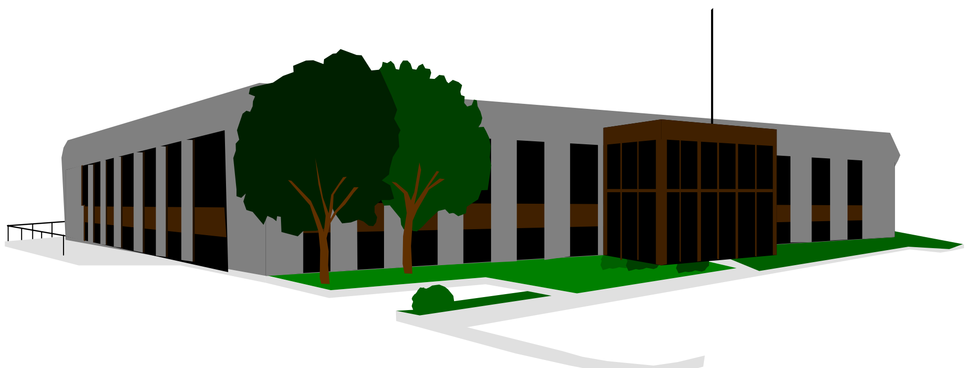
INDOOR AIR QUALITY ASSESSMENT

Leominster High School
122 Granite Street
Leominster, Massachusetts



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Bureau of Environmental Health Assessment
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Background/Introduction

At the request of a parent and the Leominster Board of Health, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) was asked to provide assistance and consultation regarding indoor air quality issues and health concerns at Leominster High School.

On October 29, 1999, a visit was made to this school by Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, to conduct an indoor air quality assessment. Mr. Feeney was accompanied by Robert Carlson of the Leominster Health Department, David Gentile, Leominster High School Head Custodian and for parts of the assessment, David Wood, Leominster School Department Director of Facilities. Due to the size of the school, a subsequent visit was made on November 9, 1999.

The school is a two story brick building constructed in 1963. The B and D wings were added to the building in 1978. The Center for Technical Education (CTE) (F wing), that contains vocational education programs, is a single floor structure that was added to the complex in 1990. The original building contains general classrooms, science area, art rooms, band room, auditorium, library, cafeteria, electronics soldering shop and metal working shop. The B and D wings contain general classrooms. The CTE contains a welding shop, autobody shop, auto mechanics shop, electrical shop, wood shop, plumbing shop, training kitchen with restaurant and general classrooms for each shop area. The gymnasium and physical education areas were not evaluated during these assessments.

Prior to this evaluation, the Massachusetts Department of Labor and Workforce Development (MDLWD), Division of Occupational Safety (DOS) conducted a series of inspections concerning: hygiene issues related to the housing of animals in science room 108 (MDLWD, 1999a); inspection of the chemical storage area (MDLWD, 1999b); and general assessment of indoor air quality in the building (MDLWD, 1999c).

Methods

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 in the vocational education wing using an HNu Systems, Photo Ionization Detector (PID) during the November 9th visit. Outdoor background TVOC measurements were taken for comparison to indoor levels.

Results

This school has a student population of over 1,600 and a staff of over 200. The tests were taken during normal operations at the school. Test results appear in Tables 1-7.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million (ppm) in twenty-six of the forty-seven areas surveyed on October 29, 1999. In the vocational education areas assessed on November 9, 1999, four of the fourteen areas surveyed had carbon dioxide levels in excess of 800 ppm. The carbon dioxide levels above 800 ppm are indicative of an overall ventilation problem in this school. Of particular note were rooms B167 and D255, which had levels of carbon dioxide in excess of 2,000 ppm during the air monitoring, which indicates little or no air exchange.

The school complex has a number of heating, ventilation and air conditioning systems throughout the complex. Exterior classrooms in wings A, C and E, have fresh air supplied by a unit ventilator (univent) system (see Figure 1). Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit. The mixture of fresh and return air is drawn through a filter and a heating coil, and is then expelled from the univent by motorized fans through fresh air diffusers. Univents were found activated in the majority of classrooms examined. Obstructions to airflow, such as boxes and book bags, were observed in classrooms. In order for univents to provide fresh air as designed, the fresh air intake, return intake and air diffuser must be unblocked and remain free of obstructions. Exhaust ventilation is provided by unit exhaust ventilators that are installed along windows. Exhaust units were also operating in most of the classrooms examined.

Mechanical ventilation for interior classrooms in the A and C wings is provided by wall-mounted air diffusers. Fresh air is delivered to these classrooms by ductwork connected to a roof-mounted air-handling unit (AHU) (see Picture 1). Exhaust ventilation is provided by wall mounted vents, which are also connected by ductwork to the rooftop AHU. The AHU has its fresh air intake vent and exhaust vent located within 5 feet of each other (see Picture 2). This close configuration of intake and exhaust vents can lead to the capture of exhaust air by the fresh air intake (called entrainment) under certain weather conditions and can also lead to the distribution of odors generated in one classroom into other classrooms. Fresh air diffusers and exhaust vents were found operational during this assessment.

Please note that the interior room fresh air supplies and exhaust vents are connected to the rooftop AHU that appears to recirculate return air. Science areas tend to use materials that generate odors or particulates. It is likely that animal generated wastes and odors noted in the MDLWD report can be drawn into return ductwork and distributed to other internal rooms by the AHU. It is imperative that chemical hoods be maintained to directly exhaust off-gassing materials from the building as recommended in the MDLWD report. In addition, odor-producing materials should be reduced or avoided in the science areas. Several rooms in the science area (A101, A108 and A110) do not have exhaust vents. Without exhaust ventilation, normally occurring indoor pollutants can build up.

Classroom C208 is a computer room that has ceiling mounted air diffusers and an exhaust vent. Installed in the ceiling are several paddle fans that draw air from the floor to the ceiling (see Picture 3). Above the paddle fan is a fresh air diffuser. The location of the paddle fan interferes with the ability of the fresh air diffuser to distribute fresh air to the classroom, since the paddle fan directs air back into the fresh air diffuser.

Mechanical ventilation for classrooms in the B and D wings is supplied by ceiling-mounted fresh air diffusers. These units appear to be connected to heat pumps located above the suspended ceiling. Fresh air is drawn through vents located on the roof (see Picture 4). The exhaust ventilation is provided by an open ceiling plenum system, which uses the space above the ceiling as a vent. Exhaust air is drawn through a suspended ceiling-mounted grille. These vents were not drawing air during the October 29th assessment. Exhaust air is directed to the roof and exits these wings through rooftop vents. An examination of the rooftop vents during the November 9th assessment found them inoperable.

The E wing contains a combination of univents and wall mounted exhaust vents. The exhaust vents in the band room were not drawing air, which would indicate that the exhaust ventilation was either deactivated or malfunctioning. In addition, one exhaust vent was blocked with instrument cases. In order to function as designed, exhaust vents must remain unobstructed.

The CTE (F wing) has ceiling mounted univents that draw fresh air through intakes located on the roof (see Picture 5). Exhaust ventilation is provided by a combination of AHUs and single use dedicated exhaust vents. Of the exhaust vents noted in the CTE, the restaurant exhaust vents were not drawing air.

In all of the wings examined, functioning fresh air supply and exhaust ventilation is necessary to provide for the comfort of occupants in this building. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. According to school department officials, servicing and balancing of these systems is an ongoing process.

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 (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 at levels measured in this building. 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 72^{o} F to 80^{o} F during the October 29^{th} visit, and within a range of 69^{o} F to 78^{o} F in the CTE during the November 9^{th} visit, which were close to the BEHA recommended guidelines. The BEHA recommends that indoor air temperatures be maintained in a range between 70^{o} F 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.

The relative humidity in this building was below the BEHA recommended comfort range in all areas sampled. Relative humidity measurements ranged from 22 to 35 percent during the October 29^{th} visit and 10 to 19 percent in the CTE during the November 9^{th} visit. 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 very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A hallway in the cafeteria contains an interior garden with living plants (see Picture 6). According to school officials, this garden was installed when the school was constructed in 1963. The internal garden appears to be below grade and it could not be determined if these planters have adequate drainage. Plants can be a source of pollen and mold, which can be a respiratory irritant to some individuals. Plants should be properly maintained and have adequate drainage. The presence of a built-in heating vent located in the front of the garden can serve to aerosolize particulates, pollen, dirt, mold and/or spores present in this planter. It appears that the heater contained a motorized fan to draw air into the return vent at the base of the wall and distribute air through an air diffuser on the top of the heater cabinet. As air is expelled from the air diffuser, a column of air is created. As this column of air moves, particulates can be drawn into the column and distributed into the hallway. To avoid this circumstance, plants should be located away from air diffusers to prevent the aerosolization of dirt, pollen or mold. A number of plants were also observed in the library with exposed roots and without drip plans.

Exterior classrooms in the A and C wings have a number of water damaged ceiling tiles, which appear to be the result of water penetration through the window system. The ceiling tiles in these classrooms are interlocking, which make tile replacement difficult. Ceiling tiles are made of materials that can serve as a medium for mold growth when wetted. Mold growth can be a respiratory irritant to certain sensitive individuals.

A musty odor was noted in the stage area of the auditorium. The source of this odor appeared to be an old refrigerator, which may be used as a stage prop. Upon opening its door, a pungent earth/mold odor emanated from the refrigerator.

Other Concerns

A number of areas throughout the building contained conditions that can result in the aerosolization of irritating materials into the school environment. In addition to repairing the ventilation system, the identification, proper storage of or elimination of these materials would serve to enhance the indoor air quality in this building.

Machine Shop (F410)

During both the October 29th and November 9th visits, the sensation of a metallic taste was noted by BEHA staff in the hallway near room C206. The production of metallic taste in the mouth is associated with exposure to aerosolized metal fume. In close proximity to this hallway is classroom F410, which contains the metal shop. An examination of this area found machinery that was in the process of cutting a metal cube (see Pictures 7 and 8). This cutting machine does not have dedicated local exhaust ventilation to remove metal fumes produced during its operation. Other equipment in this classroom also did not have local dedicated exhaust including metal lathes (see Picture 9), surface grinding wheels (see Picture 10) and metal drills (see Picture 11). As each of these machines grind or cut metal, heated metal particles (called fume) is produced and aerosolized. With the classroom hallway door open, metal fumes can move from the metal shop through the hallway door and into the hallway. The configuration of ceiling mounted heaters and wall mounted HVAC equipment can tend to enhance the spread of metal fumes throughout this room and adjacent areas. While closing the metal shop hallway door would reduce penetration into the hallway, metal fumes can continue to penetrate into the hallway through the space under the door (see Picture 12). Metal fumes can then be drawn into rooms F412 and F412a by the univent and exhaust vent through the space that exists beneath the metal shop access doors (see Picture 13).

Metal fumes are a respiratory irritant. Both the Occupational Safety and Health Administration (OSHA) and the American Conference of Governmental Industrial Hygienists (ACGIH) have established Permissible Exposure Limits (PELs) (OSHA, 1997) and Threshold Limit Values (TLVs) (ACGIH, 1999) for various metal fumes. An evaluation of the contents of the material producing fume must be done in order to ascertain which PEL or TLV applies in this situation. This evaluation, as well as an evaluation of the concentration of materials being aerosolized, should be done by a certified industrial hygienist. Please note that these exposure standards apply to healthy adult employees in the workforce. Students who are in this environment are not considered employees for the purposes of OSHA regulations or ACGIH TLVs. In this case, levels of airborne fumes should be reduced to minimally feasible levels in order to prevent student exposure to metal fumes. The ACGIH has recommended standards for local exhaust ventilation for specific operations such as surface grinders, grinding wheels, lathes, and metal band saws (ACGIH, 1998). If this is not practicable, individual personal protective equipment that is fit-tested for each individual should be considered.

Graphic Arts (F432)

The print shop has no local exhaust ventilation for printing presses. Inks containing VOCs are used in this classroom. As previously mentioned, VOCs can be irritating to the eyes, nose, throat and respiratory system. Products containing VOCs must be used with adequate exhaust ventilation to prevent exposure. A large number of printing chemical containers were found on tables. Flammable materials in schools should be stored in flammable storage cabinets that meet design criteria set forth by the National Fire Prevention Association (NFPA, 1996).

Autobody (F422)

Measurable levels of total volatile organic compounds (TVOCs) were detected in the autobody shop. The source of the TVOCs was traced to the grille of a structure within this area (see Picture 14). Within this structure is an above ground tank used as a fuel supply by a large multiple car spray paint/drying booth located in the autobody shop. This drying booth uses No. 2 fuel oil to supply heat for the paint baking process of the spray booth. Streaks of leaking No. 2 fuel oil were observed on the side of the tank, indicating either oil leakage or overfilling of the vessel. No. 2 fuel oil contains TVOCs, which can be irritating to the eyes, nose, throat and respiratory tract.

Products of combustion from the paint booth appear to be vented through metal smokestacks located on the CTE roof (see Picture 15). During the course of this assessment, fuel exhaust odors were reported in room F420. It appears that the smokestacks are several feet above the level of the roof. Under certain wind conditions, products of combustion from the smokestacks may be entrained into the building through rooftop fresh air intakes. No. 2 fuel oil combustion products can be irritating to the eyes, nose, throat and respiratory tract.

Plumbing (F439)

Students in the plumbing program were found practicing pipe joint sweating using a pipe flux that is 50% lead content. Pipe sweating is another method by which metal fumes may be aerosolized, resulting in exposure to the individuals using this compound without proper local exhaust ventilation. Lead exposure to women who have the potential of being pregnant poses a number of risks to the developing fetus (ATSDR, 1999). Lead exposure, particularly in the early stages of pregnancy when the woman may not know that they are pregnant, may result in adverse effects from *in utero* exposure to lead. Lead exposure in males has been associated with reduced fertility because of effects on sperm (ATSDR, 1999). It is highly recommended that non-lead flux be substituted for lead-containing fluxes in routine use in this program immediately. Where use of lead must be used as part of a plumbing certification process, proper protective equipment and exhaust ventilation should be used to minimize lead exposure to students. In addition, all students in this program should increase hand and face washing in order to reduce exposure from residual lead that may contaminate flat surfaces in this classroom.

In addition to the use of solder, ingots of flux were being melted in a pan heated by a gas jet from a propane tank. While this operation is located beneath the hood of a local exhaust ventilation system, the presence of a flameproof cabinet within ten feet of the gas jet poses a significant fire hazard (see Picture 16). Frequently, poorly sealed containers of flammable materials will off-gas into the flameproof cabinet, resulting in a release of vapors when the cabinet is opened. With the local exhaust ventilation system operating, vapors from the cabinet can be drawn to the propane tank jet flame and ignited. It is highly recommended that this flameproof cabinet be moved from this area.

HVAC (F443)

The welding shop was observed with smoke escaping from a welding booth, despite the presence of a local exhaust ventilation system. This escape of smoke from the welding booth is attributed to the welding stand location outside the outer lip of the exhaust hood (see Picture 17). Another factor is the lack of velocity of exhaust ventilation drawn from the elephant trunk vents connected to the exhaust fan (see Picture 18). Each of the elephant trunks was installed with an extra length of flexible hose. The extra length of flexible hose results in a condition that requires exhaust air entering the base of the vent to make an estimated 540^{o} in curves before entering the metal duct above the ceiling. As a general rule, each 90^{o} bend in ducting will reduce the draw of air by 50 percent. In this case, an exhaust hose makes roughly six 90^{o} turns (540^{o}). Assuming that the velocity of the draw of air at the metal ductwork at the top of the flexible hose equals 100 percent, the draw of air at the base of the vent is reduced to roughly 1 percent of the draw because of the six 90^{o} bends in the hose. To increase the draw of air and welding pollutants, the length of flexible hoses should be shortened to reduce the hose length and number of turns exhaust air must travel.

Auto Mechanics (F417)

The automobile repair shop had an engine parts cleaning station, which contains organic solvents. Organic solvent vapor is released when the container is opened. The auto body shop contained a paint gun cleaning station, which also uses organic solvents to clean spray guns. Organic solvents contain VOCs, which can cause eye, throat and respiratory irritation. Each of these areas should have local exhaust ventilation to prevent organic solvent vapor from evaporating into the general shop areas. This area also contains a grinding wheel without local exhaust ventilation.

Carpentry (F421)

Several local exhaust vents for wood dust generating machinery were found crushed. The reduction in diameter of the ducts can cause a build up of sawdust within the duct, resulting in blockage. Wood dust can be an irritant to the eyes, nose and throat and should be properly vented.

Electrical Soldering (C201)

Students using electrical soldering irons were observed in this room. None of the soldering benches in the room had local exhaust ventilation to draw soldering fumes away from students. Electrical solder contains a number of metals, including aluminum, tin, silver and copper. The ACGIH recommends local exhaust ventilation to draw solder fume away from operators at the soldering bench level (ACGIH, 1998).

The stage area of the auditorium had significant amounts of sawdust on the floor, indicating woodcutting without local exhaust ventilation. In addition to being an irritant, wood dust is a fire hazard that needs to be cleaned from surfaces on a regular schedule.

As noted in the metal shop area, spaces exist under each door that directly access shops from the main CTE hallway. Since a number of shops have large exterior doors (e.g., the automotive repair shop) that are left open during school hours, wind or cold air entering the shops can cause over-pressurization, which can result in shop odors and particulates being forced under the door space into hallways.

The chemical storage areas have a number of conditions that can adversely effect indoor air quality, as denoted in the previous MDLWD report (MDLWD, 1999b). The following conditions, in addition to those identified in the MDLWD report, were noted in chemical storage areas.

In many instances, chemicals were found stored in classrooms of the A wing. Of note were the conditions that indicate improper storage of chemicals that may pose fire and safety hazards. Of prime concern is the condition of the flameproof cabinet in the storeroom adjacent to room A108. As reported by school staff, this flameproof cabinet was donated to the school by a local plastic company. This cabinet is connected to ductwork, which was installed by students from the CTE.

The National Fire Prevention Association (NFPA) does not require venting in flammable storage cabinets, however, if venting is done, it must be vented directly outdoors and in a manner not to compromise the specific performance of the cabinet (NFPA, 1996). If air backflow from outdoors into the cabinet through the venting occurs, off-gassing chemicals can be forced from the flammable storage cabinet into the storeroom. Proper design of exhaust vents should prevent air backflow into the cabinet.

The installation of the exhaust vent ductwork has compromised the fire integrity of the cabinet. A flameproof cabinet has an air tight, solid outer and an inner wall, which form an enclosed inner space that reduces the transfer of heat from a fire outside of the cabinet to the interior of the cabinet. The airtight space of this cabinet was breached with the installation of the duct (see Picture 19), which opened a hole to the interior of the cabinet. With this breach, it would not be expected that this cabinet would perform as designed in the case of a fire.

The interior walls underneath the shelves and door of the flammable storage cabinet were heavily corroded, which can indicate off-gassing of chemicals from improperly sealed containers. A piece a cardboard covers the lower shelf and appears to be stained with an oily material (see Picture 20). In the center of the stain are two glass jars containing liquid, in which a substantial amount of silvery metal is stored. Each jar is sealed with a metal lid and is coated with an oily material, which is presumably the same material that saturated the cardboard.

Based on prior experience of BEHA staff, it appears that these unlabelled jars contain sodium metal. Sodium metal is water reactive (NFPA, 1991) and is an extreme fire hazard. These materials must be stored in a non-water liquid to prevent moist air from contacting the surface of this material. The liquid in the jars appears to be evaporating and working its way around the lids, which has coated the exterior of the jars. The conditions of these containers can lead to the eventual drying of the storage liquid and exposure of sodium to the air, which is unacceptable for this material.

As noted in the MDLWD report, the acid cabinet in the inorganic chemical storage room is vented with galvanized pipe (see Picture 21). The acid cabinet as well as the flameproof cabinet are connected to a *common* single duct that is connected to an exhaust vent motor on the roof. The ductwork that the acid and flameproof cabinets is connected to appears to be the dedicated local exhaust vents that draw air into wall mounted grilles located near classroom access doors. Since the cabinets are connected to a common duct, it is possible that off-gassing VOCs from the flameproof cabinet and evaporating acids from the acid cabinet can mix and react within the ductwork. Acids and VOCs should not be mixed in order to prevent unintended chemical reactions.

VOCs can react with metals, as demonstrated by the interior of the flameproof cabinet. Stored within the flameproof cabinet was a flammable gas cylinder as well as pressurized gas torch tanks, all of which can be corroded by VOCs.

Other problems noted in the science area which are or can be a fire and/or safety hazard include:

1. Shelves in classrooms outside the chemical storerooms appear to be corroded from off-gassing materials (see Picture 22). Corrosive materials appear to have corroded the metal shelf supports, coating the shelf with oxidized metal. The corroding of the metal shelf supports can lead to the undermining of the structural integrity of the shelves. Materials should be removed from the shelves and relocated.

2. A highly flammable material, “Thermit”, was stored on an open shelf (see Picture 23). This material should be segregated from general storage.
3. Water reactive materials (e.g., calcium metal) were stored on an open shelf.
4. Oxidizing materials were stored on wooden shelves.
5. Materials were stored near heating units (see Picture 24).
6. Shelves do not have guardrails to prevent accidental breaks of chemical containers.
7. Food containers are used to store materials.
8. Bottles were sealed with aluminum foil.
9. Incompatible household products are stored on the same shelf.
10. There are a number of unlabeled containers filled with unknown materials. Other containers of materials were found mislabeled.
11. Shelves are overloaded with chemicals, so that container labels cannot be seen without moving bottles.
12. Materials were found stored in layers to three canisters high.
13. Containers of materials were found upended in the flameproof cabinet.

It is highly recommended that a thorough inventory of chemicals in the science department be done to assess chemical storage and disposal in an appropriate manner consistent with Massachusetts hazardous waste laws.

Miscellaneous Areas

The art rooms have containers of flammable materials stacked inside the flameproof cabinet or have flammable materials stored in cabinets that are not flameproof. Classroom C218 had open cans of latex paint (see Picture 25). While latex paint is water-based, these products contain VOCs that can evaporate and be a source of respiratory irritation.

Classroom E244 contains two gas stoves that do not have local exhaust ventilation. Gas stoves can produce water vapor and carbon monoxide as products of combustion. In addition, cooking can distribute cooking odors and additional water vapor into the classroom and adjacent areas.

Conclusions/Recommendations

The conditions noted at Leominster High School raise a number of complex issues. The combination of the design of the building, maintenance, work hygiene practices and the condition of stored materials in the building, present conditions that can adversely influence indoor air quality in this building. For these reasons a two-phase approach is required, consisting of immediate measures to improve air quality at Leominster High School and long-term measures that will require planning and resources to adequately address overall indoor air quality concerns. In view of the findings at the time of the visits, the following **short-term** recommendations, in addition to those made in the MDLWD reports are made:

1. Discontinue the routine use of plumbing fluxes containing lead. Replace fluxes with non-lead products. Where the use of lead is required for plumbing certification, student exposure to lead should be minimized through the use of personal protective equipment and/or other relevant industrial hygiene practices. Students should be instructed to strictly adhere to good personal hygiene practices in the shop, such as thorough hand and face washing prior to exiting the classroom. School department

officials should contact the MDPH Lead Poisoning Prevention Program for information concerning remediation of lead contaminated surfaces in the shop.

2. Install weather-stripping on machine shop hallway door and keep this hallway door closed to minimize metal fume penetration into the hallway.
3. Contact a certified hazardous waste remediation company to examine the leaking oil from the storage tank in the autobody shop. Have spilled materials, including the soaked cardboard in the flameproof cabinet in the organic chemical storeroom, cleaned professionally and dispose of this waste in accordance with Massachusetts's hazardous waste disposal laws.
4. To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy independent of classroom thermostat control.
5. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
6. Remove open paint cans from classroom C218. Do not use paint indoors without following manufacturer's instructions and using proper exhaust ventilation to remove drying paint odors directly outdoors.
7. Repair the rooftop vent equipment above Wings B and D.
8. Inspect exhaust motors and belts for proper function, repair and replace as necessary.
9. Remove all blockages from univents and exhaust vents.
10. Continue with balancing operations until ventilation systems are balanced school-wide.

11. 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).
12. Replace any remaining water-stained ceiling tiles. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
13. Move plants away from univents in classrooms. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.
14. Remove plants from the indoor planter in the cafeteria hallway and examine the base of the planter for appropriate drainage, water leaks and microbial growth. If microbial growth is present, disinfect non-porous surfaces with an appropriate antimicrobial agent.
15. Consolidate chemical storage into a single room.
16. Disconnect the organic storeroom flameproof cabinet from the exhaust ventilation system. Replace the flameproof cabinet.
17. Remove water reactive materials from the flameproof cabinet and store the contents of these jars in leak-proof containers.
18. Remove all gas cylinders from the flameproof cabinet and store in a manner consistent with state and local fire codes.
19. Remove oxidizing chemicals from wooden shelves and store on metal shelves.

20. Have a chemical inventory done in all storage areas and classrooms. Properly store flammable materials in a manner consistent with the local fire code. Discard hazardous materials or empty containers of hazardous materials in a manner consistent with environmental statutes and regulations. Label chemical containers with the chemical name of its contents. Follow proper procedures for storing and securing hazardous materials.
21. Obtain Material Safety Data Sheets (MSDS) for chemicals from manufacturers or suppliers. Maintain these MSDS' and train individuals in the proper use, storage and protective measures for each material in a manner consistent with the Massachusetts Right-To-Know Law, M.G.L. c. 111F (MGL, 1983).
22. Shorten the length of flexible hose in HVAC elephant trunk local exhaust vents to maximize the draw of air.
23. Consider relocating the flameproof cabinet in the plumbing classroom to another area that does not use open flames.
24. Obtain a flammable storage cabinet for printing materials in the print shop.
25. Consider discarding the refrigerator from the stage area. If not feasible, clean the interior of this refrigerator with an appropriate antimicrobial agent.
26. Sweep up sawdust on the floor of the stage.
27. Replace crushed flexible ducts in the wood shop.
28. Install weather-stripping along edges of all doors leading to shops in the CTE to prevent odor/dust migration into classrooms and/or hallways.
29. Keep the hallway door to the CTE closed at all times to prevent odor egress into the main building.

The following **long-term** measures should be considered. A ventilation engineer should be consulted to resolve air supply/exhaust ventilation building-wide. With regard to the CTE, it is highly recommended that a certified industrial hygienist be consulted to evaluate the industrial hygiene practices and procedures in all shop areas and appropriate ventilation practices for the science area chemical storage rooms. The following areas should be addressed:

1. Have an experienced hazardous waste removal consultant evaluate the chemical preparation room 211-A for proper chemical storage and recommendations for removal of hazardous waste.
2. Provide local exhaust ventilation consistent with recommendations of the American Conference of Governmental Industrial Hygienists (ACGIH) for all metal fume producing procedures (e.g., see machine shop, soldering shop, automotive repair) (ACGIH, 1998). The construction of local exhaust ventilation for the machinery in the machine shop and printers in the graphics area are all highly recommended for shop activities to continue. Examine the feasibility of providing local exhaust ventilation for all metal fume producing machinery in the machine shop.
3. Consider extending the smokestacks for the autobody car paint-drying booth to prevent entrainment by rooftop fresh air intakes.
4. Examine the feasibility of providing exhaust ventilation to classrooms without exhaust ventilation. Particular attention should be given to interior classrooms without openable windows.
5. Consider adding ductwork to the AHU in Picture 2 to direct exhaust air away from the fresh air intakes of the unit. The ductwork should be fashioned in a manner to also prevent water entrainment into ductwork during foul weather.

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MDLWD. 1999b. Letter to Paul Flemming, Principal, Leominster High School from Ken Ridlon, Environmental Engineer and Paul Aboody, Program manager, MDLI, concerning Leominster Senior High School, dated August 31, 1999. Massachusetts Department of Labor and Workforce Development, Occupational Hygiene/Indoor Air Quality Program, West Newton, MA.

MDLWD. 1999c. Letter to Paul Flemming, Principal, Leominster High School from Ken Ridlon, Environmental Engineer and Paul Aboody, Program manager, MDLI, concerning Leominster Senior High School, dated September 16, 1999. Massachusetts Department of Labor and Workforce Development, Occupational Hygiene/Indoor Air Quality Program, West Newton, MA.

MGL. 1983. Hazardous Substances Disclosure by Employers. Massachusetts General Laws. M.G.L. c. 111F.

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Picture 1

Rooftop AHU Servicing The Internal Classrooms Of The A And C Wing

Picture 2

Fresh Air Intake **Exhaust Vent**

Fresh Air Intake and Exhaust Vents Located within Several Feet of Each Other

Picture 3

C201 Computer Room

Picture 4

Fresh Air Intakes and Exhaust Vents for B and D Wings.

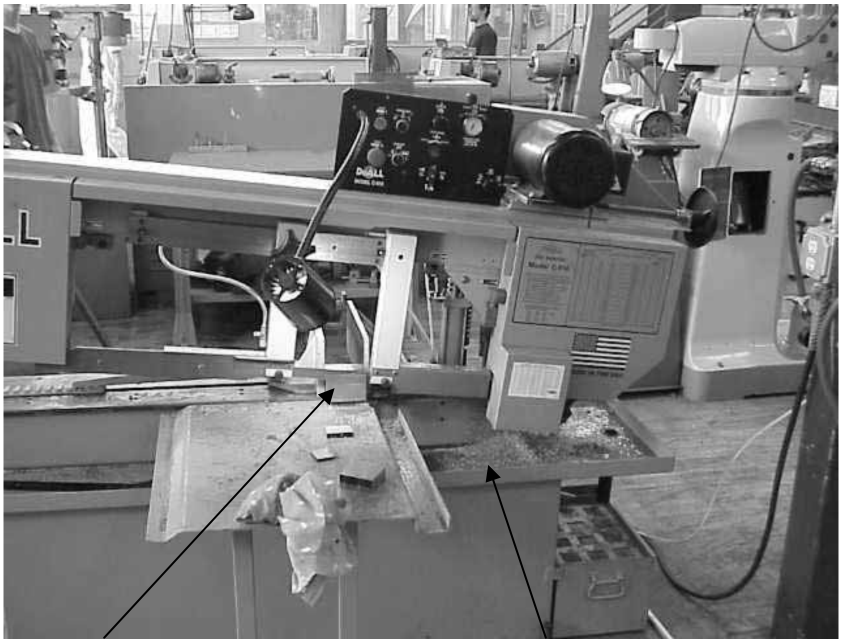
Picture 5

Fresh Air Intakes Exhaust Vent

Picture 6

Indoor Garden outside the Cafeteria

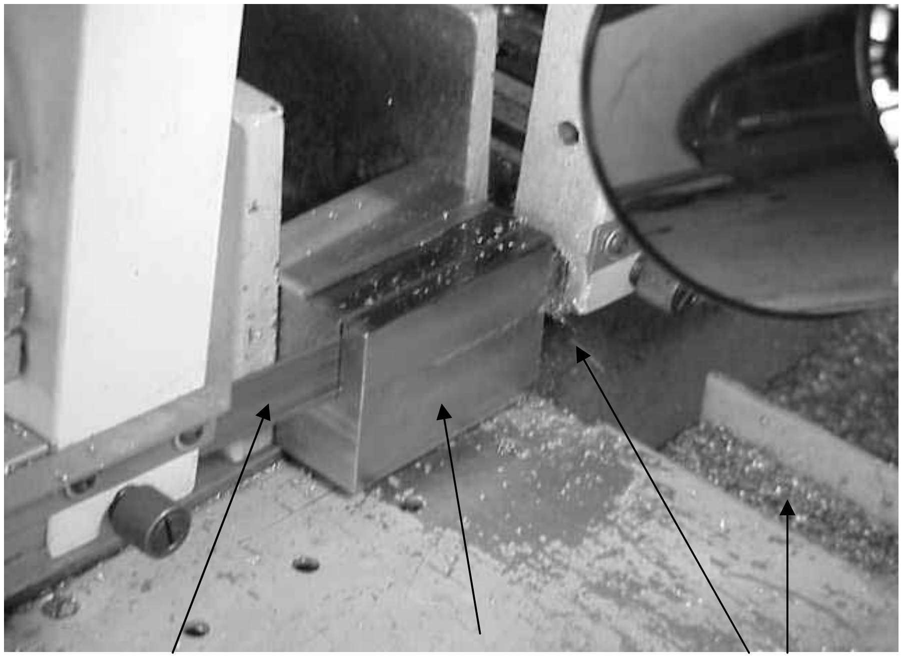
Picture 7



Metal Cube Metal Cutting Collector

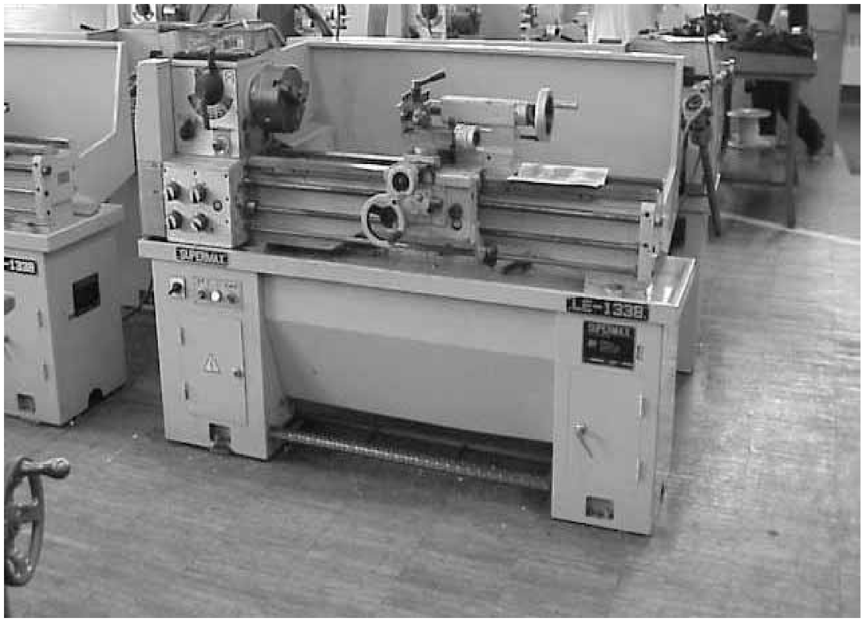
Metal Cutting Saw In Metal Shop

Picture 8



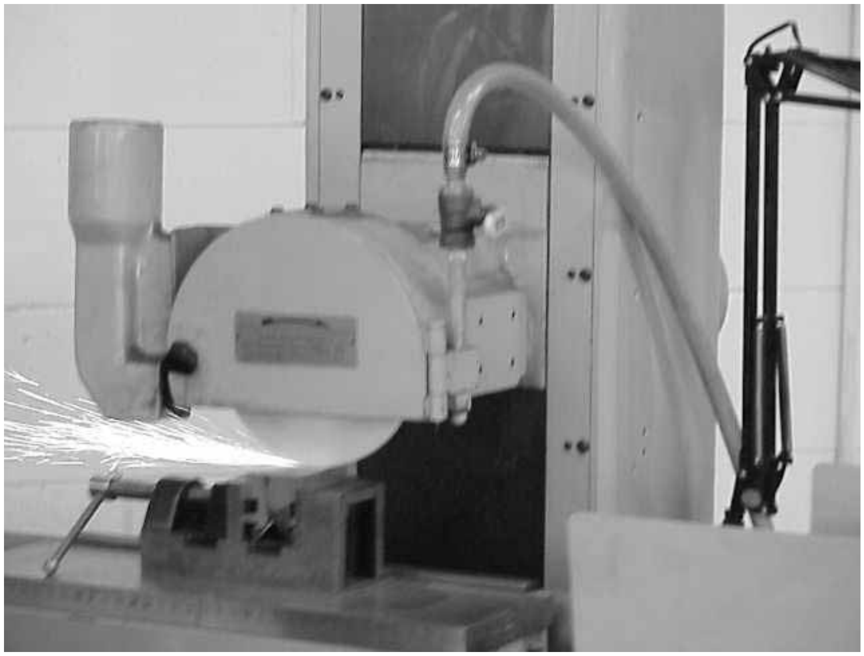
Close-up of Cutting of Metal Cube

Picture 9



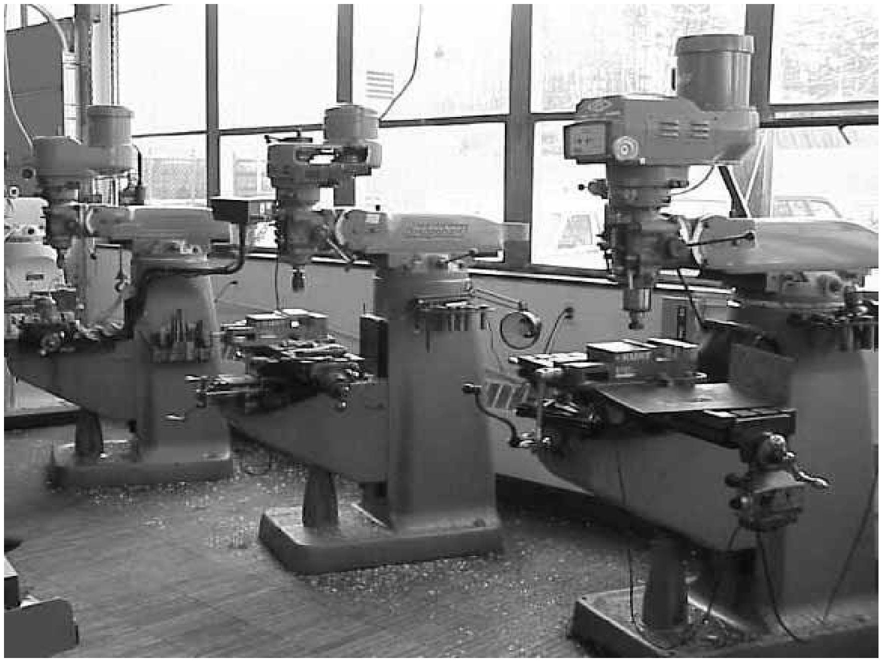
Metal Lathe in Machine Shop

Picture 10



Operating Surface Grinder in Machine Shop, Note No Local Exhaust Ventilation

Picture 11



Metal Drills, Note Metal Fragments of Floor

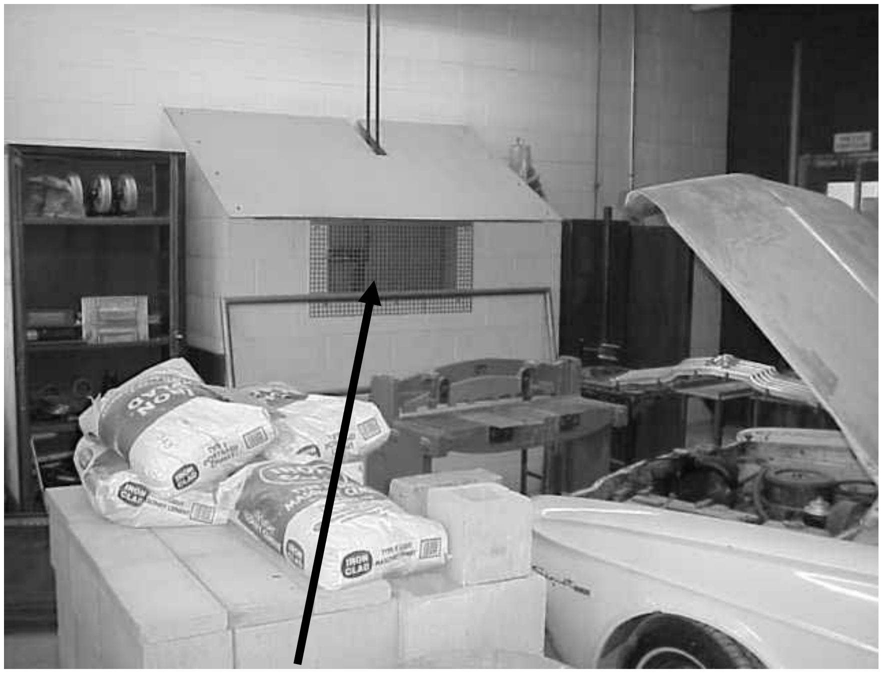
Picture 12

Space Beneath Machine Shop Hallway Door

Picture 13

Space Beneath Classroom Door Adjacent To Metal Shop

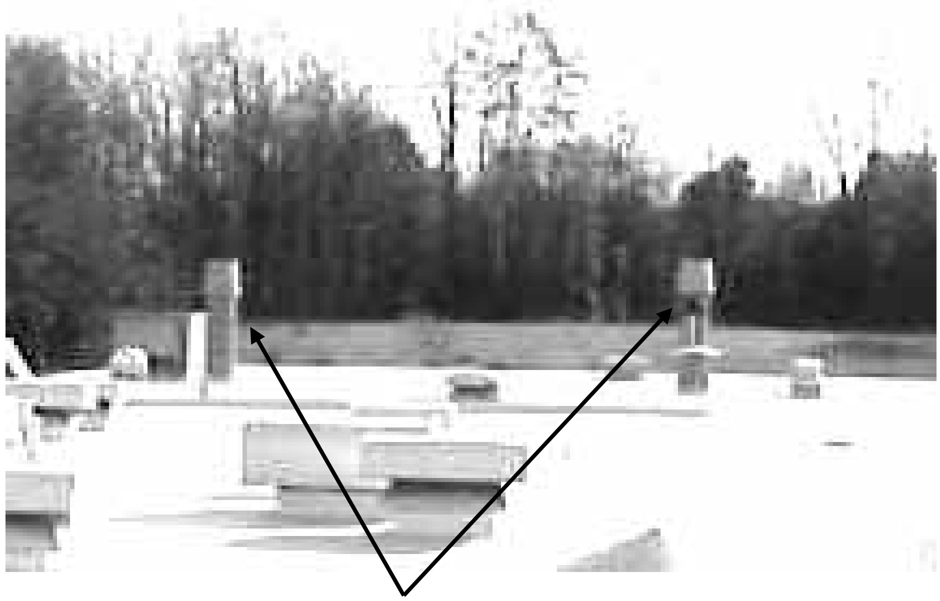
Picture 14



Oil Tank

Oil Tank in Autobody Shop

Picture 15



Smoke Stacks for Autobody Spray Booth

Picture 16

Ingot Melting Using Propane Tank, Note Flameproof Cabinet

Picture 17

Exhaust Vent Lip

Welding Table outside the Outer Lip of the Exhaust Vent

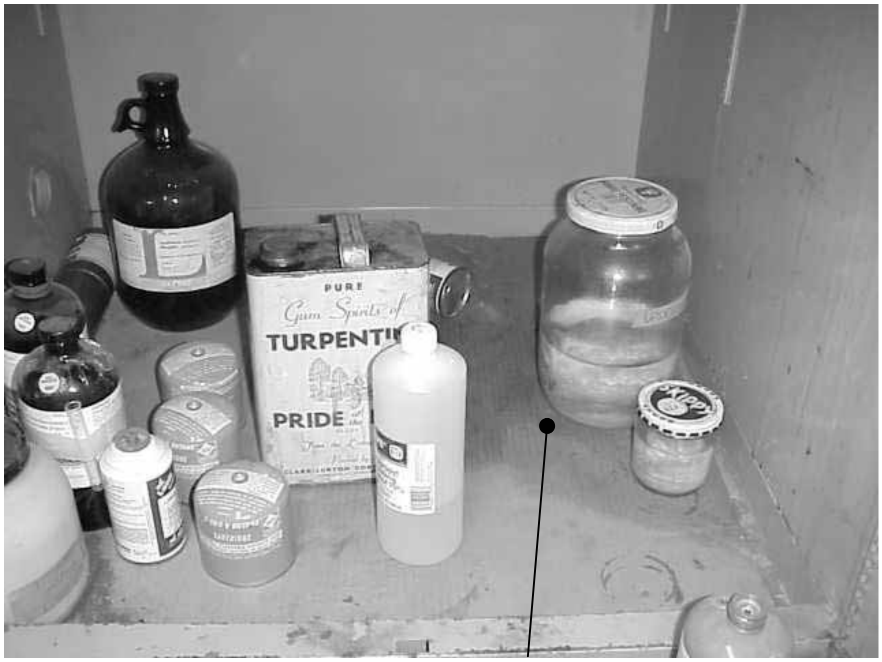
Picture 18

Bent Elephant Trunk Flexible Ducts

Picture 19

Hole Made By Exhaust Vent Ductwork in Flameproof Cabinet

Picture 20



Base Of Flameproof Cabinet Covered with Cardboard, Note Stain

Picture 21

Vent Pipe

Acid Cabinet with Vent

Picture 22

Corroded Classroom Shelves with Stored Chemicals, Note Corrosion on Shelf Supports

Picture 23

Thermit on Open Shelf

Picture 24

Science Materials Stored Against Heater

Picture 25 Open Cans of Paint

Open Cans of Paint in Classroom C218

TABLE 1

Indoor Air Test Results –Leominster High School, Leominster, MA – October 29, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	397	65	28					
C213	661	75	28	6	yes	yes	yes	window and door open, univent blocked by desk, 1 missing ceiling tile, 20+ CT, water damaged window
C214	656	77	24	1	no	yes	no	door open
C216	766	77	25	22	no	yes	yes	4 CT, door open
C218	621	76	24	9	no	yes	yes	plant, 5 open cans of paint-rustoleum
Media Center	875	75	26	12	yes	yes	yes	plants-no drip pan
C210	832	75	26	5	no	yes	yes	5 CT, door open
C219	1029	77	29	25	yes	yes	yes	window open, univent blocked by boxes, 20+ CT
Boy's Restroom – 2nd C Wing					no	no	yes	exhaust off
Girl's Restroom – 2nd C Wing					yes	no	yes	exhaust off

*** 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 –Leominster High School, Leominster, MA – October 29, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
C221	859	77	27	13	yes	yes	yes	window and door open, 14 CT
C225	1099	78	25	27	yes	yes	yes	supply and exhaust blocked by computer tables, 2 CT, 1 missing ceiling tile, 25 computers
Guidance Office	1323	73	30	9	yes	no	no	window A/C-X2
D253	1466	75	31	17	yes	yes	yes	window and door open, exhaust off, 1 CT
D255	2000+	75	35	26	yes	yes	yes	supply and exhaust off
D259	1829	76	34	23	yes	yes	yes	supply and exhaust, door open
D258	1605	77	31	25	yes	yes	yes	exhaust off, univent blocked by papers, door open, 5 CT, "stuffy"
D263	582	72	28	0	yes	yes	yes	exhaust off
D269	958	73	28	6	yes	yes	yes	univent blocked by maps
C Wing Plant Stairwell	1087	74	30					

*** 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 –Leominster High School, Leominster, MA – October 29, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
E242	1622	74	33	9	yes	no	no	
E244 – Home Ec.	947	73	34	0	yes	yes	yes	
E306	712	74	28	18	yes	yes	yes	window open, univent blocked by bookbags, 6 missing ceiling tiles
E351								
E352 – Band Room	552	73	27	3	no	yes	yes	exhaust off, cardboard instrument cases, door open, occupants gone ~10 min.
Stage						yes		old refrigerator
E302	811	73	30	15	yes	yes	yes	window and door open, supply and exhaust off, 3 missing ceiling tiles
Cafeteria	897	75	32	500+	yes	yes	yes	
C206 – Copy Center	656	77	23	1	no	yes	yes	2 photocopiers, door open
C201	747	75	25	13	no	yes	yes	soldering-no local exhaust, paddle fans

*** 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 4

Indoor Air Test Results –Leominster High School, Leominster, MA – October 29, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
C203	959	80	23	10	no	yes	yes	floor fan, door open
A108	994	79	29	22	no	yes	no	
A110	821	79	23	8	no	yes	no	
A101	1188	79	26	23	no	yes	no	6 CT
A109	975	79	26	14	no	yes	yes	univent blocked by bench, door open
A111	999	78	30	15	yes	yes	yes	univent blocked by boxes, door open
A123	855	78	28	13	yes	yes	yes	window open, exhaust off, 1 missing ceiling tile
A122	784	77	25	19	yes	yes	yes	window open
A126	640	79	26	14	yes	yes	yes	window and door open, 22 computers
B153	776	77	25	18	yes	yes	yes	exhaust off, door open
B151	641	77	23	1	yes	yes	yes	exhaust off, 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 5

Indoor Air Test Results –Leominster High School, Leominster, MA – October 29, 1999

Remarks	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
B160	1161	77	29	26	yes	yes	yes	window open, exhaust off, 1 CT
B167	2000+	77	37	24	no	yes	yes	
C212	809	79	24	16	yes	yes	no	
A100	863	79	25	10	yes	yes	yes	exhaust off
A106	687	78	22	17	no	yes	yes	exhaust off
A104	700	77	24	18	no	yes	yes	
A102	738	77	24	13	no	yes	yes	fan, door open
A103	754	77	24	16	no	yes	yes	exhaust off, door open, 1 CT
A105	746	77	24	20	no	yes	yes	exhaust off, door open
A107	695	77	23	17	no	yes	yes	
Science/Computer Lab	712	78	28	3	no	no	no	11 computers

*** 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 6

Indoor Air Test Results –Leominster High School, Leominster, MA – October 29, 1999

*** 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 6

Indoor Air Test Results – Leominster High School, Leominster, MA – November 9, 1999

Remarks	TVOCs	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
							Intake	Exhaust	
Machine Shop	2.6	605	74	16	14	yes	yes	yes	window open, flammables cabinet
Graphic Arts 412		570	75	11	10	no	yes	yes	1 CT, 1 missing ceiling tile, 16 computers
Electrical Shop 414	0.6	704	76	11	0	no	yes	yes	
Carpentry Shop	0.8	623	70	14	0	no	yes	yes	spray booth/exhaust-ok,
Print Shop 432	0.9	713	71	15	2	no	yes	yes	printing presses, 2 CT
Automotive Mechanics Shop 436	1.9	528	71	16	5	no	yes	yes	CO – 10, door open, parts washer
438	0.5	781	72	15	11	no	yes	yes	
Autobody 442	2.7	978	72	15	11	no	yes	yes	oil tank
Welding 443	0.4	625	69	14	12	no	yes	yes	grinding
Plumbing 439	0.3	693	72	15	8	yes	yes	yes	see lead flux-plumbers lead solder

*** 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 7

Indoor Air Test Results – Leominster High School, Leominster, MA – November 9, 1999

Remarks	TVOCs	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
							Intake	Exhaust	
437	0.3	896	75	15	17	no	yes	yes	univent off, 1 missing ceiling tile
Kitchen 427	0.3	832	77	17	27	no	yes	yes	
Restaurant	0.3	1320	76	19	20	no	yes	no	12 CT
420		620	78	10	0	no	yes	yes	

*** 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%