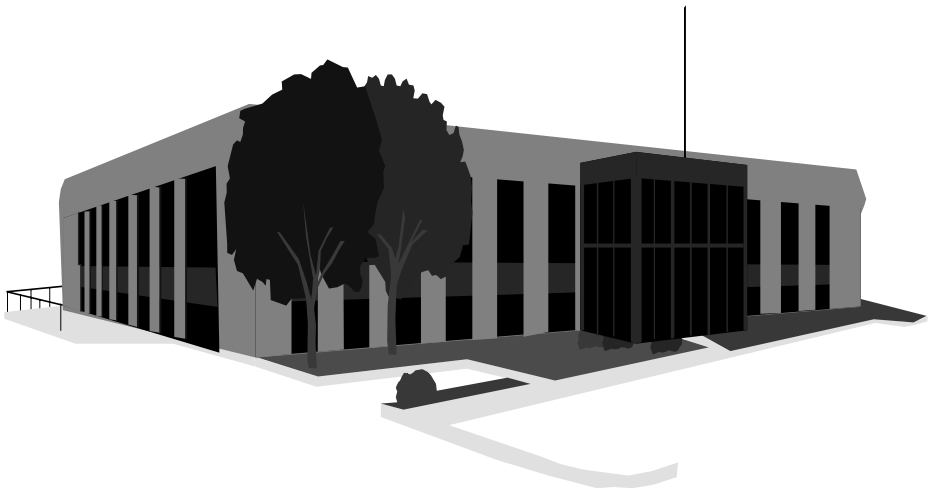
INDOOR AIR QUALITY ASSESSMENT

Sandwich High School
365 Quaker Mtg. House Road
E. Sandwich, Massachusetts



Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
March, 2000

Background/Introduction

As a result of a previous indoor air quality assessment concerning renovations, the Bureau of Environmental Health Assessment (BEHA) conducted an evaluation of the newly constructed wing of Sandwich High School (SHS). The SHS was originally visited by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, and Suzan Donahue, Research Assistant, BEHA, on June 15, 1999, in response to concerns about potential impacts of renovation generated pollutants. A letter was issued giving recommendations on how to improve indoor air quality during renovations (MDPH, 1999). During this first visit, BEHA staff offered to return to the building after the heating season had started and the new wing was completed and occupied.

On February 2, 2000 a follow-up visit was made to SHS by Cory Holmes, Environmental Analyst, ER/IAQ, BEHA. Mr. Holmes was accompanied by Suzan Donahue, Jane Crowley of the Barnstable County Board of Health and for portions of the assessment Kara Peterson, Building Liaison and Frank McDonald, Clerk of the Works. BEHA staff conducted a general indoor air quality assessment in the newly occupied wing and assessed containment of renovations for the occupied areas of the school.

SHS was originally built in 1976-1977 and is currently under renovation while occupied by students, faculty and staff. At the time of the assessment the gymnasium and new addition were complete. Building occupants moved into the new addition two days prior to this assessment. During the assessment, the D-wing was being prepared for renovation. Containment walls were in the process of being erected, which blocks off occupied areas by temporary sheet rock walls. Suspended ceilings in hallways were removed, exposing the ventilation ductwork and the ceiling cavity.

Actions on Previous Recommendations

BEHA had previously made 9 recommendations (in bold) to improve indoor air quality during on-going renovations, a number of these recommendations have been implemented. The following is an update on actions taken in response to BEHA recommendations, based on reports from: Ms. Peterson, members of the SHS teacher's union, Mr. McDonald and/or direct observation by BEHA personnel.

1. **The BEHA recommended that communications be established between all parties involved with building renovations to prevent potential IAQ problems and that a forum be developed for occupants to express concerns about renovations as well as a program to resolve IAQ issues.**

   The current forum for building occupants to relay IAQ concerns is through the Building Liaison who works in conjunction with the Clerk of the Works to resolve issues. BEHA staff also suggested the creation of a form to document time, date, location and nature of specific problems as well as an area for corrective actions taken to resolve IAQ issues. Better communication is needed in this area.

2. **Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors or dust problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.**

   Concerns are relayed to the Building Liaison located in the main office. Notification is conducted via cell phone or in person until classroom phones are operational in the new addition.

3. **When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.**

The Building Liaison states that the contractor has been cooperative in conducting large-scale projects during unoccupied periods or periods of low occupancy.

4. **Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.**

The Building Liaison accompanies the Clerk of the Works to weekly construction meetings where minutes are kept. Due to the nature and complexities of the project, scheduled itinerary is not often available or accurate. Better communication is needed in this area.

5. **Obtain Material Safety Data Sheets (MSDS') for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).**

The teacher's union has filed a grievance in an attempt to gather MSDS sheets. Representatives of the teacher's union reported that the Superintendent's office is attempting to gather MSDS'. Mr. McDonald stated that MSDS' are located in the construction office on-site and that he would speak to the construction supervisor to make them available for review upon request for concerns regarding specific renovation projects.

6. **Consult MSDS' for any material applied to the effected area during renovation including any sealant, carpet adhesive, tile mastic, flooring and roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.**

This is an on-going practice that should be strictly followed by all contractors and subcontractors working on various stages of renovations.

7. **Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the buildings HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems (when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).**

As stated previously, during the visit preparations were being made to start a new phase of renovation in D-wing and containment barriers were in the process of being erected. BEHA staff gave Ms. Peterson and Mr. McDonald several recommendations to improve containment and control of renovation pollutants (see **Renovations** section). AHUs supplying ventilation to D-wing have been deactivated. These ventilation components supply ventilation solely to D-wing

and are not connected to other portions of the building; thus renovation pollutants would not be expected to migrate into occupied areas via ventilation system ductwork.

8. **If possible, relocate susceptible persons and those with pre-existing medical conditions (i.e. hypersensitivity, asthma) away from areas of renovations.**

Both the Building Liaison and teacher's union members stated that one symptomatic individual has taken early retirement. Improved communication regarding scheduled itinerary of renovation projects is needed to coordinate the relocation of other sensitive individuals (i.e., teachers and students).

9. **Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This may include constructing barriers, sealing off areas and temporarily relocating furniture and supplies. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.**

SHS maintenance staff have been using a granular floor-cleaning material, which is designed to "knock down" and control for dust. In addition to this, BEHA staff re-iterated the importance of construction barriers, negative ventilation and wet wiping of all surfaces.

During the previous visit BEHA staff also recommended that the chemical composition of spray-on insulation material located above ceiling tiles be identified. As reported by the

Building Liaison and members of the teacher's union, the material observed above ceiling tiles has been identified as cellulose spray-on insulation.

The BEHA recommends that the above steps be taken during any renovation project within a building and are applicable to all subsequent phases of the project.

Methods

In addition to visual assessment of improvements previously recommended, BEHA staff conducted a number of tests as part of the current IAQ assessment. Air tests for carbon dioxide were taken with the Telaire, Carbon Dioxide Monitor and tests for temperature and relative humidity were taken with the Mannix, TH Pen PTH8708 Thermo-Hygrometer. Screening for total volatile organic compounds (TVOCs) was conducted using an HNU Systems, Photo Ionization Detector (PID). Samples for TVOCs were taken in several areas in the building with a focus on areas that would most likely be impacted by renovation activities. Outdoor background total volatile organic compound measurements were taken for comparison to indoor levels. Tests for carbon monoxide (CO) were taken using the Biosystems, PhD2 Atmospheric Monitor. CO measurements were taken at several locations inside the building as well as outside for comparison to indoor levels.

Results

The school has a student population of approximately 950 and a staff of approximately 120. Tests were taken under normal operating conditions. Test results appear in Tables 1-6. Sampling for carbon monoxide, carbon dioxide, temperature and relative humidity were also conducted by the Barnstable County Board of Health and are included as Appendix A.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million (ppm) in fourteen of twenty-seven areas surveyed in the new wing; and in all areas tested in the old wing, which is indicative of a ventilation problem in these areas. However, as mentioned previously the new wing had only been occupied two days prior to the assessment and the ventilation system was still in the process of being calibrated/balanced. According to Mr. McDonald, a full balancing report will be issued by the HVAC contractor upon completion.

The new addition at SHS has a centralized HVAC system consisting of two roof-mounted air-handling units (AHUs), one used for heating and one for cooling (see Picture 1). Fresh heated or cooled air is provided by the AHUs to classrooms and common areas via ceiling-mounted air diffusers connected to ductwork. According to Mr. McDonald, the AHUs are set to provide 30 percent fresh air. Each classroom is provided with a return vent connected to ductwork back to the AHU. In addition, each classroom has two fan-coil units mounted on the exterior wall that facilitate airflow. A high-pitched noise in the rooftop ventilation system was reported by an occupant of room A312, which may indicate a mechanical problem or malfunction.

Elevated carbon dioxide levels were found in all second floor classrooms tested in the old wing. BEHA staff examined rooftop AHUs providing ventilation to this area and found the fresh air intakes closed (see Picture 2). According to several school sources, on extremely cold days members of the school maintenance staff physically close fresh air intakes on the units to conserve heat. Reportedly, when fresh air intakes are left open this area experiences numerous complaints of cold temperatures. Each classroom is also provided with a return vent that is ducted back to the AHU. These AHUs are tentatively scheduled for replacement during subsequent phases of the renovation.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (BOCA, 1993, SBBRS, 1997). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the

evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings were within a range of 70^0F to 80^0F, which is close to BEHA's recommended comfort guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^0F to 78^0F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Heat complaints in classrooms on the second floor of the old wing were reported to BEHA staff. These areas were above or close to the higher end of the BEHA comfort range. As mentioned previously, fresh air intakes on the rooftop AHUs were physically shut, which can lead to increased temperatures in areas serviced by this system. This results in classroom air being returned to the AHU to be re-heated. With the fresh air intake shut, no cold outside air is introduced into the system creating a closed loop, resulting in increased temperatures.

The relative humidity in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 2 to 11 percent. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Active roof leaks were reported to BEHA staff in the hallway of the English department, the back room of the English department and in several areas of D-wing. The entire roof was replaced during previous phases of the renovation, with the exception of areas above the old wing where rooftop HVAC equipment is slated for replacement. Active leaks are frequently experienced after new rooftop installation. It is important for school personnel to work with the roofing contractor to identify and localize active leaks so that they can be repaired. Water-stained ceiling tiles are evidence of roof or plumbing leaks. Water-damaged ceiling tiles can provide a source of mold and mildew and should be replaced after a water leak is discovered and repaired. Mold can be a respiratory irritant for certain sensitive individuals.

Several classrooms had a number of plants. Moistened plant soil and drip pans can serve as a source of mold growth. Several classrooms had flowering plants on top of fan coil units. Plants should be equipped with drip pans and located away from the air stream of fan coil units to prevent the aerosolization of dirt, pollen or mold.

Water coolers were placed on carpets in the 1st and 2nd floor teachers' lounges. To avoid water damage to carpeting and/or potential mold growth, a water-resistant material such as plastic or rubber matting should be installed beneath water coolers.

Renovations

While containment walls have been erected in several areas, the sealing of these areas was not complete (see Pictures 3 & 4). BEHA staff recommended the installation of plastic sheeting on both sheet-rock barriers separating the construction zone from occupied areas on the first and second floors of D-wing. These barriers should be made as airtight as possible to prevent the migration of construction-generated dusts and odors into occupied

areas. BEHA staff also recommended that weather-stripping or foam insulation be installed to seal spaces around containment wall access doors. Other precautions would be to close internal doors inside the construction zone (see Picture 5) and/or the strategic placement of fans to direct renovation pollutants away from occupied areas. Also located in the construction zone on the second floor was a door providing entry into the auditorium (see Picture 6). BEHA staff recommended that the door be sealed on both the construction side as well as the auditorium side with plastic sheeting and duct tape to provide a duel barrier. In all of these cases, the complete sealing of construction barriers, the closing of internal doors and the placement of fans in renovation areas should be done to prevent construction-related pollutants from penetrating into occupied areas.

Ceiling tiles in a number of classrooms have been removed as part of the renovations. Ajar or missing ceiling tiles can result in the introduction of accumulated dirt, dust and debris into occupied areas. These materials can provide a source of eye and respiratory irritation to sensitive individuals

Renovation activities were being conducted in a number of classrooms flanking the second floor of the old building. None of the classroom doors were sealed to prevent the migration of renovation pollutants into occupied areas of the school.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. Carbon monoxide (CO) and TVOCs readings within the building were found to be equal to or below levels measured outdoors in all occupied areas surveyed. This indicates no unusual sources of either CO or TVOCs in the building. While there were noticeable odors from new carpet, new furnishings, painting, etc., it would seem that any VOCs, which may have been present, have dissipated, leaving only nuisance odors behind.

A TVOC measurement of 2.0 ppm was recorded inside the construction zone of the first floor of D-wing. The area where this measurement was sampled had a distinctive citrus odor. This odor was attributed to a citrus cleaner that was applied in the area. Several classrooms contained dry erase boards and dry erase board markers. Materials such as dry erase markers and dry erase board cleaners may contain volatile organic compounds (VOCs), such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999). Cleaning products and dry erase board markers and cleaners can be irritating to the eyes, nose and throat.

Conclusions/Recommendations

Renovations

BEHA recommendations to maintain indoor air quality during renovations are universal and should be applied during subsequent phases of renovation. In addition to the previous recommendations made by the BEHA (MDPH, 1999) the following recommendations should serve to decrease the impact of renovation-produced pollutants.

1. Improve communications between all parties involved with building renovations to prevent potential IAQ problems. In addition to the building liaison, consider developing a form to document time, date, location and nature of specific problems as well as an area for corrective actions taken to resolve IAQ issues.
2. Continue to utilize cell phones to communicate problems to the building liaison in areas where classroom phones are not yet operational.
3. Improve communications regarding the scheduled itinerary of renovation projects which produce large amounts of dusts, odors and emissions in order to coordinate

the relocation of susceptible persons and those with pre-existing medical conditions (i.e. hypersensitivity, asthma).

4. The complete sealing of construction barriers, the closing of internal doors and the placement of fans in renovation areas should be done to prevent construction-related pollutants from penetrating into occupied areas.
5. Seal auditorium door on both the construction and occupied sides with plastic and duct tape.
6. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. Consider purchasing a HEPA filter equipped vacuum cleaner and instituting the wet wiping of all surfaces in conjunction with current maintenance procedures.
7. Close windows adjacent to construction activities to prevent unfiltered air from entering the building.

General Indoor Air Quality

In view of the findings at the time of our inspection, the following recommendations are made to improve general indoor air quality:

1. Continue with plans to calibrate and balance the HVAC system in the new addition. Consider increasing the percentage of fresh air intake.
2. Until existing AHUs servicing the old building are replaced, consider contacting an HVAC engineer to examine the fresh air intakes for repair and increase the percentage of fresh air intake if possible.
3. Remove all obstructions from fan-coil unit air diffusers and return vents to facilitate airflow.

4. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
5. Repair any existing water leaks and replace any water-stained ceiling tiles. Examine the areas above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.
6. Move plants away from fan-coil units in classrooms. Ensure drip pans are placed underneath plants. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
7. Relocate or place tile or rubber matting underneath water coolers in the 1st and 2nd floor teacher's lounges.
8. Inspect roof for proper drainage. Examine the roof periodically for standing water.
9. Refrain from using strong scented materials. Ensure all spray bottles containing cleaning products are properly labeled for identification purposes in the event of an emergency

References

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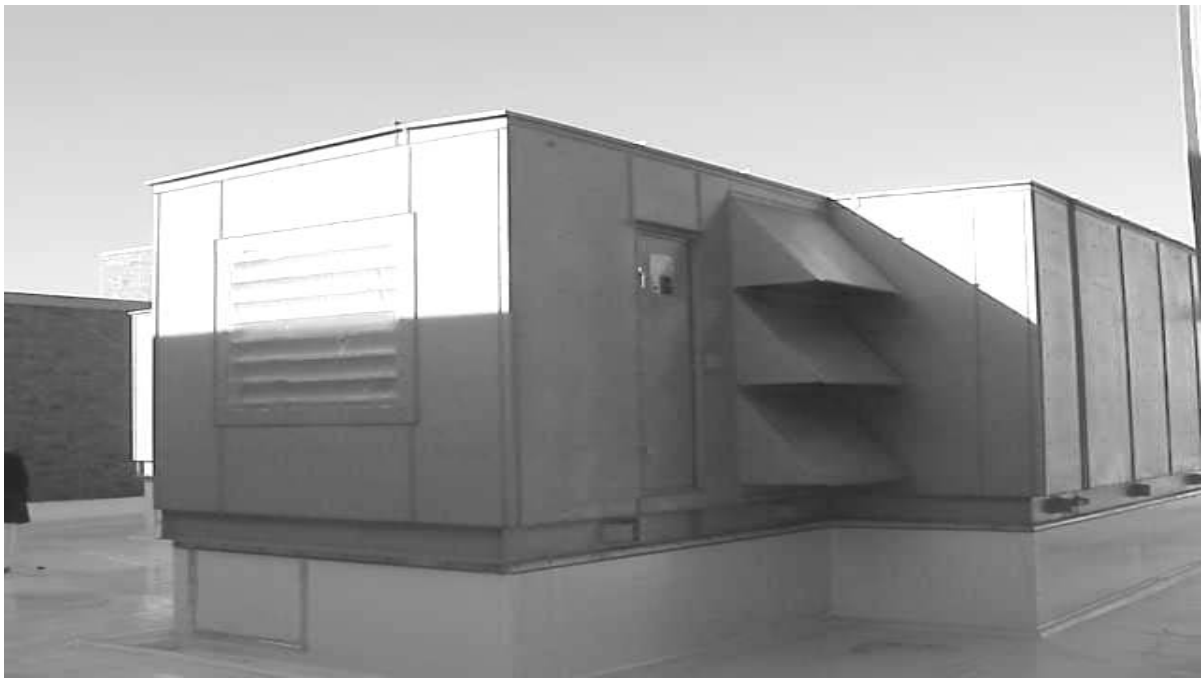
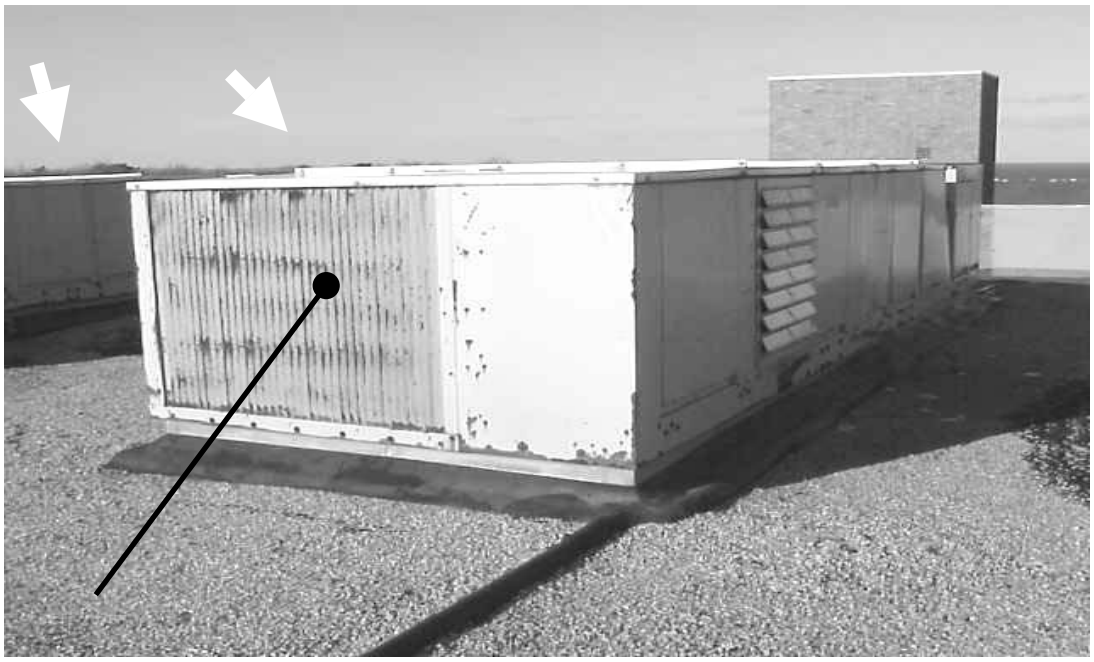
SMACNA. 1995. IAQ Guidelines for Occupied Buildings Under Construction. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

Picture 1



Air-Handling Unit for the New Addition, Sandwich H.S.

Picture 2



fresh air intake noted shut

Air-Handling Units (AHUs) for the Old Building, Sandwich H.S. Scheduled for Replacement Spring 2,000

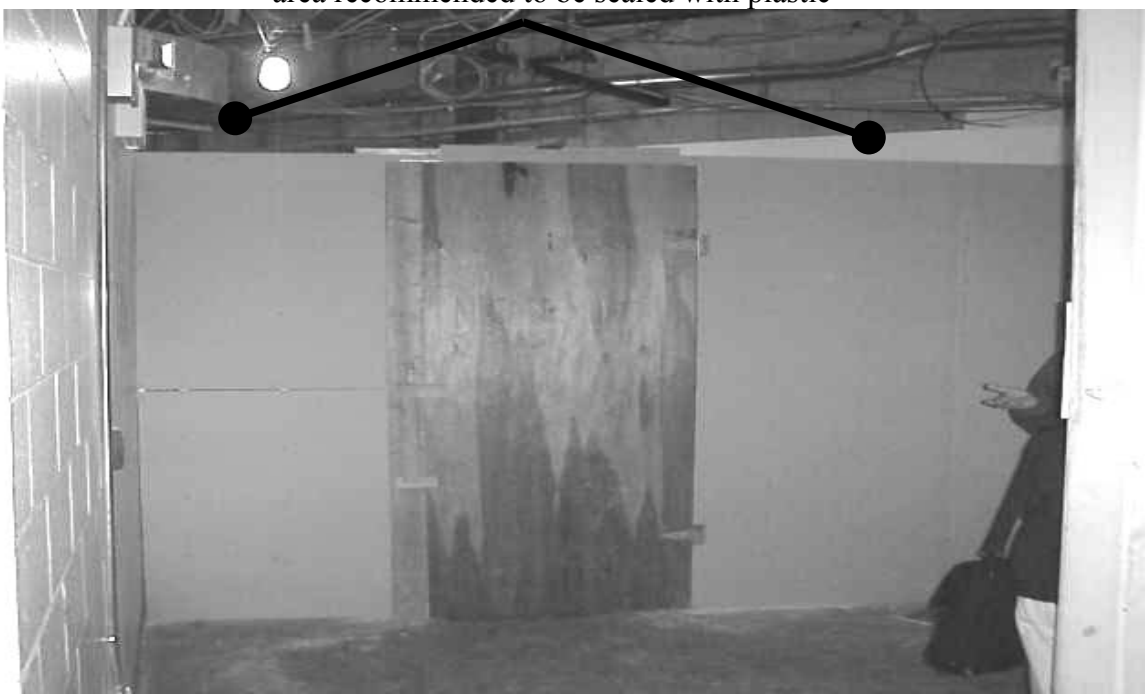
Picture 3

areas recommended to be sealed with plastic

Containment Barrier Separating Construction Zone from Occupied Areas
Note Removed Ceiling Tiles and Spaces above Containment Wall

Picture 4

area recommended to be sealed with plastic



Containment Barrier Separating Construction Zone from Occupied Areas
Note Removed Ceiling Tiles and Spaces above Containment Wall

Picture 5

Interior Doors Located In Construction Zone

Picture 6

Auditorium Doors Noted in Construction Zone on 2nd Floor of D-wing

TABLE 1

Indoor Air Test Results –Sandwich High School, Sandwich, MA – February 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	412	34	27					weather conditions: clear, sunny, breezy-NW wind 5-10 mph, TVOCs 0.3 ppm, CO 0 ppm
D-Wing Construction Zone First Floor								Sheet-rock containment barrier, spaces above wall, CTs removed, spaces around access door, TVOCs 2.0 ppm-citrus odor
D-Wing Construction Zone Second Floor								Sheet-rock containment barrier, spaces above wall, CTs removed, spaces around access door, auditorium doors-not sealed
Library	654	70	4	9	no	yes		plants, carpet
204	1119	72	11	25	no	yes	yes	carpet, chalk dust
A301	575	73	5	6	yes	yes	yes	photocopier
A303	832	73	7	19	yes	yes	yes	
A305	828	73	5	5	yes	yes	yes	plant

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results –Sandwich High School, Sandwich, MA – February 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
A309	721	71	5	1	yes	yes	no	
A201	682	71	6	14	yes	yes	yes	
A203	816	73	9	22	yes	yes	yes	dry erase board cleaner in use
A205	977	74	10	21	yes	yes	yes	1of 2 fan coil units blocked by books-off
A213	790	76	4	1	no	yes	yes	2 ceiling mounted air supply diffusers-off, carpet
A207	824	75	5	20	yes	yes	yes	
A209	624	73	5	1	yes	yes	no	plants over fan coil unit
A107	803	72	7	26	yes	yes	yes	1 of 2 fan coil unit return blocked by file cabinet
A105	1048	75	9	22	yes	yes	yes	3 computers, 1 of 2 fan coil unit return by file cabinet
A100/101	730	72	5	9	no	yes		room divider-open, 2 of 3 ceiling mounted air diffusers on, exhaust around light fixtures

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TABLE 3

Indoor Air Test Results –Sandwich High School, Sandwich, MA – February 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Auditorium	656	70	7	~50	no			carpet, upholstered seats, supply/exhaust reported off-AHU not functioning
C139	1095	74	7	5	no	yes	no	2 ceiling mounted air diffusers-off, 2 plants, chalk dust, dry erase board,
C-Wing Guidance Offices	673	74-78	4-10	3	yes/no	yes	yes	3 perimeter offices-openable windows, central main office-no windows, 15+ missing ceiling tiles, photocopier, printers, exhaust-off, 3 ceiling mounted air diffusers, heat complaints
A302	560	71	2	2	yes	yes	yes	1 of 2 fan coil units-off, door open
A312	559	71	8	1	yes	yes	yes	high-pitched noise from AHU
A303	1160	74	7	20	yes	yes	yes	1 of 2 fan coil units-off
A306	1420	75	9	32	yes	yes	yes	
A307	866	75	6	17	yes	yes	yes	2 fan coil units-off

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TABLE 4

Indoor Air Test Results –Sandwich High School, Sandwich, MA – February 2, 2000

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
A208	648	72	3	1	yes	yes	yes	1 of 2 fan coil units turned off due to rattling
A210	974	72	5	15	yes	yes	yes	
A206	830	74	4	9	yes	yes	yes	1 of 2 fan coil units-off, door open
A204	850	74	5	14	yes	yes	yes	1 of 2 fan coil units-off
A202	980	74	6	22	yes	yes	yes	
A108	787	74	5	10	yes	yes	yes	
202	1400	78	10	29	no	yes	yes	door open
206	1372	80	9	0	no	yes	yes	(20+) occupants gone ~5 mins.208
208	1346	79	8	1	no	yes	yes	(20) occupants gone ~5 mins. door open
210	1154	76	7	1	yes	yes	yes	(18) occupants gone recently left, door open
213	1053	79	7	1	no	yes	yes	

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TABLE 5

Indoor Air Test Results –Sandwich High School, Sandwich, MA – February 2, 2000

*** ppm = parts per million parts of air**
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Comfort Guidelines	
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Temperature -	70 - 78 °F
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