BOSTON Public Schools

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BPS Indoor Air Quality Monitoring and Response Action Plan

Overview

As one component of our work to ensure we are following federal, state, and city recommendations on indoor air quality and ventilation in schools, Boston Public Schools (BPS) installed Indoor Air Quality sensors in all Classrooms, Main Offices, and Nurse's Offices in all schools. The sensors report information in real time on key measures of air quality, as outlined below. The information is used to direct changes to the set-up in a classroom and note any additional work that needs to be done to reach optimal air quality and ventilation.

The following information provides details into how the sensors work, what the sensors measure, what we do with the data we receive from the sensors, and how the public can view the information we're capturing from the sensors.

I. Background

In accordance with guidance from the U.S. Centers for Disease Control and Prevention (CDC), U.S. Environmental Protection Agency (EPA), American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), Massachusetts Department of Elementary and Secondary Education (DESE), Boston Public Health Commission, and Harvard T.H. Chan School of Public Health Healthy Schools program, Boston Public Schools Facilities Management has installed **Indoor Air Quality sensors** in all BPS Classrooms, Main Offices, and Nurse's Offices, and developed this "BPS Indoor Air Quality Monitoring and Response Action Plan".

This monitoring and reporting effort is **one** strategy among many districtwide and school-based approaches to improve indoor air quality and reduce the risk of COVID-19, as recommended by the U.S. EPA and U.S. Department of Education's "layered risk reduction approach". Please visit the Boston Public Schools COVID-19 Health & Safety Information site for details regarding all BPS risk reduction strategies.

The installation of indoor air quality sensors, accompanied by a public dashboard, implements the "IAQ Monitoring and Reporting" layer of the BPS Indoor Air Quality Management Plan's layered risk reduction approach, which was historically implemented through manual testing and written reports.

Installing sensors across the district allows BPS Facilities Management to record, monitor, and analyze real-time indoor air quality parameters so Facilities staff can make scientific and data-driven decisions around making improvements in BPS buildings, taking action on elevated IAQ levels, such as identifying and remediating sources of elevated levels, educating the BPS community about indoor air quality at BPS, and proposing city and district investments in mechanical ventilation systems in BPS buildings.

II. Strategies for Achieving Optimal Indoor Air Quality and Ventilation

All BPS Buildings

- Never touch or tamper with Indoor Air Quality sensors.
- Report to Facilities Management, via Work Order System, repairs needed for HVAC systems, leaks, windows, and doors.
- Air fresheners (e.g. plug-ins) and personal cleaners (e.g. Clorox wipes or Lysol spray bottles) are never permitted as they can add irritating chemicals to the indoor air and/or interfere with the proper functioning of the air quality sensors. These personal products are not allowed per the BPS Green Cleaners Policy.
- Never block, change, or turn off HVAC systems.
- Declutter your space. Clutter collects dust, an asthma trigger, harbors pests and impedes the Integrated Pest Management contractor from inspecting and treating areas, impedes Custodial cleaning of surfaces and floors, and blocks inputs and outputs on HVAC systems. Clutter can also be a fire hazard, particularly in electrical closets, where storage is not permitted.
- Cars and buses shall follow all school-related anti-idling laws.

Central HVAC Buildings

- Leave on the existing mechanical system.
- Open one operable window to 4 inches (if applicable).
- Open one corridor-facing door.
- Turn on one air purifier - recommended to be kept on during school hours.

Buildings with Operable Windows with Limited Ventilation

- Leave on the existing mechanical system.
- Open one operable window to 4 inches.
- Open one corridor-facing door.
- Turn on one air purifier - recommended to be kept on during school hours.

Buildings with Operable Windows and no Mechanical Ventilation

- Open one operable window to 4 inches.
- Open one corridor-facing door.
- Turn on one air purifier - recommended to be kept on during school hours.

Why opening a window and a door, and turning on the air purifier are important - Our district air exchange testing demonstrated that one classroom window open at 4 inches with one classroom door open provided excellent air changes per hour (ACH), an average of 6.5-7 ACH, in non-mechanically ventilated classrooms that rely on operable windows as their main source of ventilation. The air purifier provides an additional 1-2 ACH.

III. The Sensors

Indoor Air Quality Sensors have been installed in all BPS classrooms, main offices, and nurse's offices. An Outdoor Air Quality Sensor has been installed on the roof of every BPS school building to record ambient air as a baseline for each school building.
Every sensor is recording the following IAQ parameters:

1. Carbon Dioxide (CO2)
2. Carbon Monoxide (CO)
3. Airborne particulates - Total (PM10)
4. Airborne Particulates - Respirable (PM2.5)
5. Temperature (T)
6. Relative Humidity (RH%)

The indoor air quality sensor is the SGS Smart Sensor with professional grade sensors:

- CO2 – Alphasense IR sensor
- CO – Alphasense Electrochemical sensor
- PM – TERA NEXT sensor
- T and RH% – TE Connectivity Module

Calibration
All indoor and outdoor air quality monitors will be calibrated annually and as needed. For CO2 and CO, annual calibration will include a standard two point calibration using background CO2 & CO levels using a reference device and CO2 (1000 ppm) & CO (5 ppm) certified span gas. A qualitative function test using a known concentration of challenge gas will be used to verify sensor performance. For airborne particulates, temperature, and relative humidity, annual calibration will be completed utilizing reference devices.

Connection(s) Lost
In the event an indoor and/or outdoor air quality monitor loses connection to the cloud-based management system, a service notification shall be generated for repair. A BPS contractor, ATLAS, TRC, and/or SGS Galson, will respond within 5 school days to initiate repair and recalibration of the affected monitor(s).

Maintenance Mode
In the event an indoor and/or outdoor air quality monitor's raw sensor output is found to be outside the acceptable performance range for a given IAQ parameter, the unit shall be placed in "Maintenance Mode." A service notification shall be generated for replacement of the faulty sensor(s). ATLAS, TRC, and or SGS Galson, will respond within 5 school days to initiate repair and recalibration of the affected monitor(s).

IV. Monitoring and Taking Action on Indoor Air Quality Parameters

IAQ Data and Reports
BPS IAQ Data can be accessed by visiting the BPS IAQ Sensor Dashboard. Please review the Dashboard User Guide to assist you with using and understanding the dashboard.

CO2, total airborne dust (PM10 and PM2.5), relative humidity and temperature provided in the BPS IAQ Sensor Dashboard will be reported as a 15-minute running average. CO measurements will be reported as instantaneous results.

The CO2, CO, total airborne dust (PM10 and PM2.5), relative humidity, and temperature measurements provided in the BPS Daily IAQ Report(s) will be reported as a 12-hour running average (6:00 AM - 6:00 PM). BPS Facilities Management will also include an IAQ report as part of the annual School Environmental Audit Reports.

Standards for Indoor Air Quality Measures and Responding to Exceedances
The following information describes the IAQ parameters being monitored by the sensors and the BPS response actions to exceedances.

An exceedance is a measured indoor air quality level that is above the adopted standard as described below. All exceedances, except for CO, will be based on a running 15-minute average. Because of the potential short-term health hazard of elevated CO levels, the notification process and actions will be based on the first exceedance of an instantaneous 4 ppm or greater measurement.

BPS Facilities Management (HVAC Division, Energy Division, Environmental Division, the Assistant Director of Planning & Engineering, and the Sustainability and Environmental Resource Manager) will be actively monitoring the data, as described in detail below, using the dashboard and alert notifications system.

Carbon Dioxide (CO2): Carbon dioxide is one of the most abundant gasses on Earth. Carbon dioxide is a colorless gas made by human breathing and the burning of carbon-based fuels, such as methane (natural gas), diesel, gasoline, wood, and other organic matter. Exhaled air is usually the largest source of carbon dioxide in classrooms. Carbon dioxide levels are used as a sign of adequate ventilation and air exchange rates.

For indoor air quality, the recommended upper limit for carbon dioxide levels is 600 parts per million (ppm) of CO2 above outdoor levels. For example, if outdoor air is 450 ppm CO2, then the recommended upper limit would be 1050 ppm CO2. This standard is based on ASHRAE ventilation standards for adequate ventilation, with 1000 ppm as the recommended upper limit from the EPA's Indoor Air Quality Tools for Schools program. Please note this standard is a comfort guideline and not a public health standard. 5,000 ppm is the 8-hour exposure Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV), a level that can pose health risks.

- Typical: 400-1000 ppm
- Moderate: 1000-2000 ppm
- High: > 2000 ppm

While keeping CO2 in the "Typical" range is our goal for improved indoor air quality and a healthier school environment, it is important to note that CO2 does not directly indicate risk of exposure to COVID-19 because CO2 levels do not capture the impact of filtration strategies, like a HEPA air purifier or a MERV-13 filter, or the impacts of other layered risk reduction strategies, like mask-wearing, physical distancing, disinfecting, vaccines, and self-health checks.

Response Action to Exceedance:
School-based staff (e.g. teachers in classrooms) should use the IAQ Dashboard to periodically check their classroom's CO2 trends. Response actions for non-mechanically ventilated schools (the majority of BPS schools) will include school-based staff following the recommendations described above in Section II to achieve optimal ventilation and improve air exchange rates, with opening a classroom window and door as the best first action. Following these recommendations will help the classroom lower its CO2 levels over a reasonable amount of time.

Response actions for mechanically ventilated buildings may also include, but not be limited to: the HVAC Division will investigate and respond to elevated CO2 levels for mechanically ventilated buildings, identify and control the source, and/or make recommendations to achieve optimal ventilation, as described above in Section II. Manual CO2 measurements may also be required to ensure the IAQ sensor(s) is within calibration. If the IAQ sensor(s) is found to be outside calibration (+/- 20%), the sensor(s) shall be recalibrated by SGS Galson and CO2 measurements re-verified.

Carbon Monoxide (CO): Carbon monoxide is a colorless, odorless gas. It results from incomplete decay of carbon in combustion processes. Common sources of CO in schools are improperly vented furnaces, malfunctioning gas ranges, canned heat (e.g. a Sterno), or exhaust fumes that have been drawn back into the building. Worn or poorly adjusted and maintained combustion devices (e.g., boilers, furnaces), or a flue that is improperly sized, blocked, disconnected, or leaking, can be significant sources. Auto, truck, or bus exhaust from attached garages, nearby roads, or idling vehicles in parking areas can also be sources.

Carbon monoxide at higher levels is considered to be a serious health hazard. The carbon monoxide standards for indoor air quality are the U.S. Environmental Protection Agency (US EPA) National Ambient Air Quality Standard (NAAQS) of 9 ppm CO on a 8-hour time-weighted average (TWA), and the World Health Organization Guidelines for Indoor Air Quality – Selected Pollutants of 6 ppm. However, BPS Facilities will be notified and take action at an instantaneous measurement of 4 ppm as a more conservative and precautionary approach to this health-based standard.

- Typical: 0-4 ppm
- Moderate: 4-9 ppm
- High: > 9 ppm

Response Action to Exceedance:
A notification email will be sent to the school's Principal/Head of School and the school email account. All notifications will contain the list of affected rooms with the elevated CO level(s). In the event of an emergency, a notification phone call to the school and the school's designated Operational Leader will be made with immediate response action instructions.

Because the CO standard is health-based, the notification process and action(s) will be based on the first exceedance of an instantaneous 4 ppm measurement. Response action(s) shall include, but not be limited to, an investigation by the BPS Environmental and HVAC Divisions to identify and control the source of CO. The investigation may include monitoring real-time instantaneous CO results, monitoring trending 8-hour time-weighted average CO results, investigating HVAC equipment (e.g. boiler, radiators, etc.), and making recommendations to achieve optimal ventilation, as described above in Section II. Manual CO measurements may also be required to ensure the IAQ sensor(s) is within calibration. If the IAQ sensor(s) is found to be outside calibration (+/- 20%), the sensor(s) shall be recalibrated by SGS Galson and CO measurements re-verified.

In the event of an emergency, the response action shall require immediate action by the school, including, but not limited to, relocation of staff and students, possible evacuation of the classroom or school, notification to the Boston Fire Department (BFD), and any action(s) required by BFD.

Airborne Particulates - Total (PM10) and Respirable (PM2.5): Particulate matter (also referred to as PM) is a complex mixture of solid and/or liquid particles suspended in air. These particles can vary in size, shape and makeup. Some examples of particulates found near or inside schools include pollen, mold spores, dirt, dust, tobacco smoke, or construction dust.

BPS shall monitor two types of airborne particulate matter, PM10 and PM2.5.

- PM 10.0 µg - Inhalable particles, with diameters that are generally 10 micrometers and smaller.
- PM 2.5 µg - Fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller. How small is 2.5 micrometers? Think about a single hair from your head. The average human hair is approximately 70 micrometers in diameter, which is 30 times larger than the largest fine particle.

The PM10 standard for BPS will be based on the Environmental Protection Agency (EPA) 24-hour time-weighted average NAAQS for airborne particles less than 10 microns in diameter of 150 ug/m3 (0.150 mg/m3). However, BPS Facilities will be notified and take action at 75 ug/m3 (0.075 mg/m3) as a more conservative and precautionary approach to this health-based standard.

- Typical: 0-75 ug/m3 (0.075 mg/m3)
- Moderate: 75 ug/m3 (0.075 mg/m3) - 150 ug/m3 (0.150 mg/m3)
- High: > 150 ug/m3 (0.150 mg/m3)

The PM 2.5 standard for BPS will be based on the Environmental Protection Agency (EPA) 24-hour time-weighted average NAAQS for airborne particles less than 2.5 microns in diameter of 35 ug/m3 (0.035 mg/m3). However, BPS Facilities will be notified and take action at 17.5 ug/m3 (0.0175 mg/m3) as a more conservative and precautionary approach to this health-based standard.

- Typical: 0-17.5 ug/m3 (0.0175 mg/m3)
- Moderate: 17.5 ug/m3 (0.0175 mg/m3) - 35 ug/m3 (0.0350 mg/m3)
- High: > 35 ug/m3 (0.0350 mg/m3)

Response Action to Exceedance
Response actions shall include, but not be limited to: the HVAC Division will investigate and respond to elevated for PM10 and PM2.5 levels, identify and control the source, and/or make recommendations to achieve optimal ventilation, as described above in Section II. Manual PM10 and PM2.5 measurements may also be required to ensure the IAQ sensor(s) is within calibration. If the IAQ sensor(s) is found to be outside calibration (+/- 20%), the sensor(s) shall be recalibrated by SGS Galson, and PM10 and PM2.5 measurements re-verified.

Temperature (T): Air temperature is a measure of how hot or cold the air is. Air temperature depends on the weather and daily amount of sun and cloud cover, or the effectiveness of a mechanical heating and/or cooling system inside of a building.

The temperature standard for BPS is the temporal comfort guideline of 68–78 degrees Fahrenheit from the Massachusetts State Sanitary Code (Chapter 2 for Habitable Housing, 105 CMR 410.201) during the heating season (all school buildings) and cooling season (only for mechanically ventilated buildings with AC).

- Typical: 68-78 degrees Fahrenheit
- Low: < 68 degrees Fahrenheit
- High: > 78 degrees Fahrenheit

Response Action to High and Low Temperatures
The Energy Division will monitor temperature readings, and respond to high and low temperatures by making adjustments to heating and cooling (where applicable) settings.

Response actions shall also include, but not be limited to: replacing a faulty temperature sensor, investigating the HVAC equipment (if applicable), and/or making recommendations to achieve optimal ventilation, as described above in Section II.

Relative Humidity (RH%): Relative humidity is a measure of the amount of moisture in the air relative to the total amount of moisture the air can hold. If the relative humidity is 50%, then the air is only half saturated with moisture. If relative humidity is 100%, then it is probably raining!

The relative humidity standard for BPS is the ASHRAE recommended range of 30-60 RH% for occupant comfort.

- Typical: 30-60%
- Low: < 30%
- High: > 60%

International, Federal, State, Local, and Professional Guidance Referenced:

- World Health Organization (WHO)
- U.S. Centers for Disease Control and Prevention (CDC)
- U.S. Environmental Protection Agency (EPA)
    - Indoor Air Quality Tools for Schools Program
    - U.S. Air Quality Index
- U.S. Department of Labor Occupational Safety and Health Administration (OSHA)
- Massachusetts Department of Elementary and Secondary Education (DESE)
- Massachusetts Department of Environmental Protection (MassDEP)
- Boston Public Health Commission (BPHC)
- American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)
- American Conference of Governmental Industrial Hygienists (ACGIH)
- Harvard T.H. Chan School of Public Health Healthy Schools program
- Center for Green Schools
- American Lung Association

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