Chignecto-Central Regional School Board

Highland Consolidated Middle School

Indoor Air Quality Issues
Mechanical Systems

Prepared by:
Neil Van Rossum, P.Eng.
CJ MacLellan & Associates
Antigonish, Nova Scotia

November 2012 CJM File: 8983-13

Table of Contents

Summary

An investigation in to mechanical systems was conducted to determine if these might be a contributor to air quality issues at the Highland Consolidated Middle School. Plumbing, boiler stack, ventilation and infiltration were examined.

A number of plumbing upgrades have been done over recent years to remove old drains and vents. Upgrades are ongoing and it is believed that the plumbing system is unlikely to contribute to the current air quality issues in the building.

The boiler stack arrangement meets the code requirements. Some testing (by Stantec) still needs to be done to determine if the unique arrangement of the building contributes to recirculation of exhaust gases from the boiler.

Ventilation was found to be below the minimum current standards and the effectiveness of the existing ventilation is likely reduced due to upgrades to the building envelope.

Air infiltration (leakage) was found to be a governing source of fresh air and did not contribute effectively to the ventilation of individual class rooms. Wind direction and velocity determine the overall movement of air within the building.

Given the low ventilation rate and the relatively large effect of wind and wind direction on ventilation, a mechanical fresh air make up system is recommended for this school.

Background and Introduction:

CJ MacLellan and Associates (CJMac) was retained by the Chignecto Central Regional School Board (CCRSB) to conduct an investigation of the building mechanical systems of the Highland Consolidated Middle School (HCMS) in Westville.

Several visits to the school were made by CJMac over the period of investigation and CJMac representatives attended various coordination and review meetings to help with the investigation effort.

The investigation was to include a review of:

- The original mechanical ventilation system and current operating conditions
- Infiltration (air leakage)
- Plumbing vents and drains
- Boiler vent and possible recirculation effects
- Changes made to the school that could affect the original operating conditions
- How current conditions may be contributing to the odor issues.

CJMac was one member of a team of specialists working with the CCRSB to complete the intrusive investigation of the odor issues in the school.

This report details the mechanical examination and provides some conclusions and recommendations related to mechanical systems.

Plumbing

A number of issues were noted with the plumbing system and a significant amount of work has been done to repair/replace/eliminate sewer drains and vents. There are still some older vents and drains in the pipe chases. Some of these have been slated for replacement due to minor leaks and/or cracks. Negative pressure in the building will exacerbate any sewer or vent leaks.

There was a report of a "sagging" drain from the building to the street main. This is to be scoped with a camera and results will be reported in a future revision to this report.

Boiler Stack

Physical measurements of the boiler stack were made. The stack is about 4 feet away from the nearest roof and the top of the stack is about 4.5 feet above this roof line. Other roofs in the area are either well below this height or at least 50 feet away.

Code requirement for this stack is defined in B139 Installation Code for Oil-Burning Equipment. When a stack is close to an adjacent building (like in this case) the stack outlet needs to be at least 2 feet above the elevation of the adjacent building. The existing stack is well above this minimum requirement and therefore meets the intent of the code.

Air Quality Testing

Tests were done (by Stantec) to measure Carbon Dioxide levels in the building during occupied periods. Data indicates that the Carbon Dioxide levels are not at dangerous levels but above a suggested limit of 1000 ppm. Carbon dioxide is naturally produced by the occupants and is not a serious health hazard. Rather, it causes occupants to find a room stuffy and/or causes fatigue.

Carbon Monoxide levels (< 1 part per million – ppm) were tested below the outside air values (1.2 ppm) and well below the level of concern.

Ventilation & Air Infiltration

Current Ventilation

The school has an exhaust-based system with no mechanical fresh air make-up air system but this type of system is typical for the period of construction (1960's). Fresh air enters the building by infiltration (leakage) through perimeter windows, doors and other small gaps in the building envelope. During the winter season, extensive perimeter heaters temper the air before it reaches the occupants.

Existing ventilation fans (approx. flows)

Lab – Roof mounted (manual – normally off)	2000 CFM
Washroom – In-Line (timer – ON 7a-7p)	2000 CFM
Copier Room – In-Line (timer – ON 7a-7p)	150 CFM
Gym Roof Fans – Roof mounted (ON as required)	10,000 CFM
Total Exhaust Air Flow Capacity	**14,150 CFM**

Note that flow rates are estimated based on the fan dimensions and can easily vary 25% based on the "tightness" of the building. These fans are not capable of producing high negative pressure and air flow rates will drop off quickly with improvements to the building envelope.

Ventilation strategy is still exhaust-based with no mechanical make-up fresh air system.
Fewer windows and new windows have reduced the infiltration in the class rooms.
Window infilling and wind barriers have further reduced infiltration into the classrooms.
With new windows and in-fill there is likely higher negative pressure in the building with lower total infiltration through classrooms.
Relatively higher infiltration through exterior doors and short circuiting of flow through the hallways and into the washroom and gymnasium.

It should also be noted that fresh air is not getting into the class rooms so, although the rate appears to be high, it is not very "effective" at ventilating the classes.

Fresh Air Ventilation Rates

A rough estimate of required ventilation rates was made based on population (300 +/-) of the school and approximate floor areas. Using 15,000 square feet for class rooms plus 9,000 square feet for corridors and gymnasium. No physical measurements of flows were made – flows were estimated based on experience, physical dimensions of duct and equipment and typical velocities in low pressure duct.

Based on current population, ventilation rate standards defined by ASHRAE in their Standard 62.1 Ventilation for Acceptable Indoor Air Quality the following minimum ventilation rates (cubic feet per minute) were calculated.

Classrooms	285 students x 10 CFM per student	= 2850 CFM
Admin	15 people x 10 CFM per person	= 150 CFM

Classrooms	15,000 SF x 0.12 CFM/SF	= 1800 CFM
Hallways/Stairwell	3000 SF x 0.06 CFM/SF	= 180 CFM

Gym	6000 SF x 0.06 CFM/SF	= 360 CFM
Total		**5300 CFM**

Observations of Air Infiltration

On September 27th, 2012 a qualitative examination of air infiltration was made at the school. The bathroom exhaust fan was ON and the administration area exhaust fan was ON. The wind was moderate at 20 to 30 kph from the southwest.

There was a definite wind pressure on the west side of the building. Opening of a west side classroom window let in plenty of outside air. Opening of an east side windows let air out of the east classrooms. During smoke tests on both floors, with windows closed and washroom exhaust fan ON, the general direction of air flow was from west to east and from south to north.

Flow through the second floor classrooms is noticeable. There are likely openings in the high wall area (these were observed in one classroom in a previous visit). Windows were found to be relatively tight and no other lower wall openings were observed. From a ventilation standpoint, these openings are probably good and allow fresh air into the classrooms. The openings may have some other negative effects on the building envelope and will allow odours from the roof into the classroom.

There was no noticeable or unusual flow conditions observed in the central stairwell. When doors were closed, air was somewhat stagnant and generally rising.

Air was also flowing into the bathrooms and this was clearly seen with smoke at the doorway to the washrooms. Air flow was also observed in to the Lab when the exhaust fan was ON. By far, however, the predominant flow in the building appeared to be due to wind pressure.

Observations were made in the old locker rooms under the stage at the west side of the gymnasium. Air was stagnant with no significant flow in any direction.

Observations were made in the gymnasium. When gym fans were ON, air flowed into the gymnasium. These fans are relatively large compared to the other fans so were able to cause negative pressure in the gym. Also, since the gym is on the east side of the building, there should be less wind pressure effect from a southwest wind.

Options/Solutions

To provide consistent and proper fresh air to each room in the building, there is really only on solution – a mechanical fresh air distribution system. There are variations on this option - central air versus multiple small units. To minimize costs and still provide the appropriate ventilation rates a multiple rooftop heat recovery system is preferred. Air can then be ducted down to each room with minimal disruption to existing ceilings and interior spaces.

Assuming the electrical air heating capacity is not available, and then a piped heating system is needed to temper the air during the coldest days of winter. Electrical feeds will be needed to power the air handler fans.

Probable Costs

Mechanical – Fresh Air Makeup System	$180,000
Architectural / Structural	$30,000
Electrical / Controls	$30,000
Sub-Total	**$240,000**
Engineering & Construction Phase Services	$20,000
TOTAL	**$260,000**

Assumptions

- Ventilation rates are based on 15 classrooms at 700 square feet each and 25 children per class.
- Four new rooftop Heat Recovery Ventilators (commercial grade) for the main building
- One new HRV for the Annex building
- Ducting to be routed directly down through a new chase within a second floor classroom or hallway.
- No allowance for building automation but controls could be centralized in the Administration area.
- Since this estimate is not based on any firm quotations from contractors or a tendering process it can be considered somewhere between a Class C and Class D estimate.

Conclusions & Comments

There are some issues with the plumbing system and many drains have been replaced to date. This is not believed to be a significant contributor to the existing odour issues in the building.

While the boiler stack appears to meet the geometric requirements of the code there may be some unique issues with recirculation in the area. Further testing will be done by Stantec to gauge the potential for the stack to contribute odours to the interior of the school.

Current fresh air ventilation rates are likely lower than the minimum required for full occupancy. Design ventilation rates indicate that with the lab fan off, fresh air ventilation rates are at about half the required rate for classrooms. The gym needs minimal ventilation, unless fully occupied during an occasion major event, and likely gets plenty of fresh air through infiltration for day-to-day activities.

Infiltration (Fresh air) rates are likely substantially lower in the building after renovations – window upgrades, wind barrier additions, etc.

Infiltration (fresh air) rates are likely much higher than necessary in the hallways and this fresh air does not easily migrate into classrooms. It can, however, migrate into the gymnasium if the gymnasium roof fans are operating.

If the Lab fan and the Gym fans are off (which is typical), the air flow is likely about 2100 CFM which is about half the required fresh air flow.

Gymnasium roof fans are likely not operated all day during winter season due to high flow rate. These fans were likely installed for high use periods (assembly or sporting events) and for heat ventilation during warm weather.

While exhaust fans induce negative pressure in the building, the wind pressure has a much greater effect and governs air flow through the building when winds are 20 km/h or higher.

Note that the recommendation below for mechanical make-up air does not necessarily apply to all schools of this age or style. The need for mechanical make-up air depends on the air quality and can also be justified by energy savings. Each school would need an individual evaluation to determine the need for or value of a mechanical make-up air system.

Recommendations

Repair or replace sections of drains and vents to eliminate leaks (both gas and liquid).

Install a mechanical fresh make-up air system for the school to ensure fresh air is distributed to the classrooms. It is likely that this system will reduce the overall energy use by the school. A make-up air system will

- Reduce uncontrolled leakage
- Allow for better control of ventilation rates
- Allow for a heat recovery system