INDOOR AIR QUALITY ASSESSMENT

Chicopee Public Safety Building
Fire Department Headquarters
80 Church Street
Chicopee, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program

March 2003

Background/Introduction

In response to a request from Louise Hebert, Chicopee Board of Health, an indoor air quality assessment was done at the Chicopee Public Safety Building, Chicopee Fire Department Headquarters, 80 Church Street, Chicopee, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) as part of an overall evaluation of the Chicopee Public Safety Building.

A visit was made to the building by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ) on July 11, 2002. The Chicopee Public Safety Complex (CPSC) is a multistory complex that is divided into three sections: the Chicopee Fire Headquarters/Fire Station (the fire station), Chicopee Police Headquarters and Emergency Operations Center/Board of Health Offices (EOC/BOH). Since each section has separate functions and have separate heating, ventilating and air conditioning (HVAC) systems, a separate report was written assessing indoor air quality of the fire station and police station. The subject of this report are the indoor environmental conditions of the fire station.

The CPSC was constructed in 1976. The fire station is a three-story structure in the northern portion of the CPSC, with the EOC/BOH on its south wall (see Figure 1). The second floor of the fire station contains the bunkhouse, kitchen, alarm room, recreation room and showers/restrooms. The first floor houses the engine bays and fire department offices. The ground floor contains the fire equipment repair shop with three engine bays. No openable windows exist in this structure.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The fire station has a population of greater than 10 employees on a daily basis. The tests were taken under normal operating conditions. Test results appear in Tables 1-3.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were below 800 parts per million parts of air [ppm] in all areas sampled. These carbon dioxide levels indicate that an adequate fresh air supply exists.

The fire station has a rooftop air-handling unit (AHU) designed to supply fresh air (see Picture 1). The AHU appears to provide fresh air supply and/or exhaust ventilation for multiple areas on multiple floors of the building. Shower areas/restrooms have local dedicated exhaust vent systems. The first floor has a specially designed exhaust ventilation system for operating fire engines and related vehicles (see Picture 2). The ground floor repair shop also has specially designed exhaust fans (see Picture 3) that were not activated during the assessment.

A large Trane® AHU supplies air to all areas of the second floor and the Fire Department administrative offices on the first floor. Exhaust air is vented from the AHU through vents on the AHU casing.

The Trane® AHU is connected by ductwork to wall or ceiling-mounted fresh air diffusers. Many fresh air diffusers in bunkhouse rooms were sealed with cardboard or newspaper (see Picture 4), indicating either poor temperature control or that drafts from the fresh air diffusers were directed onto individuals sleeping in the room. Since each bunkhouse room is serviced by the AHU by common ductwork, the sealing of one fresh air diffuser results in an *increase* of air delivery to other bunkhouse rooms, creating an imbalance in the ventilation system.

The Trane® AHU had its fresh air intake louvers closed. This condition results in the constant recirculation of air. The closing of the fresh air vent also results in the minimization of air exhausted from the AHU. As the return air louvers are restricted, air volume builds and pressurizes the pre-louver chamber, forcing return air out through two passive louver vents (see Picture 5). With the return air vent fully open (100 percent) and the fresh air intake restricted, no positive air pressure is created and no air is exhausted from the AHU. Without dilution and removal, environmental pollutants present inside the building can build up and be redistributed throughout the second floor.

The orientation of the Trane® AHU can produce conditions that allow for uncontrolled entrainment of cold air during winter through the passive exhaust vent. The passive exhaust vents face north and south. Prevailing winter winds are generally of a northwestern orientation. As NW winds blow across the face of the Trane® AHU, this airflow can lift the edge of the passive vents and force air in an uncontrolled manner into the return air chamber. The condition is enhanced by lifting of the exhaust vent louvers when return vent louvers restrict airflow. Adjustment to increase fresh air intake would be expected to result in the exhaust vent louvers flapping in a westerly breeze. In the winter this condition can introduce cold air that may result in the AHU coils freezing.

During warm, humid weather, uncontrolled air introduction can result in increased condensation inside the Trane® AHU cabinet.

Restrooms, storage areas, showers and the former oxygen bottle filling machine room have special dedicated exhaust ventilation systems that are separate from the general HVAC system. An examination of rooftop exhaust vents found three of eight exhaust motors deactivated. Without exhaust ventilation, environmental pollutants in these areas are not removed, which can lead to indoor air quality/comfort complaints.

In order to have proper ventilation with a mechanical supply and exhaust system, these systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air. The date of the last servicing and balancing of these systems could not be identified at the time of the evaluation. Industrial standards for ventilation recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). 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 happens 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. For more information concerning carbon dioxide, please consult Appendix I.

Temperature readings ranged from 71^{o} to 75^{o} F, which were within the BEHA recommended guidelines. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} to 78^{o} F 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. It is also difficult to control temperature without the mechanical ventilation system functioning properly (e.g. intake louvers shut/minimal exhaust).

Relative humidity measured in the building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 31 to 37 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. It is important to note however, that relative humidity measured indoors exceeded outdoor measurements (range +1-6 percent). This increase in relative humidity can indicate that the exhaust system alone is not operating sufficiently to remove normal indoor air pollutants (e.g., water vapor from respiration, cooking and drying fire equipment). Moisture removal is important since the sensation of heat conditions increases as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter. If moisture is removed, the comfort of the individuals is increased. Removal of moisture from the air, however, can have some negative effects. 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 Growth/Moisture Concern

Water damage to ceiling tiles exists in several areas on the second floor. Ceiling tiles, acoustical tiles and plywood are porous materials that can serve as mold growth media if moistened.

Other Concerns

Under normal conditions, a firehouse can have several sources of environmental pollutants present from the operation of fire vehicles. Sources of such pollutants can include:

- Vehicle exhaust containing carbon monoxide and soot;
- Vapors from diesel fuel, motor oil and other vehicle liquids which contain volatile organic compounds;
- Water vapor from drying equipment;
- Rubber odors from new vehicle tires; and
- Residues from fires on vehicles, hoses and fire-turnout gear.

Of particular importance is vehicle exhaust. The firehouse is equipped with a mechanical exhaust system to remove exhaust from the engine bays during vehicle idling. Each fire engine is connected to the mechanical ventilation exhaust system by using a flexible hose (see Picture 6). As the mechanical exhaust vent system operates, vehicle exhaust is drawn to a fan motor. A number of pathways exist for odors and other pollutants from the first floor engine bay into the offices and second floor.

- The doors between the engine bays and reception office have spaces in the doorframe when closed.
- The gaskets on the clamshell doors that seal around the fire pole in the ceiling has spaces when closed. (see Picture 7).
- The ceiling of the engine bays is penetrated by holes for utilities (see Picture 8). These holes are not sealed.

Each of these conditions present pathways for air to move from the engine bays to the reception office and second floor. As motor vehicles operate indoors, the production of exhaust in combination with cold air moving from outdoors through open exterior doors into the warmer engine bays can place the garage under positive pressure. Positive pressure within a room will force air and pollutants through spaces around doors, utility pipes and other holes in walls, doors and ceilings. To reduce airflow into the second floor, sealing of pollutant pathways to the second floor should be considered.

Periodic odors are reported in and around the alarm room area. A cabinet containing electrical wire exists in the alarm storeroom (see Picture 9). This electrical wire penetrates into the floor cavity. A similar hole exists in the ceiling of the former oxygen cylinder filling room locate near the rear of the ground floor garage (see Picture 10). In order to explain how odor generated in the garage may be migrating into the second floor, the following concepts concerning air, pressurization and behavior of vapors/fumes/dusts heated air and fossil fuel exhaust must be understood.

1. Heated air will create upward air movement (called the stack effect).
2. Westerly winds blowing into the garage through open bay doors, this airflow pressurizes the ground floor.
3. Air in the garage is heated by operation of electrical equipment (intended or otherwise).
4. Cold air moves to hot air, which creates drafts.
5. As heated air rises, negative pressure is created, which draws cold air to the equipment creating heat (e.g., fluorescent light bulbs, radio equipment).
6. Airflow is created, intended or otherwise, from items that produces heat (e.g., fluorescent light bulbs).
7. Combusted fossil fuels contain heat, gasses and particulates that will rise in air. In addition, the more heated air becomes, the greater airflow increases.
8. Airflow created by the stack effect, drafts or mechanical ventilation can draw particulates into the air stream.

Each of these concepts has influence on the movement of odors from the garage into the alarm room. The opening in the box within the alarm room and in the ceiling of the former oxygen cylinder filling room forms a pathway within the internal wall space for garage air and odors to travel upward into the building interior. This pathway may allow for garage odors to penetrate through seams or hole interior walls in upper floors, particularly through large openings in the floor like that shown in Picture 9. The exhaust vent in the oxygen cylinder room was not drawing air. If this exhaust vent was operating, then the migration of odor upwards through the ceiling hole may be reduced.

The alarm room storeroom has a carpeted floor. Located on the floor of this room is a rack of acid batteries used for backup power for electrical systems (see Picture 11). Carpeting in battery storerooms is ***not recommended*** as a floor covering for several health and safety reasons. Of important note is the possibility of the carpet becoming contaminated by chemical spills. A carpet contaminated with chemicals may also serve as a reservoir for off-gassing of irritating substances. Once contaminated with chemicals, cleaning of the carpet is not a viable option. At sufficient levels, contaminated surfaces of the carpet would be considered as a hazardous waste, requiring disposal in a manner consistent with Massachusetts hazardous waste laws and regulations. Of further concern is the interaction of spilled chemicals with the constituent materials of the carpet itself. Frequently, carpet consists of man-made materials (i.e., synthetic fibers). If contaminated with an organic solvent of strong acid, synthetic fiber may breakdown into its constituent chemicals, resulting in the release of hazardous materials. Some chemicals may react violently with synthetic materials resulting in fire. For these reasons a smooth, nonporous, nonflammable floor covering is preferred in a battery storeroom.

Conclusions/Recommendations

In view of these findings at the time of the visit, the following recommendations are made:

1. Examine the feasibility of installing a protective hood over the AHU exhaust vent to prevent flapping and to limit uncontrolled fresh air entrainment.
2. Avoid sealing fresh air diffuser in the bunkhouse. Consider repositioning beds or installing alternatively designed fresh air diffusers to direct the air stream away from sleeping occupants.

3. Repair exhaust vents on roof if necessary. Operate exhaust ventilation in all areas of the building.
4. Seal utility holes in the walls and ceiling of the engine bays.
5. Repair firepole clam shell doors to form as airtight a seal as possible.
6. Install weather stripping along the doorframe and a door sweep on the underside of all doors that access the first floor engine bays and ground floor garage.
7. Render airtight the hole in the ceiling of the former oxygen cylinder filling room to prevent garage odors from penetrating into the building interior wall space.
8. Render the hole in the floor of the alarm room storeroom airtight.
9. 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. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
10. Replace water damaged ceiling tiles.
11. Examine the feasibility of ducting the kitchen stove hood outdoors.
12. Consider installing a window mounted exhaust vent fan near the turnout gear racks to remove any residual odors.

References

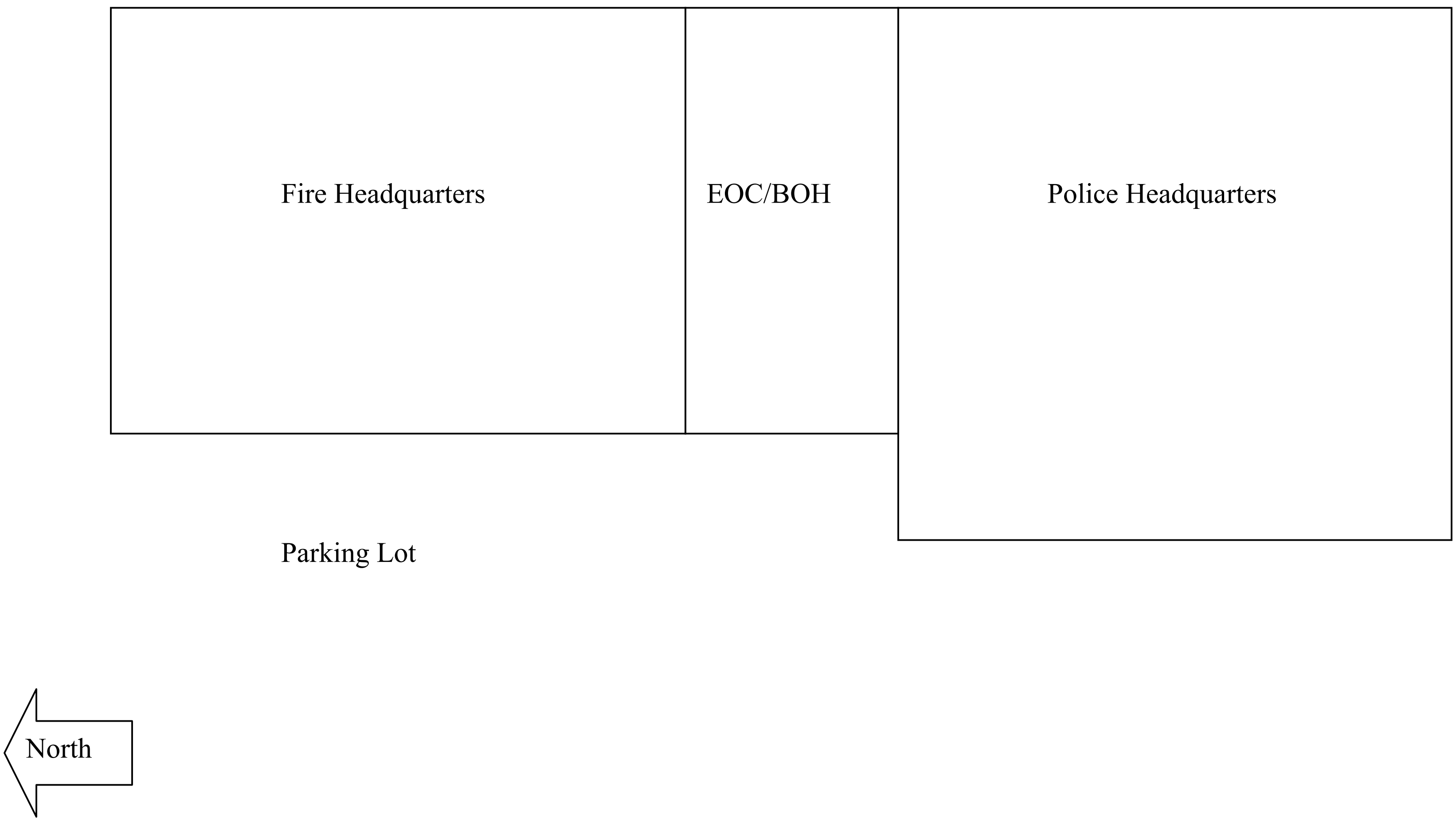
BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL. M-308.1

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, WV.

Figure 1
Configuration of Chicopee Public Safety Building



Drawing Not to Scale

Picture 1

Rooftop AHU

Picture 2

Special Design Vehicle Exhaust Removal System for Operating Fire Engines and Related Vehicles

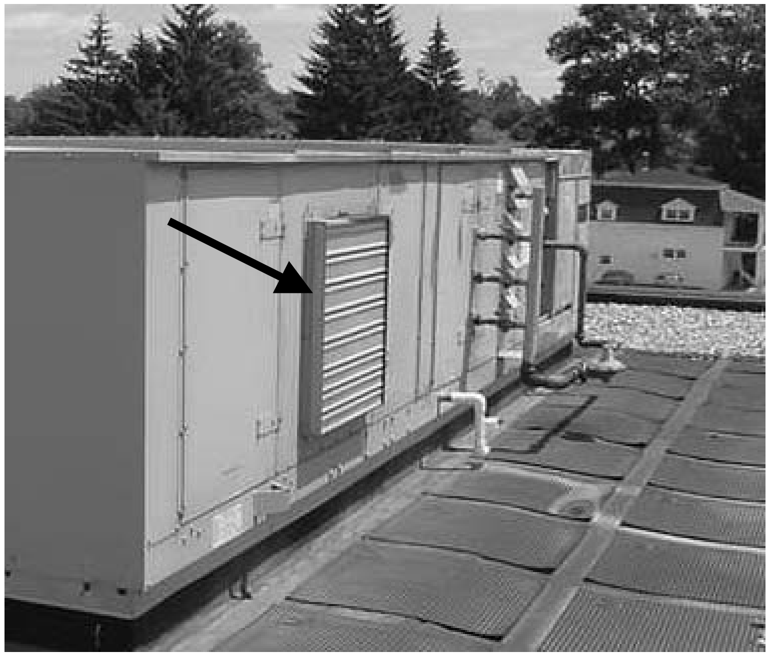
Picture 3

Ventilation System for Repair Shop

Picture 4

Fresh Air Diffusers in Bunkhouse Sealed with Cardboard or Newspaper

Picture 5



AHU Passive Louver Vents

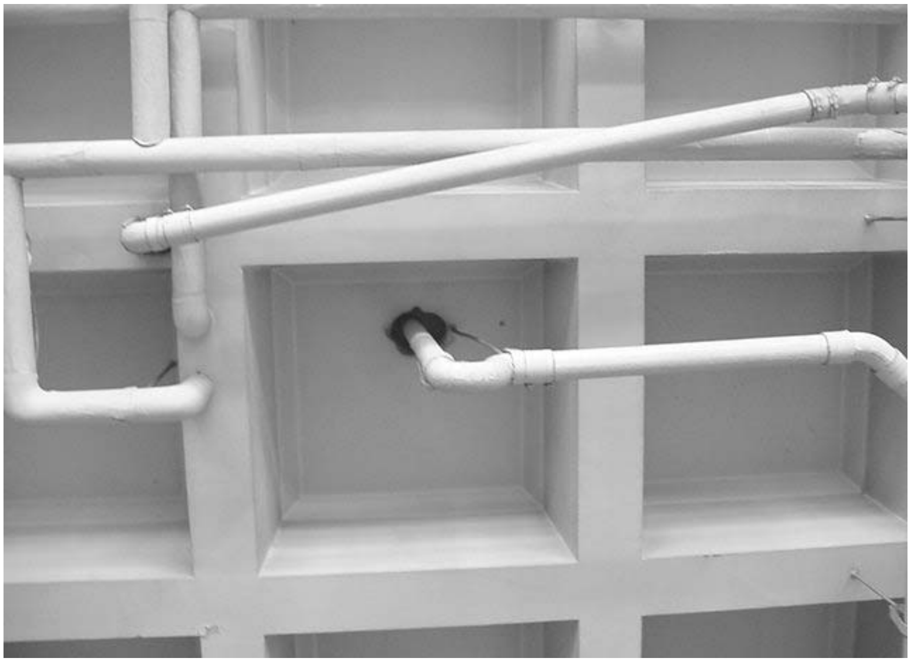
Picture 6

Flexible Hose for Vehicle Exhaust Removal System

Picture 7

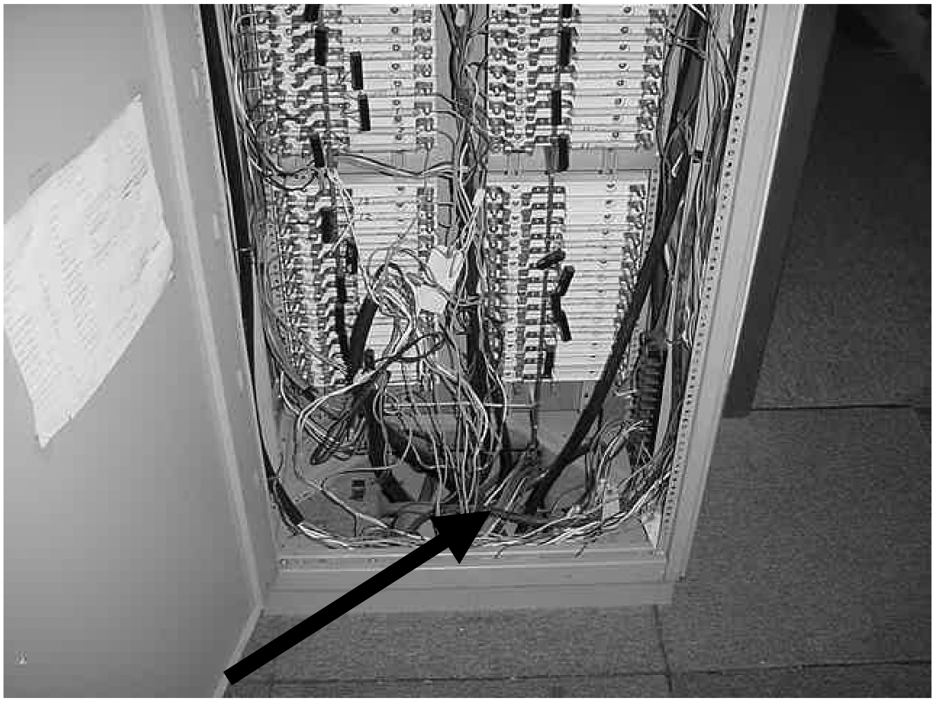
Clamshell Door Does Not Seal Around the Fire Pole

Picture 8



Ceiling of the Engine Bays Is Penetrated By Holes for Utilities

Picture 9



Cabinet Containing Electrical Wire In the Alarm Storeroom, Note Hole in Floor

Picture 10

Hole in the Ceiling of the Former Oxygen Cylinder Filling Room on Garage Level

Picture 11

Acid Batteries in Alarm Storeroom

TABLE 1

Indoor Air Test Results – Chicopee Public Safety Building - Fire Station - Chicopee, MA – July 11, 2002

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	419	73	31					
Room 2	523	74	30	0	N	Y	Y	CT 4 Door open
Room 3	491	73	30	0	N	Y	Y	Door open
Room 4	495	73	31	0	N	Y	Y	Door open
Hallway					N			Water bubbler above carpet
Room 5	484	73	31	0	N	Y	Y	Door open
Room 6	490	73	32	0	N	Y	Y	Newspaper blocking supply Door open
Room 7	488	73	33	0	N	Y	Y	Newspaper blocking supply Door open
Room 8	472	72	33	0	N	Y	Y	CT 1 Door open
Room 9	474	72	33	0	N			CT 4 Door open

*** 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 – Chicopee Public Safety Building - Fire Station - Chicopee, MA – July 11, 2002

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Room 10	479	72	34	0	N	Y	Y	Door open
Dining Area	498	72	34	0		Y	Y	Kitchen hood - no vent to outdoors Door open
Recreation Room	725	73	35	7	N	Y	Y	5 refrigerators Door open
Room 11	482	72	35	0	N	Y	Y	CT 1 Supply covered with cardboard
Room 12	490	71	35	0	N	Y	Y	
Room 13	484	71	35		N	Y	Y	
Alarm Room	483	72	36		N	Y	Y	Radio equipment
Storage Room					N		Y	Hole in floor to lower levels 19 Nickel-Cadmium batteries
Classroom 1	506	72	33		N	Y	Y	
Chief office	574	73	36	1	N	Y	Y	Plants Door open

*** 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 3

Indoor Air Test Results – Chicopee Public Safety Building - Fire Station - Chicopee, MA – July 11, 2002

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Fire Prevention	610	73	35	1	N	Y	Y	Door open
Laboratory	561	73	36	1	N	Y	Y	CT 1 Plant on sink
Secretary/Clerk Front Office	549	73	35	1	N	Y	Y	
Secretary Clerks Office	541	72	35	2	N	Y	Y	Plants Photocopier – door open
Watch Room	536	71	36	0	N			
Engine Room	478	75	37	0	N	Y	Y	8 vehicles
Department Chief	480	73	37	1	N	Y	Y	Door open
Maintenance Garage	419	73	33	1	N			2 vehicles, exterior garage doors open

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

Comfort Guidelines
tiles

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