we observed the paint fume odor downstream of the filters as well as in the supply air from the ceiling diffusers in the office space.

Thus, it appears that the filters selected for mitigating the paint fumes have insufficient material to insure the contaminant removal efficiency necessary to keep the concentrations below the odor detection threshold during episodic periods of high concentrations of paint fume contaminants.

RECOMMENDATIONS

In summary, there are a number of locations in the building which are receiving either not enough supply air and/or not enough outside air under certain operating conditions. This finding is consistent with the occupant survey conducted by the UCSF office of Environmental Health and Safety where 46% of the building occupants reported experiencing "stuffy stagnant" air. This condition of not enough ventilation air may also explain why 37% of the occupants report air temperatures "too hot". These were the two highest symptom prevalence rates reported by the building occupants. To remedy these complaints the building ventilation system needs to be balanced to meet the maximum projected occupancies in each area. This lack of ventilation in portions of the building is a violation of Cal-OSHA 5142 and should be addressed as soon as possible.

The lack of adequate ventilation during cold periods when the building is operating with a minimum amount of outside air combined with indoor sources of volatile organic compounds and formaldehyde produce elevated indoor concentrations which can cause many of the physical discomforts being experienced by employees at MCB including the

four highest health complaints documented in two health and comfort surveys: headache, burning itching eyes, congestion, and dryness of throat or mouth.

The proximity of the auto body paint shop next to MCB is both a source of volatile organic compounds and diisocyanates in the building air. The low efficiency charcoal filters currently installed in the building air handlers have neither sufficient efficiency, nor capacity, to preclude paint odors from entering the indoor space.

The following are our recommendations to improve the indoor air quality at the UCSF MCB:

1.) Adjust the ventilation supply air flow rate in each area to vary between 0.5 and 1.5 cfm/ft² according to the maximum anticipated heat load. This means installing minimum stops on all VAV boxes such as those at Site 4 on the sixth floor. Installation of re-heat coils may also be required at each VAV box to insure thermal comfort during low load conditions. A building wide survey of maximum and minimum heat loads from people, lighting, and equipment will be required to do this task.

2.) Set the outside air economizer controls to provide a minimum delivery of outside air of 1.0 air change per hour or 20 cfm per occupant whichever is greater to each occupied portion of the building at all times. Currently the minimum outside air percentage is 7.5% in SF-10 and 31% in SF-5. The optimal percent outside air percentage from indoor air quality and energy perspectives should be selected based upon a complete building air balance report and occupancy count according to ASHRAE 62-1989 (i.e. see critical zone analysis as described in ASHRAE 62-89 Section 6.1.3.1.). In any newly renovated spaces, a minimum of 3 ach of outside air should be maintained until the odors and/or irritation associated with the new building materials have dissipated.

3.) Calibrate each thermostat and check for correct operation of temperature control actuators (e.g. VAV box dampers). Verify operation and system responsiveness by measuring the temperature and air flow rates of the supply air on full heating and full cooling thermostat settings. Repair sticky valves and dampers as necessary. This repair work should be done prior to any re-balancing work. Also the location of thermostats should be checked to see that they are not divorced from the loads they are controlling (e.g. located in a different room).

4.) Continue to pursue mitigation methods for eliminating paint fumes from entering the building. The most sure means of accomplishing this is to stop the painting activities at the adjacent auto body shop. If this is not possible, then a combination of improving the dispersion of exhausted paint fumes from the auto body shop with installation of higher efficiency activated charcoal filters should be able to eliminate most of the paint fumes from entering the building at concentrations above the odor threshold. The dispersion of paint fumes may be improved if they are centrally collected into an exhaust duct which discharges the fumes above the wake of MCB (e.g. 1/3 the building height). Effective filtration of the fumes can only be accomplished with a packed bed charcoal filter. A pilot study of such a system should be conducted to select the appropriate media and amount of media.

5.) Consider re-locating the wet process copy machine located in Room 116 to an enclosed room with an exhaust air system in order to prevent circulation of the contaminants generated from the copier. Adjust the exhaust air flow rate to 0.5 cfm/ft² and adjust the flow rate of supply air to maintain a negative pressure in this room.

6.) Set the ventilation system operating schedule for a minimum of three air changes of outside air through the space before occupants enter the building to purge the building of the contaminant build up during the shut down period. Also, schedule the building ventilation system to operate at 100% outside air during all janitorial cleaning operations (e.g. carpet cleaning, floor waxing etc.) in the building. Continue ventilation to the building for a minimum of three outside air changes following the cleaning work.

7.) Institute a pro-active indoor air quality plan as described in Appendix A. Contaminant Control Guidelines for Building Renovations for all building renovation work. With respect to carpet installations, select low emitting products and install carpet with the appropriate amount of ventilation as described in the guidelines.

8.) Upon completion of the on-going occupant survey, review the data and conduct an indoor air quality diagnostic study of each area with unacceptably high occupant symptom prevalence rates.

Table 4. Air Contaminant concentrations of hexamethylene diisocyanate (HDI) measured at indoor and outdoor locations in the UCSF Mission Center Building located at 1855 Folsom Street in San Francisco, CA on November 5, 1993.

Site ID	Location	HDI Concentration	Detection Limit	Guideline ^b
		ppb	ppb	ppb
1	1st Floor Rm 116	BDL ^a	0.013	0.5
2	5th Floor Rm 549	BDL	0.013	0.5
3	5th Floor Rm 505A	BDL	0.013	0.5
4	6th Floor Rm 630	BDL	0.013	0.5
5	4th Floor Air Handler S-5 OA inlet	BDL	0.013	0.5
6	4th Floor Air Handler S-10 OA inlet	BDL	0.013	0.5
9	1st Floor Rm 130L Daycare	BDL	0.013	0.5
10	3rd Floor Rm 300	BDL	0.013	0.5
11	4th Floor Rm 411	BDL	0.013	0.5
a) BDL = Below detection limit. b) Guideline for indoor exposure to airborne hexamethylene diisocyanate (HDI) is 1/10th OSHA PEL guideline.				
Indoor Environmental Engineering - December, 1993.				

Table 5. Contaminant concentrations of airborne metals at indoor and outdoor locations in the UCSF Mission Center Building located at 1855 Folsom Street in San Francisco, CA on October 20, 1993.

[illegible]

a) BDL = Below detection limit.

b) Guideline for indoor exposure to airborne heavy metals is 1/10th OSHA PEL.

Indoor Environmental Engineering - December, 1993.

Table 6. Concentrations of airborne viable microbiological contaminants collected indoors and outdoors at UCSF Mission Center Building located at 1855 Folsom Street in San Francisco, CA on October 20, 1993.

Sample Location:	Site 1: Rm 116	Site 2: Rm 549	Site 3: Rm 505A	Site 4: Rm 630	Site 5: S-5 OA	Site 6: S-10 OA
Fungi Species						
Alternaria	-	-	-	-	-	-
Cladosporium	-	9	-	106	945	1095
Drechslera	-	-	-	-	-	-
Epicoccum	-	-	-	-	-	-
Fusarium	-	-	-	-	-	-
Acremonium	-	-	-	-	-	-
Beauveria	-	-	-	-	-	-
Penicillium	-	-	-	18	177	124
Aspergillus fumigatus	-	-	-	-	-	-
Aspergillus flavus	-	-	-	-	-	-
Aspergillus niger	-	-	-	-	26	9
Aspergillus species	-	-	-	-	-	-
Aspergillus versicolor	-	-	-	-	-	-
Aureobasidium pullulans	-	-	-	-	-	-
Botrytis	-	-	-	-	-	9
Rhinochadiella	-	-	-	-	-	-
Rhizopus	-	-	-	-	-	-
Mucor	-	-	-	-	-	-
Ulocladium	-	-	-	-	-	-
Chaetomium	-	-	-	-	-	-
Stachybotrys	-	-	-	-	-	-
Sporothrix	-	-	-	-	-	-
Streptomyces	-	-	-	-	-	-
Sterile mycelia	-	-	9	26	18	26
Scopulariopsis	-	-	-	-	-	-
Phoma-like	-	-	5	-	-	-
Trichoderma	-	-	-	-	-	-
Fungi Total	<9	9	9	150	1175	1263
Bacteria Total	9	18	9	26	26	79

a.) Fungi collected onto sabouraud dextrose agar (SAB). Bacteria collected on trypticase soy agar (TSA). Concentrations reported in colony forming units per cubic meter of air (CFU/m³).

Source: Indoor Environmental Engineering, December, 1993.

Table 7. Contaminant concentrations of individual volatile organic compounds (IVOC) at upstream and downstream locations of the charcoal filters of air handler #S-5 in the UCSF Mission Center Building located at 1855 Folsom Street in San Francisco, CA on October 22, 1993.

Compound	Site 7. S-5 Upstream	Site 8. S-5 Downstream	Removal Efficiency ^a
	$\mu\text{g}/\text{m}^3$	$\mu\text{g}/\text{m}^3$	
Total Volatile Organic Compounds	451	374	0.17
2-Propanone (acetone)	31	6.7	0.78
1,1,1-Trichloroethane	6.5	3.5	0.46
Benzene	10	7.4	0.26 ⁴
Toluene	32	22	0.31
Tetrachloroethene	2.3	1.8	0.22
Butyl Acetate	5.9	3.5	0.41
Ethylbenzene	6.5	4.2	0.35
m-,p-Xylene	21	13	0.38
1,2,4-Trimethybenzene	6.2	3.5	0.44
Limonene	6.5	4.2	0.35
Naphthalene	1.3	0.7	0.46
a) Contaminant removal efficiency is calculated as $[1 - (\text{downstream concentration}/\text{upstream concentration})]$.			
Indoor Environmental Engineering - December, 1993.			

Table 8. Projected indoor air contaminant concentrations under minimum outdoor air ventilation conditions at four indoor locations in the UCSF Mission Center Building located at 1855 Folsom Street in San Francisco, CA.

Site	Location	TVOC ^a	HCHO ^a	CO ₂ ^a
		μg/m ³	μg/m ³	ppm
1	1st Floor Rm 116	3920	144	4550
2	5th Floor Rm 549	770	30	1110
3	5th Floor Rm 505A	2490	140	4540
4	6th Floor Rm 630	820	58	1720
	Recommended ^b Guidelines	1000	60	1000
a) Projected indoor contaminant concentrations under minimum outdoor air ventilation rate conditions prepared assuming a constant indoor contaminant emission rate equal to that measured October 20, 1993, a contaminant removal efficiency by the charcoal filters of 17% for TVOC and 0% for HCHO and CO₂, and an average return air concentration equal to the average of the concentrations measured at the two sites served by each air handler except for TVOC at Sites 1 and 3 where the average return air concentration was assumed to be equal to the concentration just in Site 3. b) Recommended indoor air quality health and irritant guidelines: TVOC - Total Volatile Organic Compounds - IEE Guideline. HCHO - Formaldehyde - California Air Resources Board (CARB), 1992. CO₂ - Carbon Dioxide - ASHRAE 62-1989.				
Indoor Environmental Engineering - December, 1993.				

Figure 1. Locations of air contaminant and ventilation rate measurements conducted on the 1st floor of UCSF Mission Center Building located in San Francisco, CA.

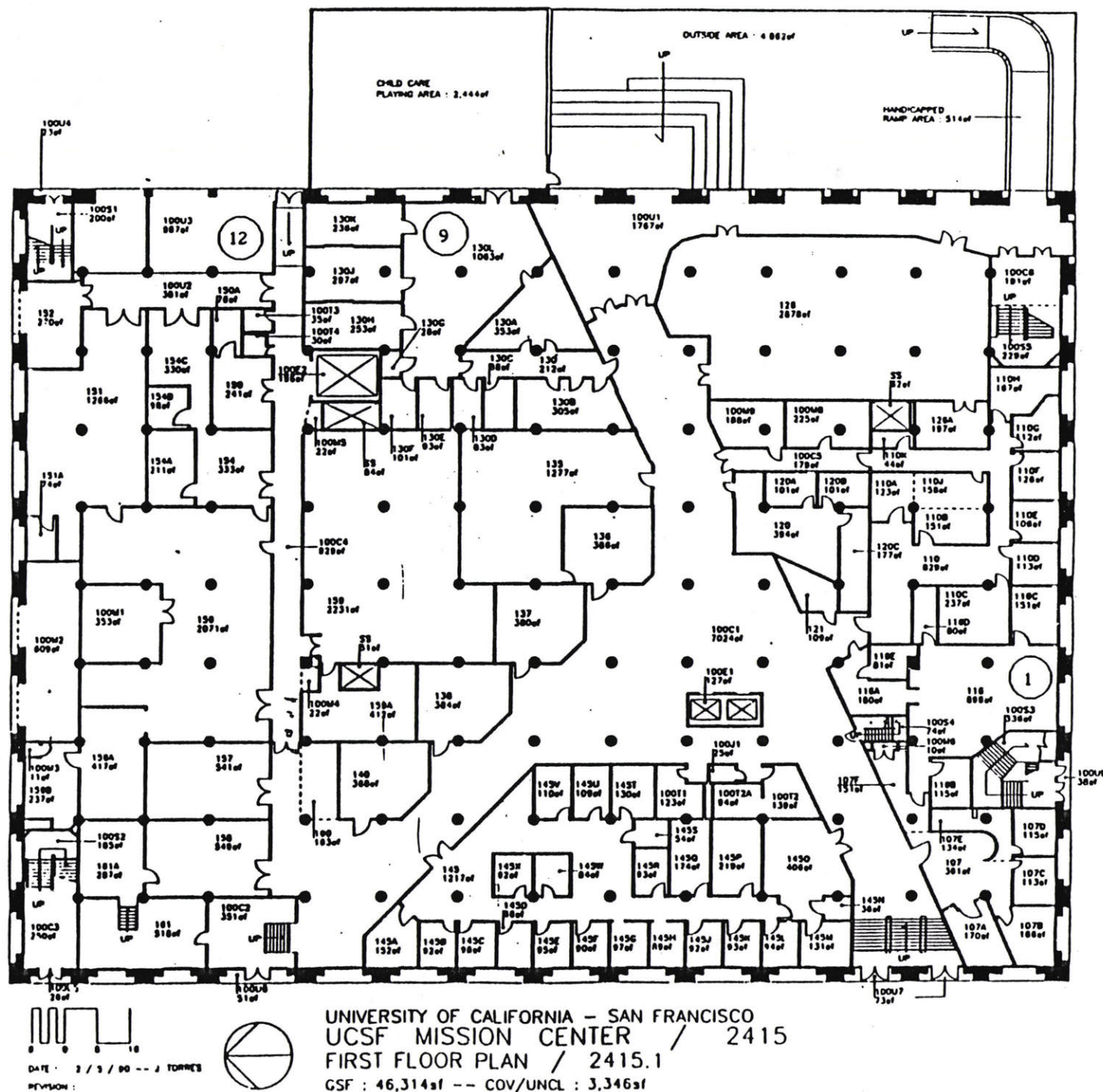
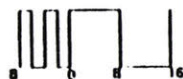
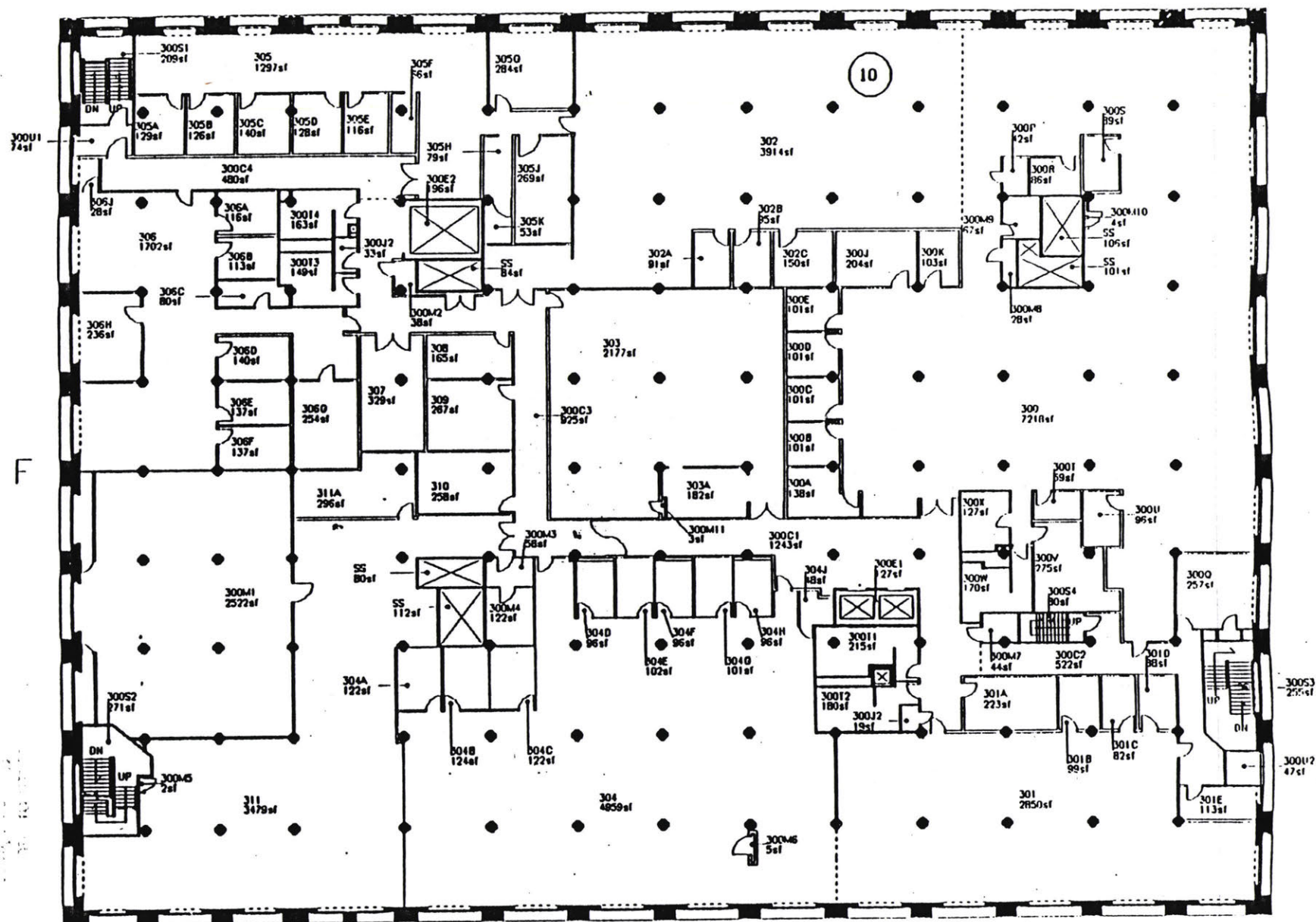
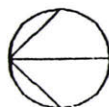


Figure 2. Locations of air contaminant and ventilation rate measurements conducted on the 3rd floor of UCSF Mission Center Building located in San Francisco, CA.



DATE : 02/13/1990 -- J. TORRES

REVISION : 11/09/1992 -- J. TORRES



UNIVERSITY OF CALIFORNIA - SAN FRANCISCO
UCSF MISSION CENTER / 2415
THIRD FLOOR PLAN - 2415.3
GSF : 48,988sf -- COV/UNCL : 121sf

Figure 3. Locations of air contaminant and ventilation rate measurements conducted on the 4th floor of UCSF Mission Center Building located in San Francisco, CA.

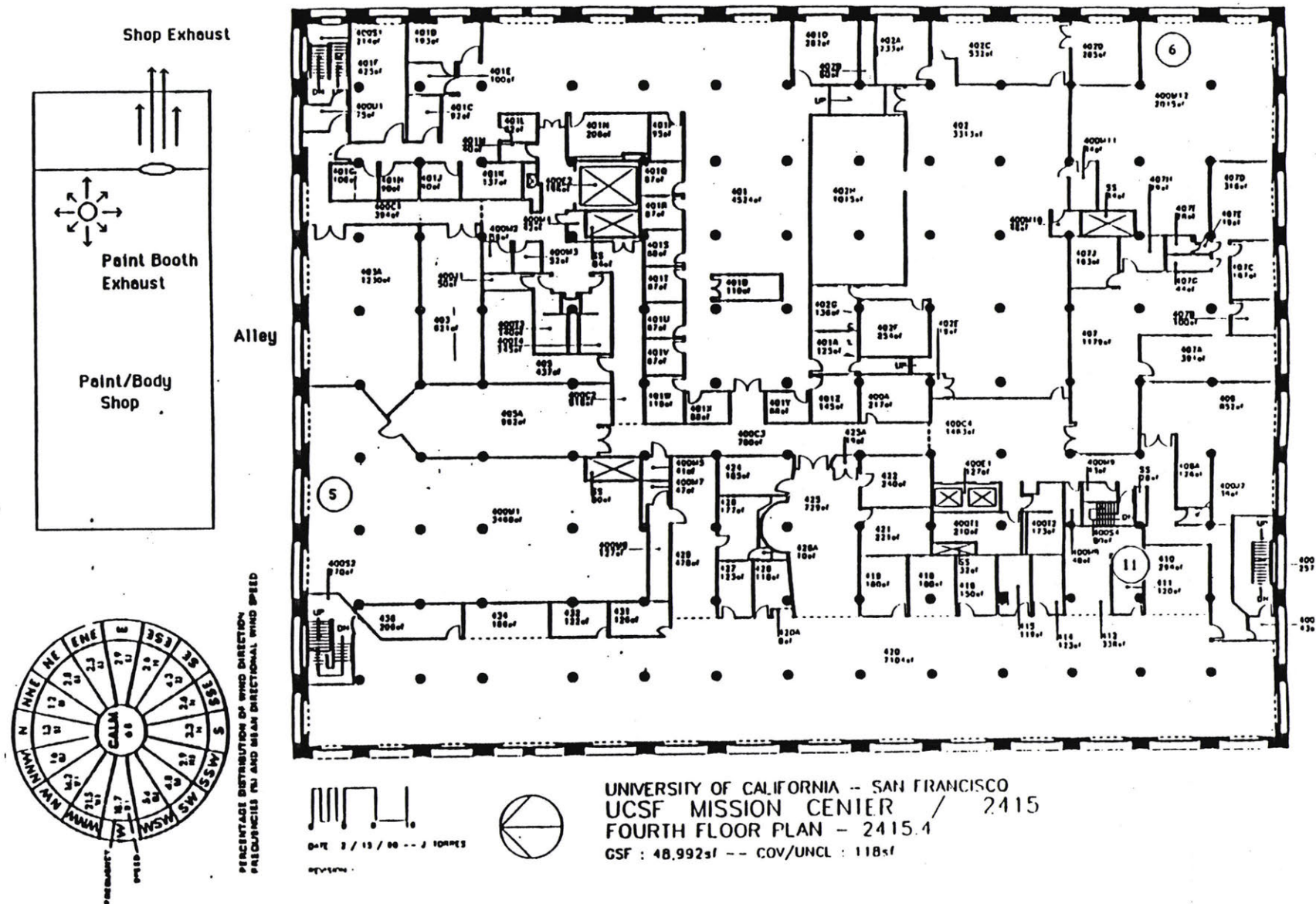
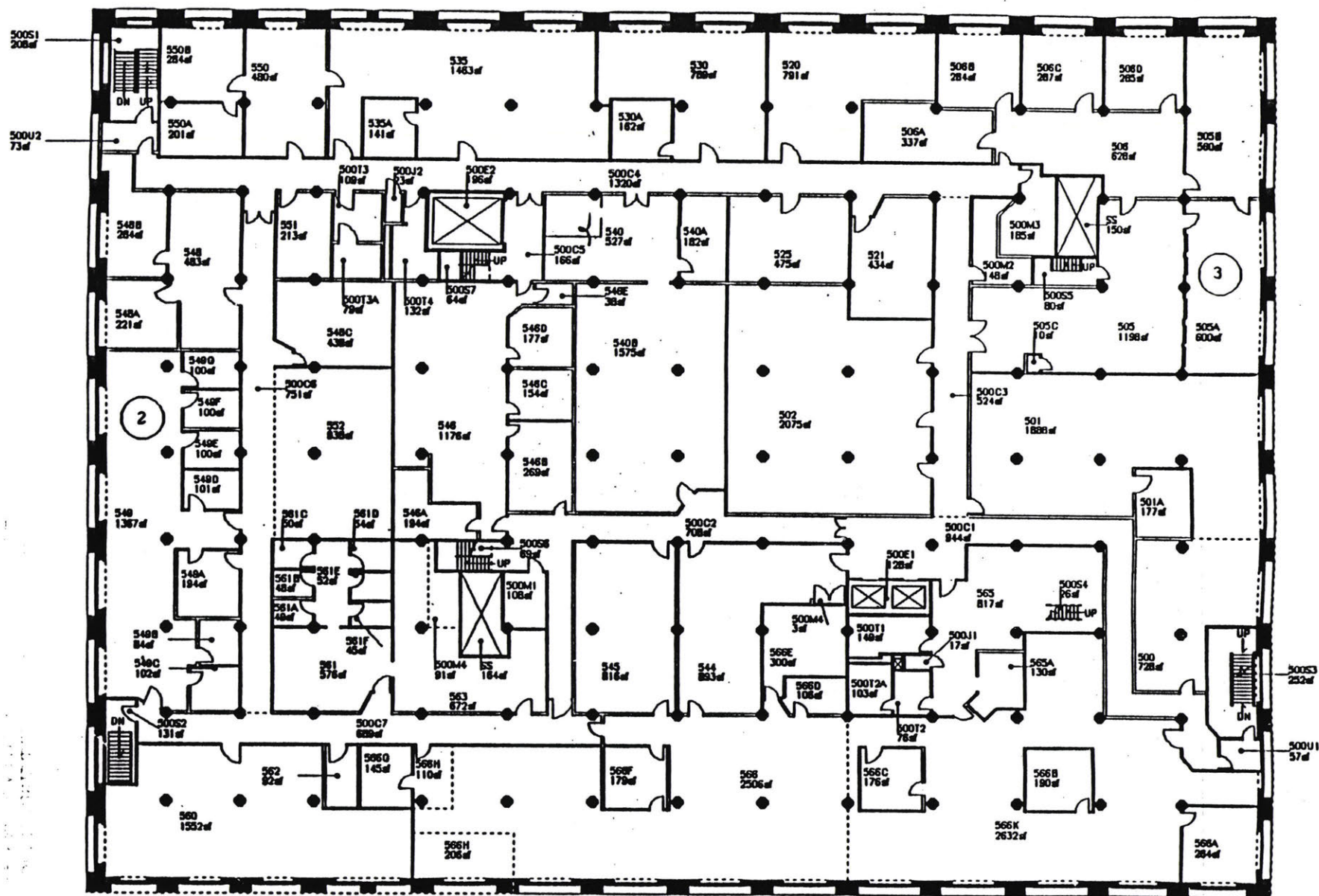


Figure 4. Locations of air contaminant and ventilation rate measurements conducted on the 5th floor of UCSF Mission Center Building located in San Francisco, CA.



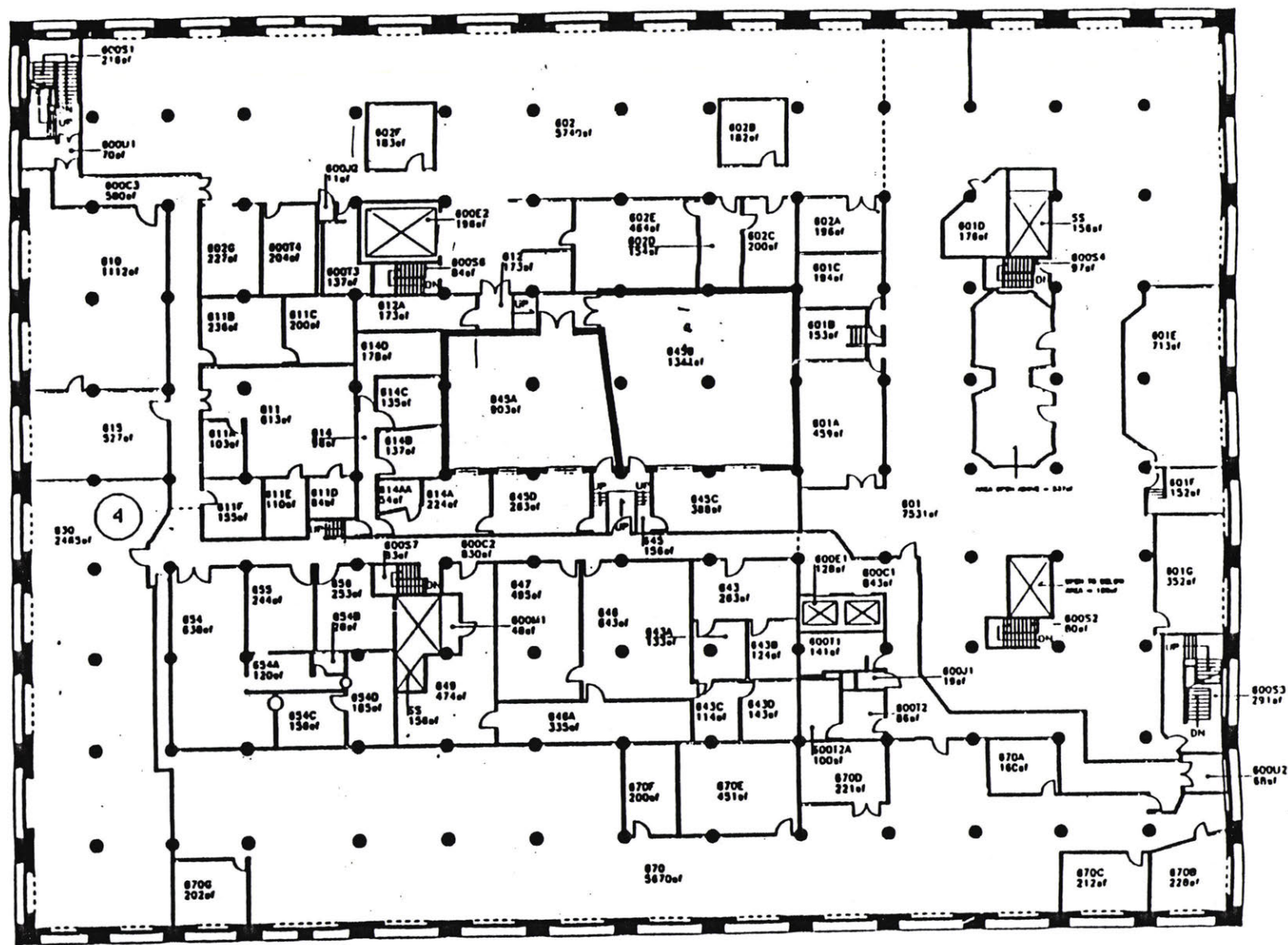
DATE : 02/07/1990 -- J. TORRES

REVISION : 05/01/1991 -- J. TORRES

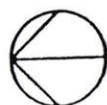


UNIVERSITY OF CALIFORNIA - SAN FRANCISCO
UCSF MISSION CENTER / 2415
FIFTH FLOOR PLAN - 2415.5
GSF : 48,980sf -- COV/UNCL : 129sf

Figure 5. Locations of air contaminant and ventilation rate measurements conducted on the 6th floor of UCSF Mission Center Building located in San Francisco, CA.



DATE : 2 / 12 / 90 -- J. TORRES



REVISION :

UNIVERSITY OF CALIFORNIA - SAN FRANCISCO
UCSF MISSION CENTER / 2415
SIXTH FLOOR PLAN - 2415.6
GSF : 48,327sf -- COV/UNCL : 138sf

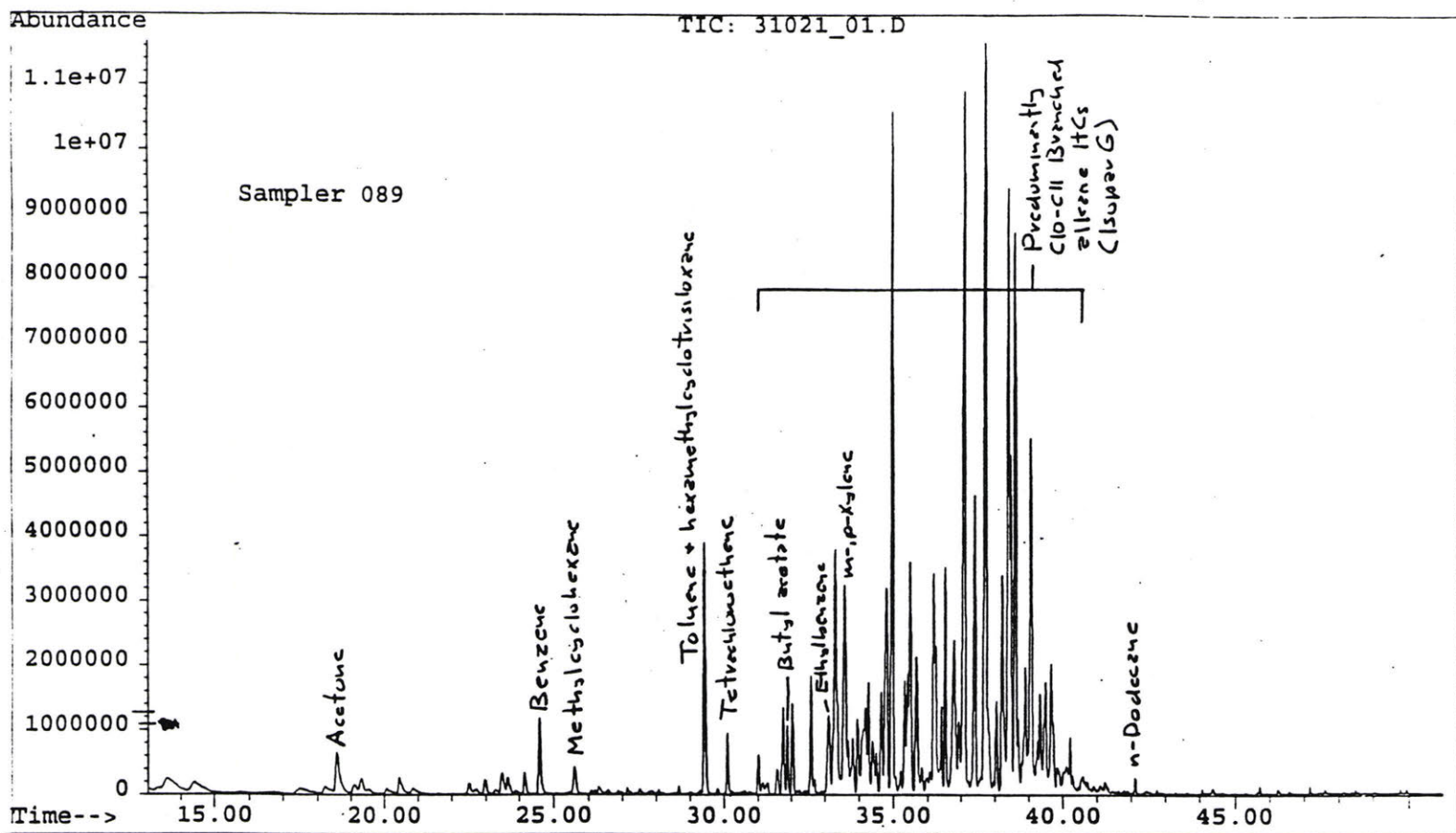


Figure 6. Gas chromatography / mass spectrometry (GCMS) chromatogram of the individual volatile organic compounds measured at Site 1 of the UCSF Mission Center Building located in San Francisco, CA.

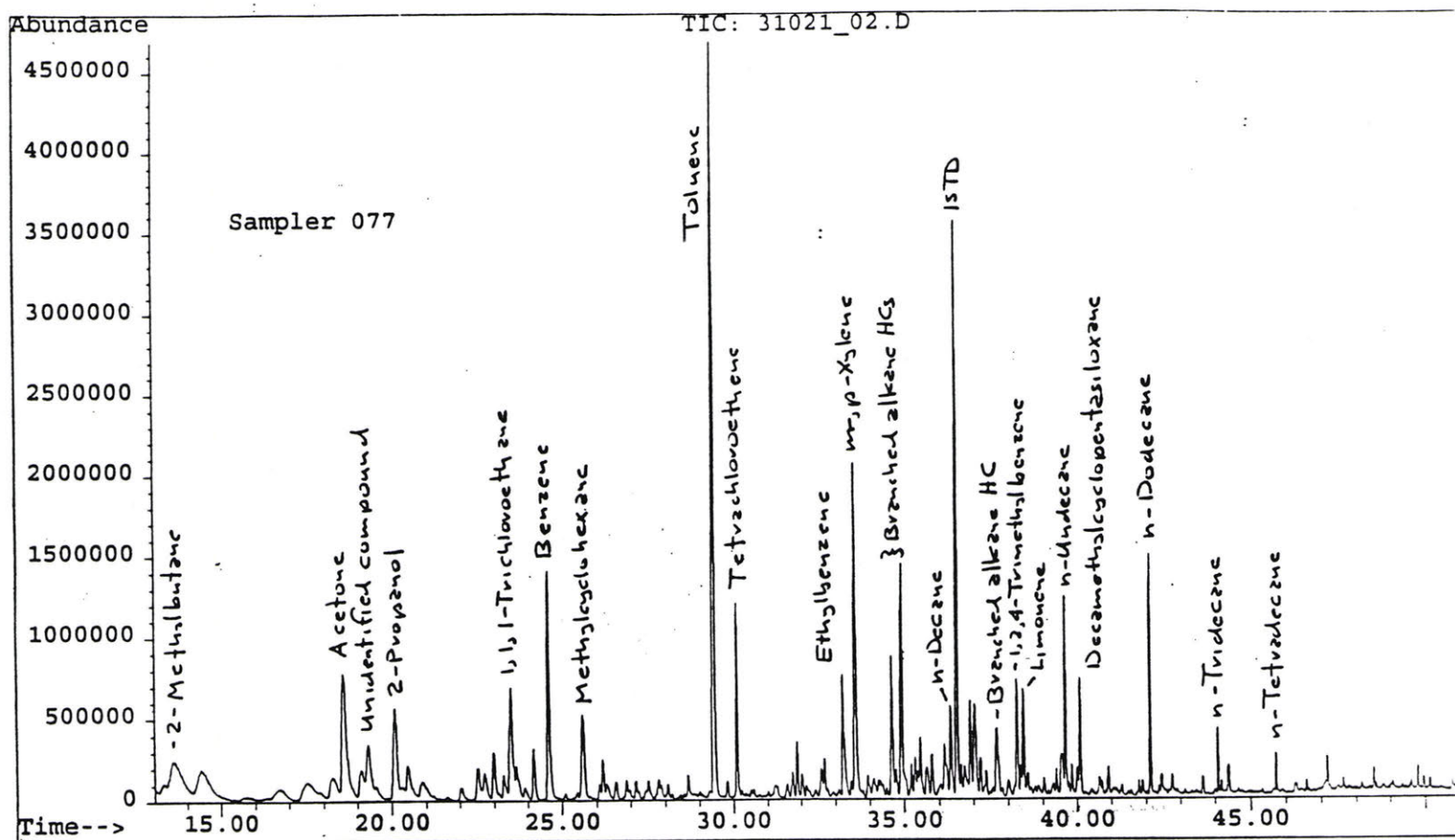


Figure 7. Gas chromatography / mass spectrometry (GC/MS) chromatogram of the individual volatile organic compounds measured at Site 2 of the UCSF Mission Center Building located in San Francisco, CA.

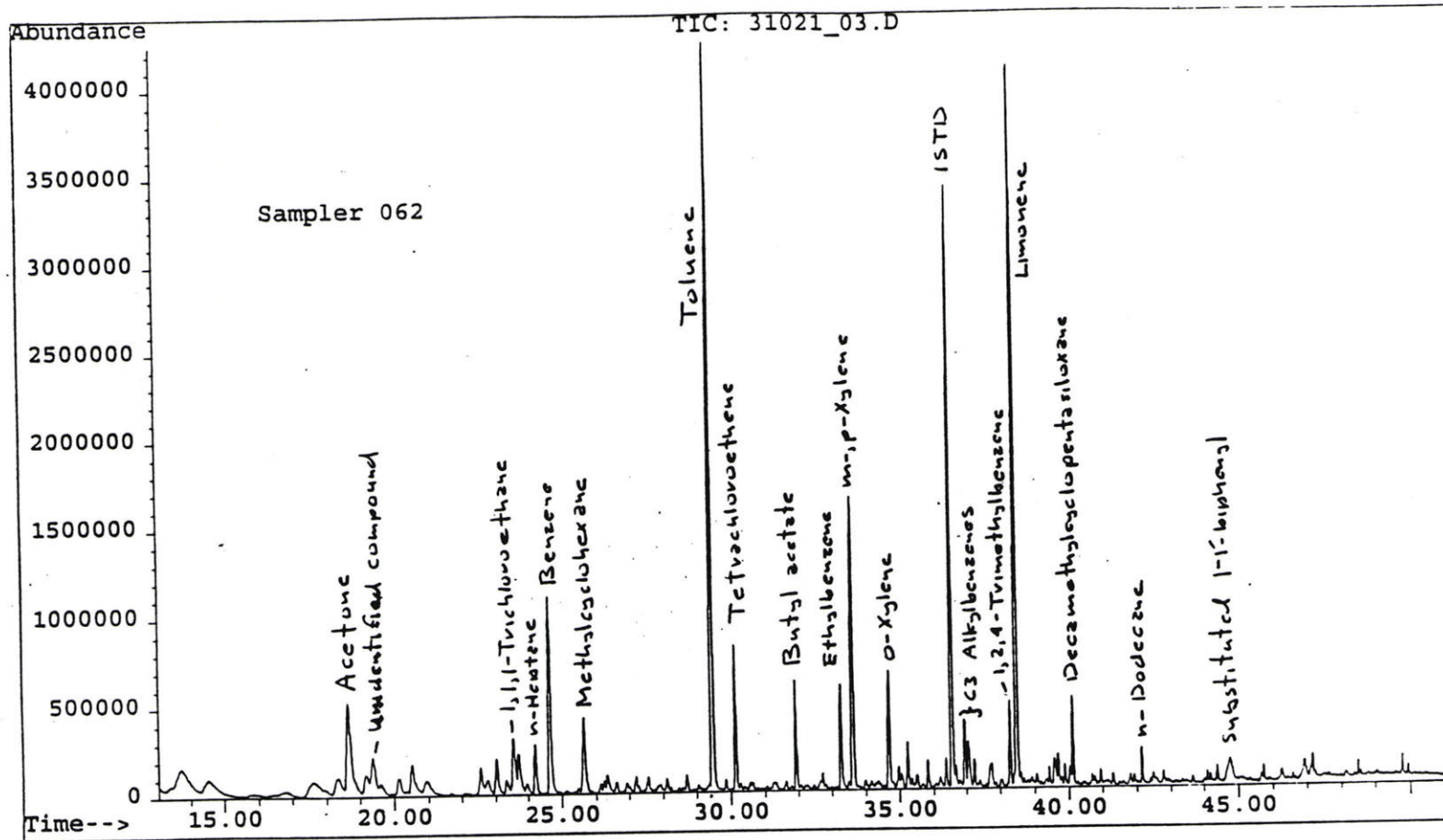


Figure 8. Gas chromatography / mass spectrometry (GCMS) chromatogram of the individual volatile organic compounds measured at Site 3 of the UCSF Mission Center Building located in San Francisco, CA.

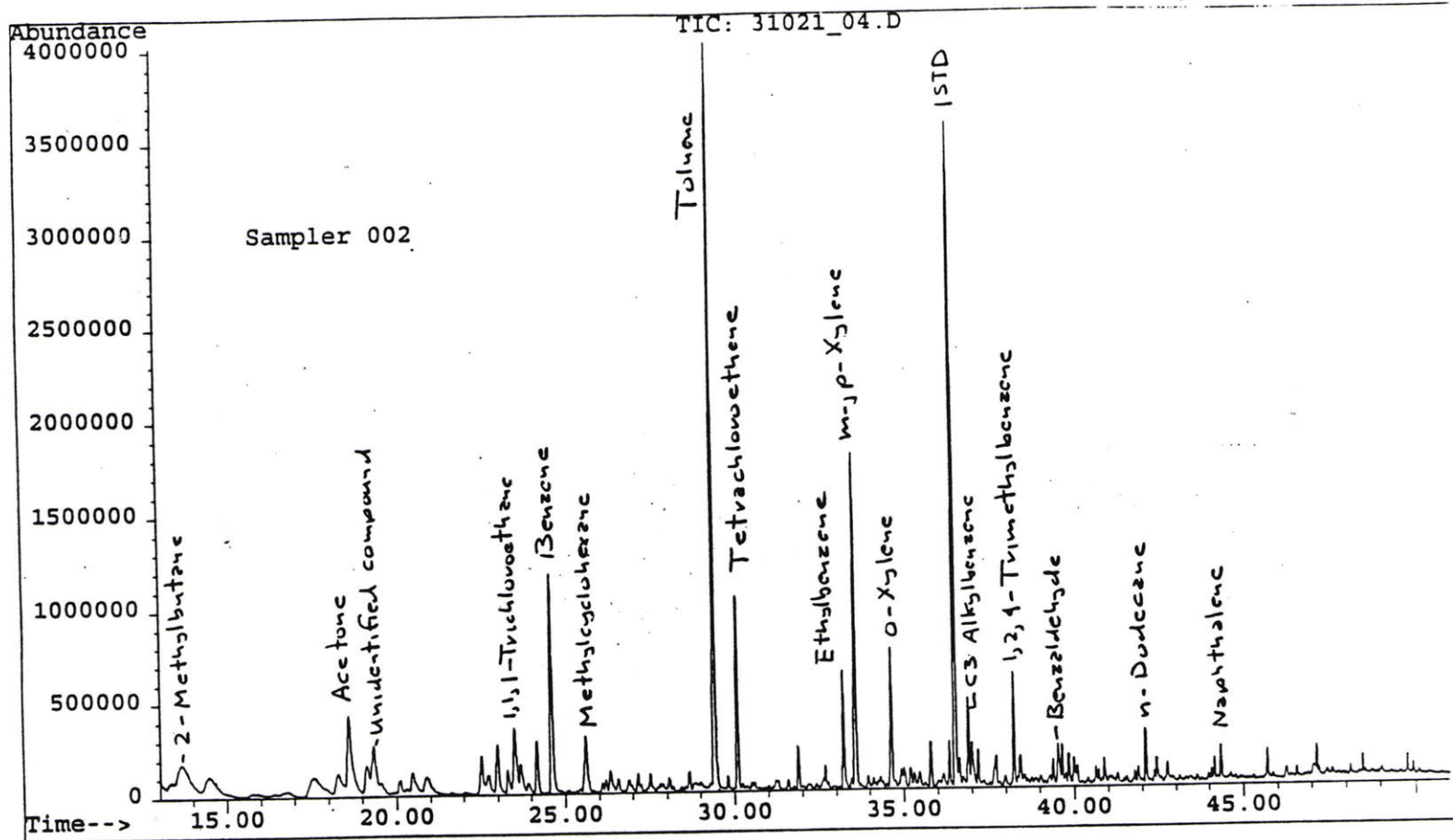


Figure 9. Gas chromatography / mass spectrometry (GCMS) chromatogram of the individual volatile organic compounds measured at Site 4 of the UCSF Mission Center Building located in San Francisco, CA.

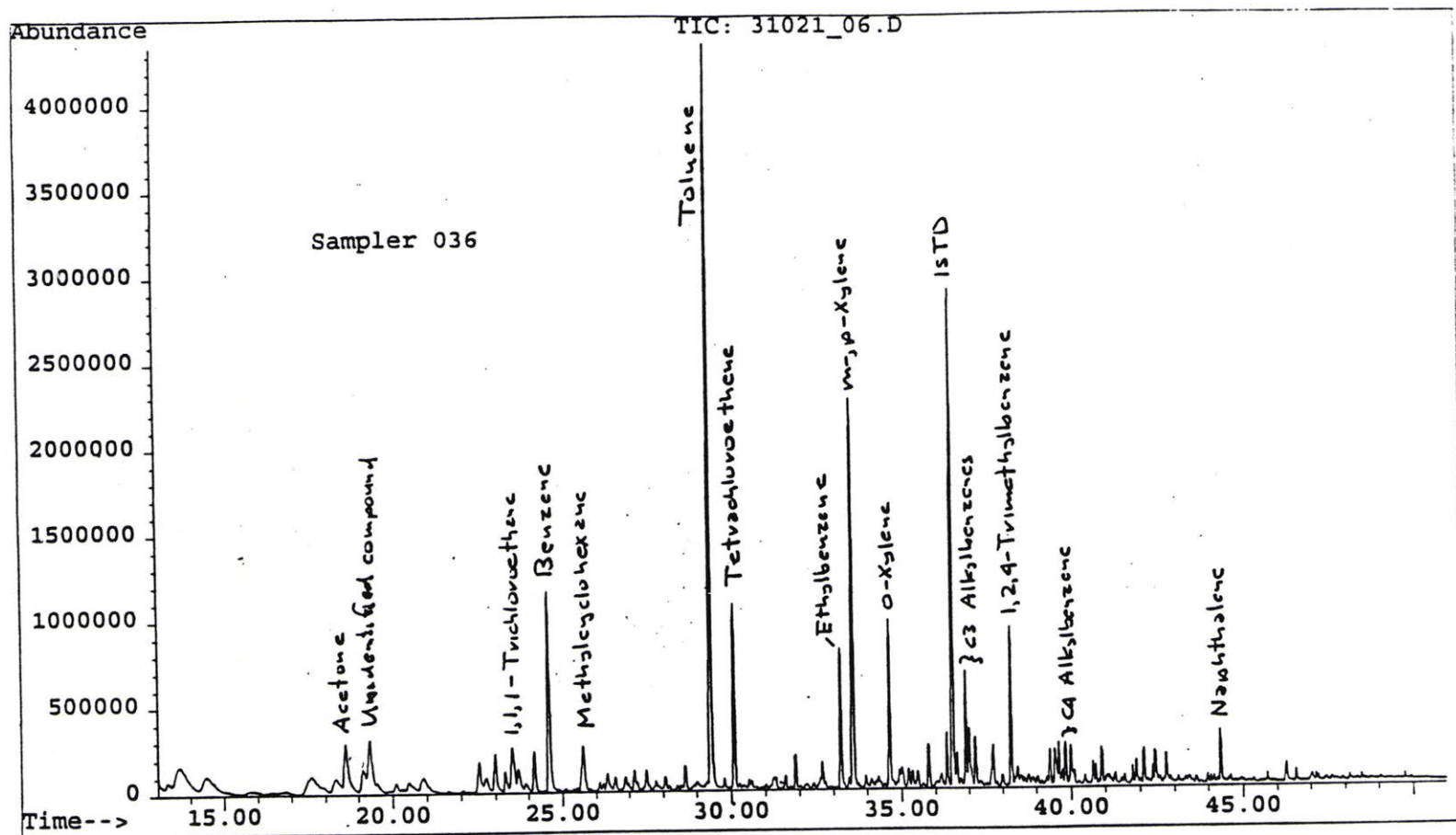


Figure 10. Gas chromatography / mass spectrometry (GCMS) chromatogram of the individual volatile organic compounds measured at Site 5 of the UCSF Mission Center Building located in San Francisco, CA.

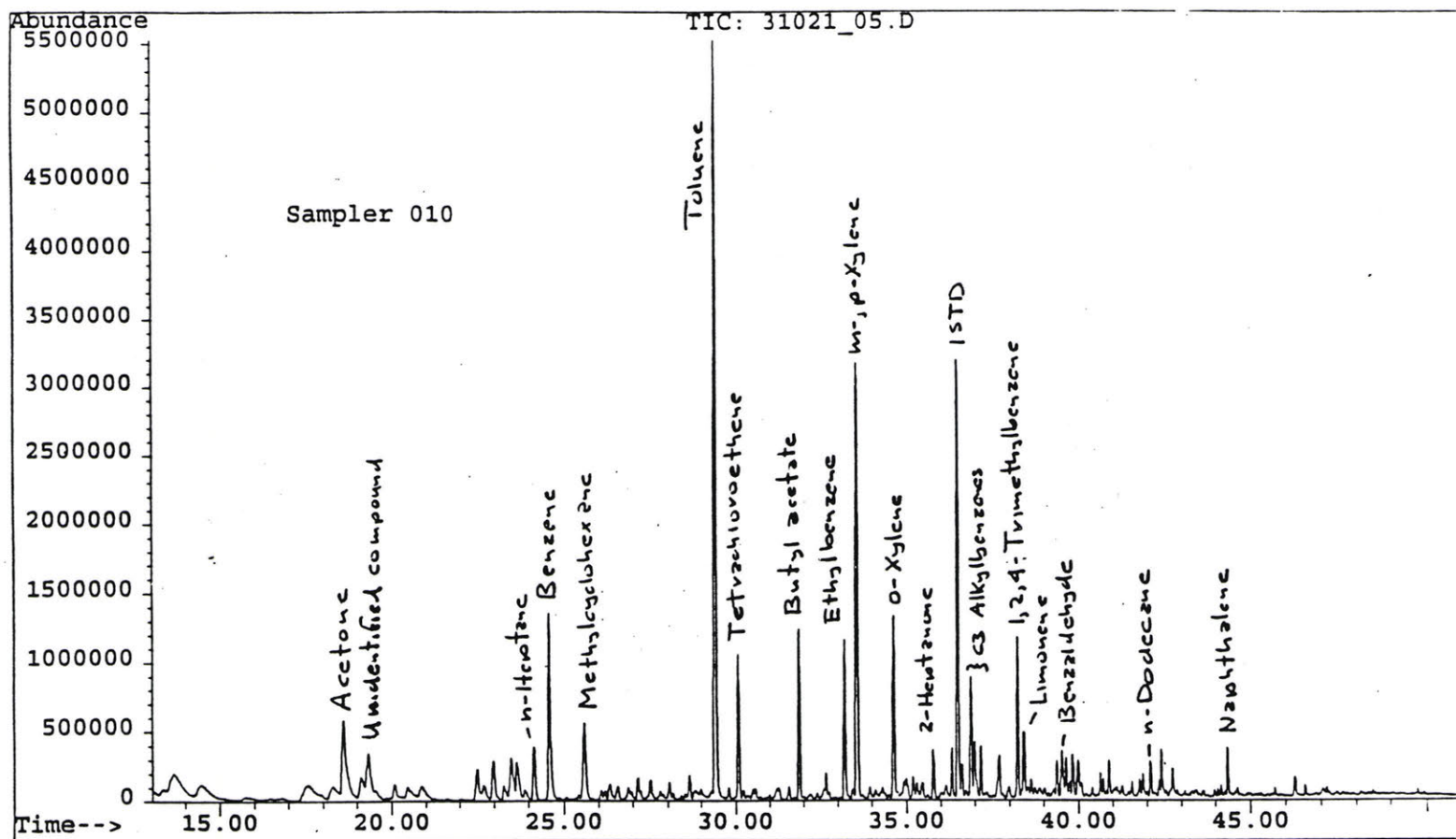


Figure 11. Gas chromatography / mass spectrometry (GCMS) chromatogram of the individual volatile organic compounds measured at Site 6 of the UCSF Mission Center Building located in San Francisco, CA.

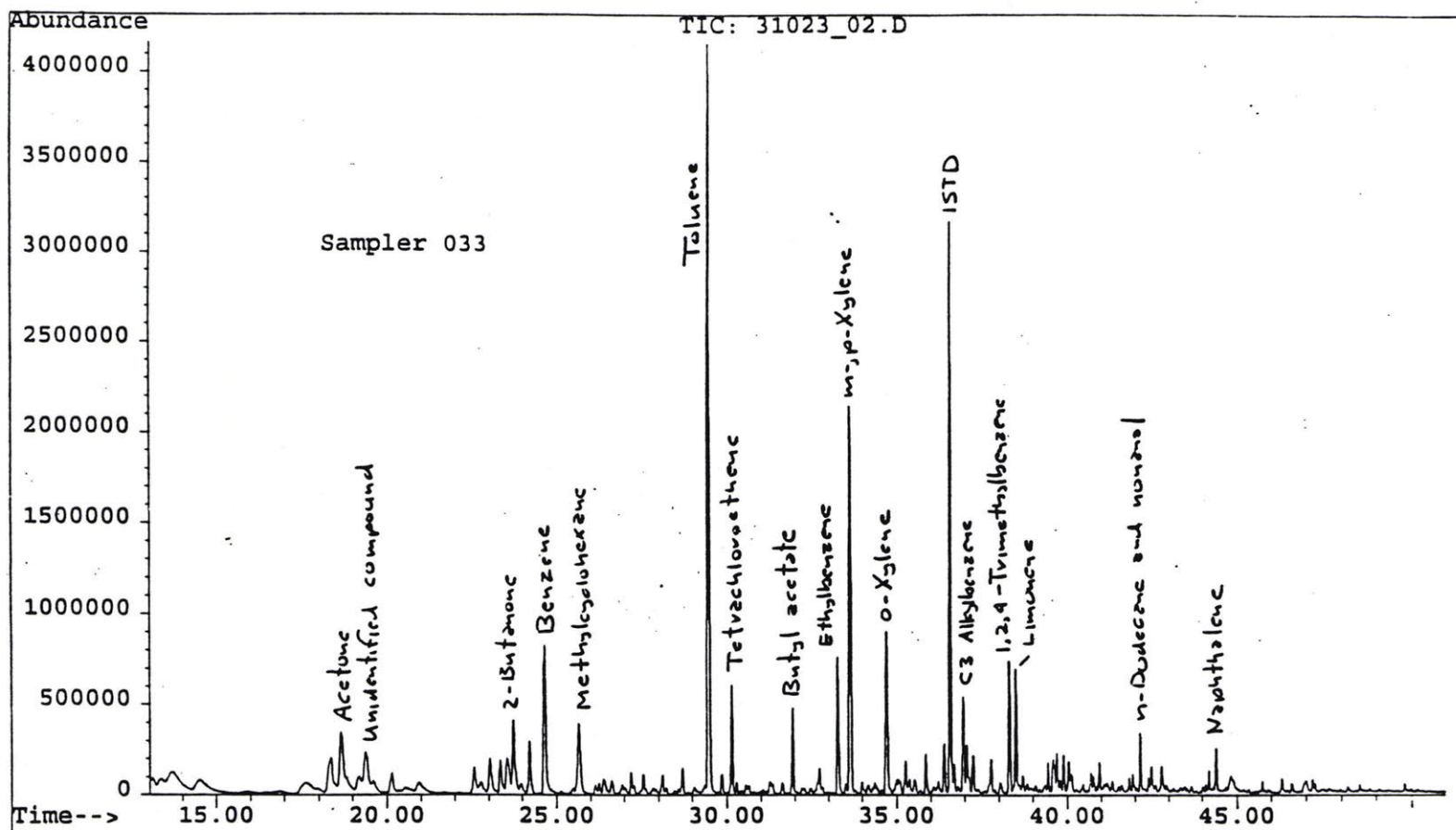


Figure 12. Gas chromatography / mass spectrometry (GCMS) chromatogram of the individual volatile organic compounds measured at Site 7 of the UCSF Mission Center Building located in San Francisco, CA.

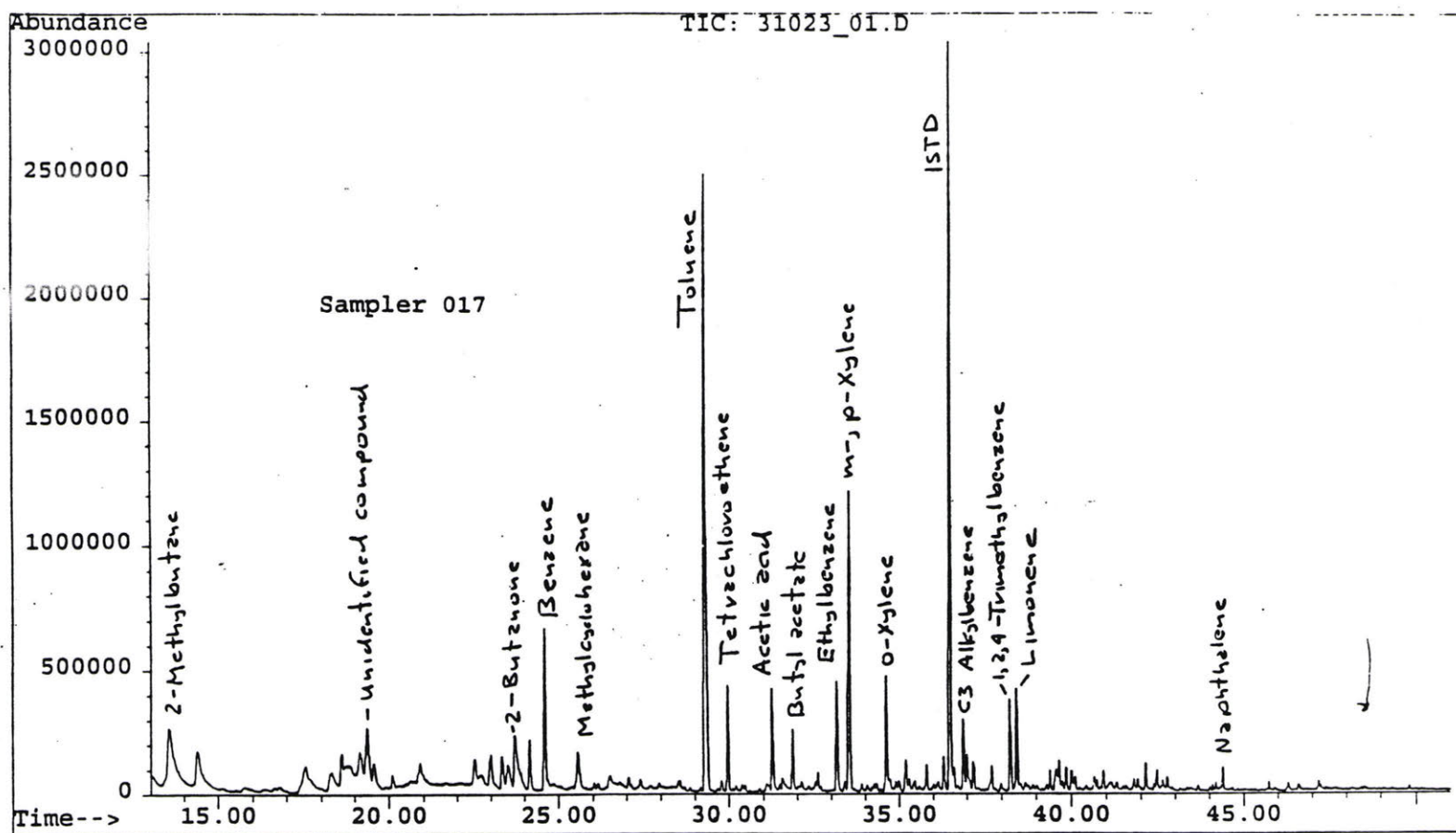


Figure 13. Gas chromatography / mass spectrometry (GCMS) chromatogram of the individual volatile organic compounds measured at Site 8 of the UCSF Mission Center Building located in San Francisco, CA.

Contaminant Control Guidelines For Building Renovation Projects

Renovation Zone. The HVAC system in the renovation zone should be modified to exhaust air from the building directly through window or wall mounted exhaust fans at selected locations to provide a uniform distribution of ventilation air through the renovation zone. This is to protect the return air portion of the ventilation system from contamination. Bathroom and other dedicated exhaust fans may be used.

The renovation zone should be provided with a minimum of 3 air changes per hour outside side during renovation hours. More ventilation may be required for operations involving significant contaminant emissions (e.g. vinyl tile removal using solvents, spray painting). During periods of renovation work not involving significant amounts of solvents usage such as dry wall work the supply of outside air may be shut off at night. Periods of work involving significant solvent usage such as painting and gluing should maintain a minimum of 3 air changes per hour continuously for a 72 hours drying period following completion of the work. The supply of outside air may be provided totally by the HVAC system serving that zone, provided it is operating on 100% outside air with no recirculation so as not to contaminate the supply air portion of the system, or by a separately installed temporary system (e.g. portable system or window fans).

The balance of outside air supply and renovation air exhaust should be set to provide a negative pressure with respect to the adjacent occupied zones of 0.05 inches water gauge. This may be accomplished by either producing a negative pressure in the renovation zone (i.e. a higher exhaust air flow rate than outside air supply flow rate) or a positive pressure in the adjacent occupied zones (i.e. a higher outside air supply flow rate than exhaust air flow rate). Care should be taken to consider maintenance of the 0.05 inches pressure differential between the renovation and occupied zones when the ventilation system supply air flow rates in either zone are changed (e.g. during night time shut down). If the balance of the outside air and exhaust air flow rates in the renovation zone result in a pressure in the

zone which is negative with respect to the outdoor air then care should be taken to assure that there are no vented combustion devices operating (e.g. hot water heaters). Operation of vented combustion devices in a space under negative pressure may result in back drafting of the exhaust flue and potential asphyxiation from carbon monoxide present in the exhaust gas.

All porous materials (e.g. ceiling tiles, partitions, carpeting etc., should be removed from the construction zone during any solvent applications or drying periods to avoid adsorption and subsequent re-emission. Alternatively a limited amount of protection of porous materials may be provided by carefully sealing them with a cover of 6-mil polyethylene plastic.

The indoor temperature during renovation work involving solvent usage such as painting and adhesive application should be maintained at a minimum of 70 °F to expedite drying. In cold months supplementary heaters may need to be installed. Warmer temperatures will expedite drying however temperatures in excess of 85 should be avoided since structural damage from thermal expansion may result in damage to components of the building (e.g. windows, floor tiles, etc.)

Occupied Zone. The outside air supply inlet for the HVAC system in this zone should be checked for possible entrainment of exhaust fumes from the renovation zone. Modifications to the outside air inlet location or the renovation exhaust location should be made if entrainment is suspected or odors are detectable in the vicinity of the outside air inlet.

Since the renovation contaminants are being prevented from entering the occupied zone through differential pressure control the outside air ventilation rates in the occupied zone need not be increased above normal rates (e.g. for office spaces a minimum of 20 cfm/occupant or one air change per hour which ever is greater continuously during all occupied hours). A pressure transducer connected to a data logger an alarm may be set up in the occupied zone to provide surveillance of the 0.05 inches of water gauge positive pressure between the occupied zone and the renovation zone.