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Department of Public Health
Bureau of Environmental Health
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February 22, 2012

Cheryl L. Henlin, Environmental Planner
City of New Bedford Environmental Stewardship Department
New Bedford City Hall
133 William Street
New Bedford, MA 02740

Dear Ms. Henlin:

As requested by the City of New Bedford Environmental Stewardship Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health's (BEH) Indoor Air Quality (IAQ) Program conducted an IAQ assessment at New Bedford High School (NBHS), 230 Hathaway Boulevard, New Bedford, MA. Concerns regarding particulate/debris emanating from unit ventilators (univents; Picture 1) and its potential for exacerbating eye/respiratory/allergy symptoms prompted the request. On February 9, 2012, the NBHS B-Block was visited by Cory Holmes and Sharon Lee, Environmental Analysts/Inspectors in BEH's IAQ Program.

Beginning in December 2011, building occupants in B-Block classrooms expressed concerns that a white, powdery material was being ejected from univents that were installed during July/August 2010. This material was reportedly being distributed throughout the classroom and settling on flat surfaces. City/School officials contacted their environmental consultant, TRC Companies, Inc, who analyzed the white, powdery material using a number of methods including: polarized light microscopy, reflected light microscopy, scanning electron microscopy and energy dispersive x-ray spectrometry. The lab report concluded the material was primarily composed of aluminum oxide, with minor components consisting of rust, paper pulp, quartz and calcite/dolomite (EMSL, 2012).

The New Bedford School Department (NBSD) has since assembled a team consisting of a Certified Industrial Hygienist (CIH); a mechanical ventilation engineer; NBSD engineering and maintenance staff; and a representative from the univent manufacturer (Trane) to discuss issues related to this aluminum oxide issue. More recently, Trane has provided the NBSD with an Engineering Bulletin that addresses the oxidation occurring in the univents (Appendix A). Based on discussions with members of the NBSD team and information from the Engineering Bulletin, all affected univents have been retrofitted with a filter medium. This secondary filter is installed beneath the air diffuser to reduce/capture debris that may be distributed via the univent fans (Picture 2). School maintenance staff were also instructed to increase cleaning efforts.

Although formation of aluminum oxide is expected to occur on metal components of HVAC equipment over time, an explanation for the present rate at which the white, powdery material is being produced and aerosolized could not be determined. It has been suggested by both NBSD engineering staff and Trane that condensation formed in these univents during the cooling season is causing the oxidation. According to Mr. Manuel Velosa, NBSD Engineer, the configuration of the univent coils makes drainage of condensation difficult. This exposes aluminum components to moisture for an extended period of time. During the heating season, moisture is removed, allowing previously oxidized materials to become aerosolized.

As reported by Mr. Velosa, the aluminum oxide debris was most prevalent in third floor classrooms; this phenomenon was also observed to a lesser extent in some classrooms on the second floor in the B-Block. The third floor univents are under more stress due to rising heat and solar gain. This increased need for the univents to provide the desired cooling capacity may account for the greater amount of oxide production in third floor units when compared to second floor univents.

BEH staff conducted airborne particle testing with univents operating to determine whether airborne particles were of a sufficiently small size to lodge deeply into the lungs. Testing was conducted with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. The US Environmental Protection Agency (US EPA) has established National Ambient Air Quality Standards (NAAQS) for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 µm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter (µg/m3) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 µg/m3 over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations the day of the assessment were measured at 8 to 12 µg/m3 (Table 1). PM2.5 levels measured inside the building ranged from 6 to 16 µg/m3 (Table 1), which were below the NAAQS PM2.5 level of 35 µg/m3. The highest reading of 16 µg/m3 was taken in classroom B-309 while the univent was operating with the retrofitted filter removed.

Please note, PM2.5 air measurements are only representative of the indoor air concentrations present at the time of sampling. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of activities that occur indoors and/or mechanical devices can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, use of stoves and/or microwave ovens in kitchen areas; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Although indoor levels of PM2.5 were below the NAAQS, a substantial amount of visible powder/debris was observed accumulated within the univent cabinets. This material may present a source of eye and respiratory irritation (OSHA, 2012). Some of the aluminum oxide debris was being distributed by the univent fans, and settling on flat surfaces on and around the unit (Pictures 3 through 5). Even in areas where the retrofitted filter medium was installed, some debris was noted on and around univents (Picture 6). Materials accumulated on flat surfaces (e.g., desktops, shelving and floors) in occupied areas can also be re-aerosolized, causing further irritation.

It is unlikely that any long-term health effects would be experienced due to limited exposure and control measures implemented. Steps should be taken to reduce opportunities for acute impact.

Conclusions/Recommendations

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

1. Continue to utilize retrofitted filters in affected classroom univents as a temporary measure. Efforts should be made to fit filter media to eliminate gaps/spaces where particulates can bypass filters.

2. Use a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of surfaces is recommended as needed (e.g., before/after school) to control dusts/particulates.

3. Check filters periodically and change if/when saturated with debris. It is important to note that these activities are time-intensive and not economically feasible and therefore should only be used in the interim until a more permanent solution can be determined.

4. Consider disassembling univents for cleaning. Because it would appear that there is a finite amount of material currently accumulated in univents, the units should be disassembled (e.g., coils/components be removed) over the February vacation, in order to conduct as thorough a cleaning as possible. The removal and cleaning of the bulk of accumulated material should greatly reduce the distribution of debris in classrooms.

5. Continue to consult with an HVAC engineering firm and manufacturer regarding a more permanent correction of this issue, such as replacing coils with coated aluminum fins or coating current coils with a corrosion-resistant material. Such work should be conducted in coordination with the manufacturer, while units remain under warranty.

6. Operate all ventilation systems (e.g., univents and classroom exhaust vents) continuously during occupied periods.

7. Encourage the closing of classroom doors during occupied periods to facilitate air exchange.

Please feel free to contact us at (617) 624-5757 if you are in need of further information or technical assistance regarding this issue.

Sincerely,

Suzanne K. Condon, Associate Commissioner
Director, Bureau of Environmental Health

cc:
Michael Feeney, Director, Indoor Air Quality Program, BEH
Jan Sullivan, Director, Community Assessment Program, BEH
Mary Louise Francis, Ed. D., Superintendent, New Bedford Public Schools
Deborah Brown, School Business Manager, New Bedford Public Schools
Andrew Kulak, Headmaster, New Bedford High School
Manuel Velosa, Building Engineer, New Bedford Public Schools
Michael Medeiros, Acting Supervisor of Custodians, New Bedford Public Schools
The Honorable Senator Mark Montigny
The Honorable Representative Antonia F. D. Cabral

Enclosure(s)

References

EMSL. 2012. EMSL Analytical, Inc. Laboratory Report. Full Particle Identification Project: NBHS/115058.820.3. Dated January 11, 2012.

OSHA. 2012. Occupational Health and Safety Guideline for Aluminum. http://www.osha.gov/SLTC/healthguidelines/aluminum/recognition.html

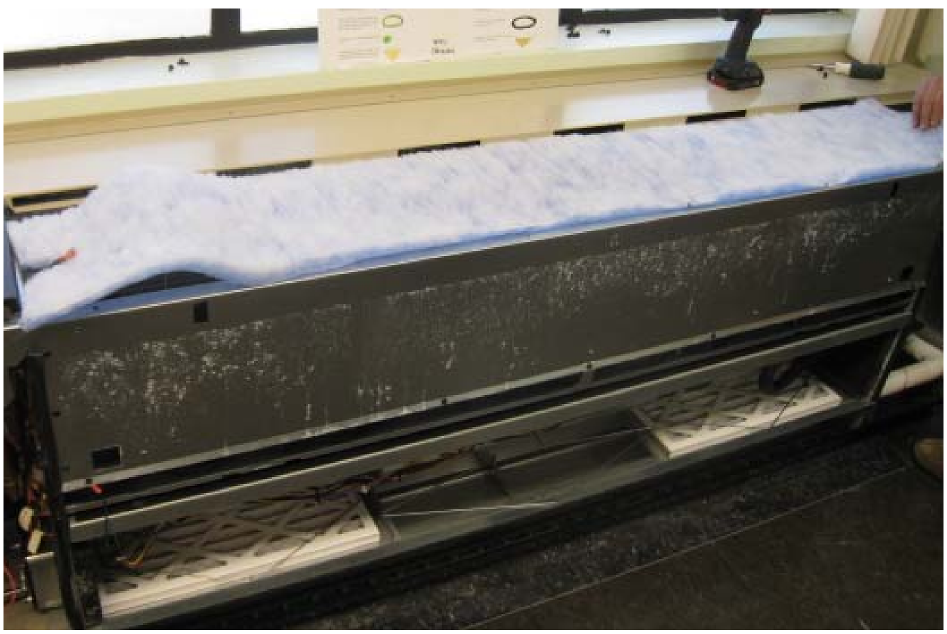
Trane. 2011. Engineering Bulletin: Aluminum Fin Surface Oxidation on Air-Cooling Coils (PROD-PRB001-EN). Dated September 2011.

US EPA. 2006. National Ambient Air Quality Standards (NAAQS). US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html

Picture 1

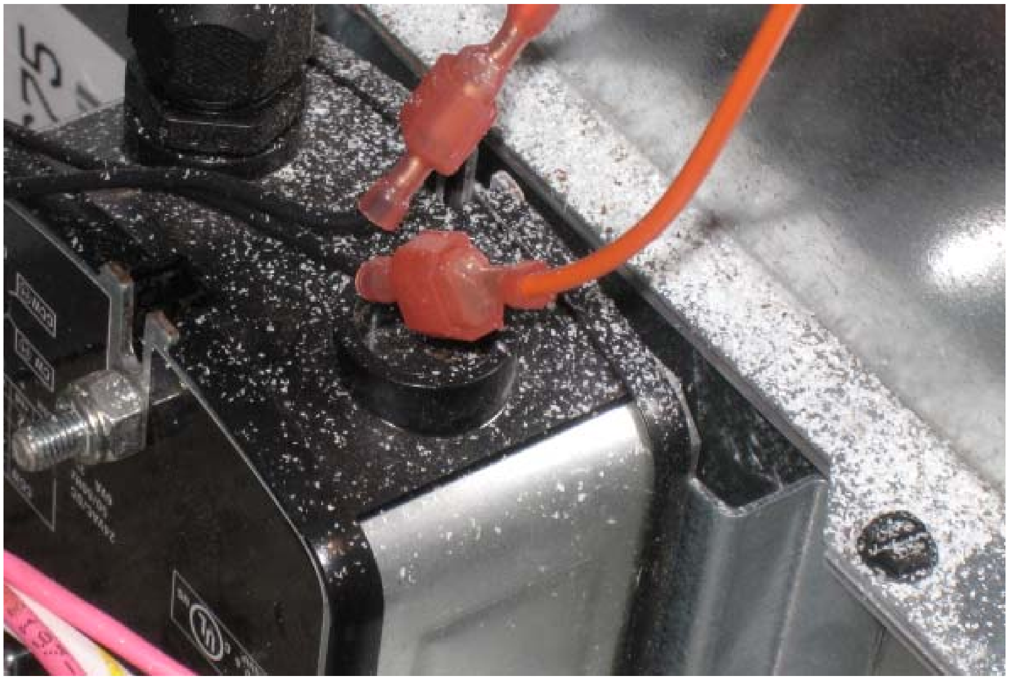
Typical Classroom Univent Installed Summer 2010 B-Block

Picture 2



Filter Media Retrofitted into Univent Air Diffuser (Top of Unit), 2nd and 3rd Floor Classrooms B-Block

Picture 3



White Particulate/Debris inside Univent Cabinet Classroom B-309

Picture 4

White Particulate/Debris inside Univent Cabinet Classroom B-309

Picture 5

White Particulate/Debris inside Univent Cabinet Classroom B-309

Picture 6

White Particulate/Debris on Univent Cabinet in Classroom B-309 Where Univent was Retrofitted with Filter Media

Location: New Bedford High School

Address: 230 Hathaway Blvd, New Bedford, MA 0274

Table 1

PM2.5 Particulate Testing

Date: February 9, 2012

Area	PM2.5 (µg/m^3)	Comments
Outside/(Background)	8-12	Clear, sunny, west winds 2-12 mph, gusts up to 17 mph
1st floor hallway outside B-109	9	
B-109	8	UV-operating, no retrofit filters installed
2nd floor hallway outside B-212	9	
B-212	9	UV-operating, retrofit filters installed
3rd floor hallway outside B-309	10	
B-309	10	UV-operating, retrofit filters installed, white debris on surface of UV, adjacent countertops and in UV cabinet
B-309	16	UV-operating, retrofit filters removed, visible debris distributed via UV fan

µg/m^3 = micrograms per cubic meter

UV = univent

Guidelines

Particle Matter 2.5 < 35 ug/m^3

Appendix A

TRANE

Engineering Bulletin

Topic Overview

Aluminum Fin Surface Oxidation on Air-Cooling Coils

ATTENTION: Warnings, Cautions and Notices appear at appropriate sections throughout this literature. Read these carefully:

⚠WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠CAUTION	Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It could also be used to alert against unsafe practices.
NOTICE:	Indicates a situation that could result in equipment or property-damage only accidents.

Background

The development of copious amounts of flaky, white powder from indoor coils has been a recognized industry issue for a couple decades now. The first known occurrences were reported on residential heatpump systems that used refrigerant as the heat transfer fluid. Commonalities between reported cases were coils constructed with bare aluminum fins in an air cooling/dehumidifying application. The problem would surface during the heating season of the year when the dehumidifying coil's fin surface was dry of condensate and within the first couple years of operation of the equipment.

Large commercial equipment applications, while still rare, have also been reported as well as chilled water systems in a variety of light commercial and terminal products. As additional occurrences have been identified over the last 10 to 20 years, it has now been shown to happen to any type of dehumidifying coil with bare aluminum fins operating in a system that also supplies forced air heating during the winter season.

The incident rates have been low over the years and until recently limited to coastal areas mostly regionalized in the southern United States. With millions of aluminum fin coils

⚠SAFETY WARNING

Only qualified personnel should install and service the equipment. The installation, starting up, and servicing of heating, ventilating, and air-conditioning equipment can be hazardous and requires specific knowledge and training. Improperly installed, adjusted or altered equipment by an unqualified person could result in death or serious injury. When working on the equipment, observe all precautions in the literature and on the tags, stickers, and labels that are attached to the equipment.

September 2011

PROD-PRB001-EN

Appendix A

shipped in the reported time period, problem jobs only number in the dozens. The phenomenon has been reported across additional geographical areas in the Southeastern and Midwestern United States, Europe and Asia. But, the primary regions have continued to be hot and humid climates or milder climates that had severe cooling seasons prior to development of the problem. Cases have not been reported in dry, arid climates or on coils that are in heating only applications utilizing hot water, hot glycol solution or steam. There are no documented cases with coils that have non-aluminum fins (copper, steel, etc.) or with coils that have fin surface coatings (corrosion resistant or hydrophilic).

System design does not seem to be an important contributing factor. A variety of applications have demonstrated the capability to produce the white flakes such as coils using either chilled water, chilled glycol solution or volatile refrigerant; 100 percent return air, 100 percent outside air or mixed outside and return air.

Once the coil has been installed and operated for a few cooling/heating seasons its vulnerability is drastically reduced. The phenomenon has only been reported within the first one or two heating seasons and has yet to be reported during a cooling season. Theories suggest that the coils might still be producing the white flakes during the cooling season, but the condensate on the fins formed from dehumidifying the airstream prevents the powder from becoming airborne and thus from being detected.

Figure 1. Looking at the leaving airside of a coil, aluminum oxidation can be seen uniformly across a heavily oxidized fin surface.

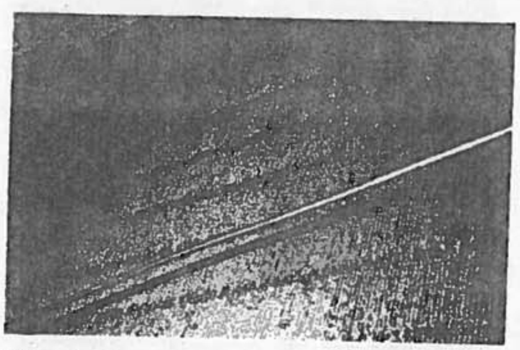


Figure 2. Drainpans are typically the first place that flakes accumulate. The amount of powder found can be noteworthy especially when no detectable breakdown of the fin surface is observed.

What is it?

Laboratory analyses conducted at multiple third-party laboratories have shown the white flakes to be aluminum hydroxide oxide.

Initially, most third-party laboratories will identify the substance as aluminum oxide (alumina) using simple tests.

The initial investigations concerning these occurrences utilized Scanning Electron Microscopy (SEM) to determine the elemental composition of the powder. The results were always aluminum and oxygen with trace amounts of sulfur, chlorine or other elements. There were never any agents present in sufficient quantities to cause this rapid oxidation of aluminum or any other metal in the unit. Lacking any other testing it was erroneously concluded that the flakes were aluminum oxide (Al_2O_3), commonly called alumina.

In the late 1990s, a sample of white powder was analyzed by X-Ray Defraction (XRD) to reveal the crystal structure of the powder. Combining the elemental composition and the crystal structure

Appendix A

usually specifies the composition of a compound. In this case the composition is aluminum oxide hydroxide $AlO(OH)_2$. The SEM analysis had shown that the powder contains aluminum and oxygen but was incapable of identifying the presence of the hydrogen in the compound. The XRD analysis showed that the crystal structure of the powder was one that only occurs with hydroxides of aluminum and does not occur with oxides of aluminum. Aluminum oxide hydroxide forms on aluminum when it is nearly constantly wet. It is characterized as a white, flaky powder.

White powder is aluminum oxide hydroxide $AlO(OH)_2$. It is not aluminum oxide (Al_2O_3).

Details

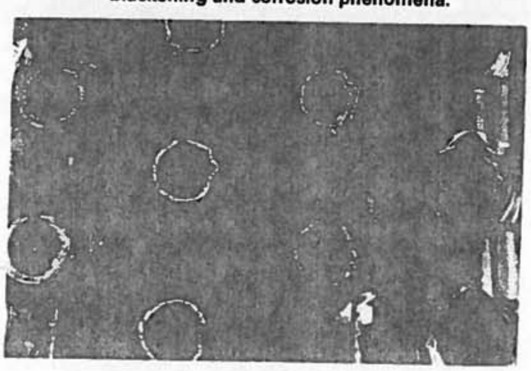
Even today there has been no mechanism proposed that explains the set of events necessary to create a loosely-bound flake form of oxidized aluminum rather than the normally-formed, tenaciously-bound crystalline aluminum oxide. It is known that the aluminum surface corrosion occurs during cooling operation. The nature of the flakes formed suggests the coil must remain wet or damp for very long periods of time. The actual flaking occurs during heating operation when the coil is dry and hot. The flake shape allows for it to be easily entrained in the fast-flowing air through the coil and deposit quickly in the living space where air velocity is low. Experience tells us that once initiated, the formation of white flakes does not cease.

All indications seem to point to the initial catalyst being some type of jobsite specific condition. This conclusion has been drawn from the fact that multiple products from the same manufacturer that were made in different manufacturing plants on different dates, with different processes and process fluids, different materials and different cleaning procedures have all exhibited the white flakes on a single jobsite. The problem has repeated on a jobsite when a new coil was installed one to two years after the original installation with identical material construction. Since thousands of coils were produced and successfully installed and operated without incident by this manufacturing facility between the two problem jobs, it becomes evident that the common problem must be outside the manufacturing facility and not directly related to the coil construction or the materials. Multiple alloys of aluminum from aluminum mills all over the world have been used in coils that have been problematic. There are also accounts of job sites with multiple, competing manufacturers that were creating the white flakes at the same time.

Root cause analysis is very difficult due to the extremely low incident rates. With only a few cases out of hundreds of thousands of coils, there is very little evidence to collect and analyze. Because the initiating reaction is believed to occur during the cooling season, there is no evidence left when the coils begin to form flakes during the following heat season.

This condition has not been shown to be related to galvanic corrosion between aluminum and copper. The mechanism appears to be more related to aluminum oxidation and corrosion rather than galvanic action between dissimilar metals.

Figure 3. A close-up view of the fin surface shows the blackening and corrosion phenomena.



Appendix A

What are the safety risks?

When any type of substance is produced or emitted by a mechanical device whether it is liquid, solid or gaseous, it is common to inquire about the safety implications. Toxicology and pulmonology experts have been consulted in regards to the health affects of the aluminum hydroxide oxide powder and it has been shown to not be chemically harmful to people. These analyses also showed the physical size of these flakes to be too large to cause pulmonary problems if inhaled. Risks associated with inhalation, skin, and eye irritation are unwarranted.

How can the problem be fixed?

Because no single source or catalyst of the problem has been identified, the most common means to mitigate the problem has been to address the coil that is producing the white flakes. The coil is not necessarily the cause of the problem as illustrated above, but being the source of the flakes makes it a likely starting point.

As mentioned previously, replacing the coil with an identical coil could allow for the condition to return. This is not going to happen every time as jobsite conditions change over time, but reemergence of the problem is possible.

From a customer standpoint, the main complaint has been the house keeping issues of having white powder distributed from the HVAC ducts and diffusers. Post filtration or final filtration has been successfully applied in containing the flakes within the air handler systems or duct work. While not all systems will be conducive to applying additional filtration, it has been shown that very minimum particle efficient filters are more than capable or remove the large white flakes from the airstream. Field experience has shown that coil cleaning at best offers only short term relief as the flake production will inevitably return.

Replacing the affected coil with coated aluminum fins eliminates the problem. Common coatings would be some type of corrosion resistant coatings that are optional on some product lines. While this is easily accomplished in residential equipment, much more effort, time and cost is involved in replacing coils in large commercial equipment.

Using alternate materials for the fin surface such as copper or steel will also prevent the white flakes from forming since there is no aluminum material.

There is no known material treatment or coil cleaning process that will stop the chemical breakdown reaction.

Evaluations of jobsite conditions such as chemical treatments and cleaners, indoor pollution or outdoor pollution could help to determine causal relationships. Source control of the reaction catalyst will be the best approach to successfully eliminating the problem from reoccurring in the building.

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