HEALTH AND SAFETY GUIDE

MERCURY HAZARD IN SCHOOLS FROM RUBBER-LIKE POLYURETHANE FLOORS

For the New Jersey School Boards Association (NJSBA)

New Jersey Education Association (NJEA)
New Jersey Work Environment Council (WEC)
Healthy Schools Now Coalition (HSN)

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Eileen Senn, M.S.; Diana Crowder, M.S., C.I.H.; and Adrienne Markowitz, M.S.[1]

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[1] The authors are WEC industrial hygiene consultants. They have based this document on good industrial hygiene practices, the cited technical resources and ATSDR health consultations, and expert reviewer comments.

The Mercury Problem

Rubber-like polyurethane floors using 1,000 to 2,000 parts per million (ppm) of phenyl mercuric acetate (PMA) catalyst have been installed in school multipurpose rooms, gyms, cafeterias, auditoriums, stages, and indoor and outdoor tracks since the 1960s. PMA breaks down and releases odorless, colorless mercury vapor at room temperatures. The floors and items that have been in contact with them emit mercury vapor indefinitely. Exposures are worse if floors are damaged or deteriorated, in hot rooms with poor ventilation, no outdoor air being pulled in, or no air conditioning.

Mercury vapor inhalation and skin absorption are health hazards, especially toxic to children and fetuses. Mercury can damage the central nervous system, kidneys, lungs, eyes and skin.

It isn't known how many of these floors currently exist, whether they are still being installed, or what schools have them. Two have been identified and removed in New Jersey – one in a public middle school gym in Bergen County and one in a public elementary school in Burlington Township. But there are likely to be many more in New Jersey – perhaps hundreds. The state of Arizona has identified 176 potential mercury floors in 220 school districts. Not every polyurethane floor used mercury as a catalyst and not every floor that used mercury as a catalyst is a public health hazard. But some are.

This guide describes the problem and actions that need to be taken to identify suspect floors and reduce or eliminate any mercury exposure.

The mercury floor problem is not like asbestos, which can be managed in place as long as it isn't damaged. These floors give off mercury vapor all the time. Managing them in place requires excellent ventilation and air conditioning, which many schools do not have. The only way to permanently eliminate the hazard of a mercury-containing floor is to remove it. Many are near the end of their life-expectancy and need to be replaced soon in any case.

Mercury Health Concerns

The health effects of mercury are diverse and include damage to the nervous system, lungs, and kidneys. It is especially harmful to young children and fetuses whose bodies are still developing. Therefore, children and pregnant, or soon to be pregnant, staff and older students are the most vulnerable to harm from mercury-containing floors. The risk varies depending on how much mercury a person is exposed to, how long and often a person is exposed, and their age and health status. The risk is greater if the person has additional mercury exposure from eating fish like tuna, having dental fillings made with amalgam, or spending time anywhere where liquid mercury has been spilled and not properly cleaned up. The risk is also greater if the person has exposure to other heavy metals, such as lead from paint or in drinking water. It is not known if the floors cause exposure to the organic mercury compound used as a catalyst, usually Phenyl Mercuric Acetate (PMA). If it turns out that these floors do create exposure to PMA, that would worsen the health hazards posed by the floors. PMA should be treated as a carcinogen because it causes kidney cancer in animals.

School staff members that spend the most time in rooms with mercury-containing floors are likely to have the most mercury vapor exposure. This would likely be physical education and athletic staff. Custodians who clean and maintain the floors may also have significant exposure, especially if they use methods that raise dust or abrade the floor such as buffing or vacuuming.

Breathing mercury vapor is dangerous because inhaled mercury vapor is almost completely absorbed by the body. Skin absorption is also a significant route of exposure.

Inhaled mercury vapor easily enters the blood stream where it is carried throughout the body. It can travel to the brain and affect the central nervous system (CNS). Symptoms of CNS involvement include tingling of the extremities, limb weakness and impaired motor control.

Health effects caused by long-term exposure to mercury vapors are not completely know but may include changes in mood or personality, anorexia, sleeping problems, loss of appetite, irritability, fatigue, forgetfulness, tremors, and changes in vision and hearing.

The low-level mercury exposures anticipated from mercury floors will hopefully not lead to immediate or long-term adverse health effects among those exposed. Urine testing and medical treatment are not anticipated to be needed. But the levels of exposure will vary in each situation depending on floor condition and room temperature and ventilation. For example, exposure from outdoor tracks might be lower than indoor tracks. Some exposures may turn out to be quite high. And in most schools the exposures have been ongoing for decades. Therefore, exposed school staff who have health concerns and families who have health concerns about their exposed children should see the **For More Information** section for where to access specialized medical help.

Special Risks for Students

Since most students are shorter than adults, their breathing zone is closer to the floor where higher mercury vapor levels would typically be found. Students involved in physical education would likely be engaged in an activity that would increase respiration. Some activities may put children in direct contact with the floor. Coupled with their lower body weight and higher intake rate, the result would be a greater dose of mercury vapor per unit of body weight.

Urine Test for Mercury Exposure[2]

Urine levels of mercury are the most appropriate way to assess elemental mercury exposure, both acute and chronic. A 24-hour urine specimen collected in a plastic container is the preferred specimen. However, a first morning void can also provide a close approximation of the urine level.

The impact of airborne mercury levels below 10,000 nanograms per cubic meter of air (ng/m3) is likely to be indistinguishable from background urinary mercury levels. Therefore, only if airborne exposures are believed to have been higher, might a urine test for mercury be useful.

Blood analysis for mercury is not recommended because interpretation is complicated by dietary sources of mercury such as tuna fish. Hair analysis is not recommended because it also primarily measures organic methyl mercury from fish.

Relationship of Urinary Mercury Concentration with Health Effects in Adults

Urinary Mercury Concentration (µg/L)	Signs and Symptoms
Less than 20	None
20 to 100	Decreased response on tests for nerve conduction, brain-wave activity, and verbal skills. Early indication of tremor on testing.
100 to 500	Irritability, depression, memory loss, minor tremor, other nervous system disturbances. Early signs of disturbed kidney function.
500 to 1000	Kidney inflammation, swollen gums, significant tremor and nervous system disturbances.

[2] *Evaluating Mercury Exposure: Information for Health Care Providers, ATSDR, February 2009, https://www.atsdr.cdc.gov/mercury/docs/physician_hg_flier.pdf*

Identifying Suspect Floors

The floors that may contain mercury are synthetic polyurethane, not wood or vinyl tile. They are rubber-like and water-resistant. They are most likely to be found in school multipurpose rooms, gyms, cafeterias, auditoriums, stages, and indoor and outdoor tracks. They may have been tinted any color. They are usually one-piece and poured in place but sometimes pieced. They can be smooth, stippled, or mesh-like. They may have been covered by another floor.

Safety Data Sheets (SDSs) for floors are often unavailable or do not disclose whether or not mercury was used as a catalyst. **The only way to determine whether a particular polyurethane floor contains mercury is to collect several representative full-thickness bulk samples for analysis by an accredited laboratory using EPA Method 7471A.** School districts will need to hire a competent environmental or industrial hygiene consultant to do the testing.

For more on these floors, see **Appendix 1: Background on Mercury Floors**.

Action Plan

The following action plan is designed to ensure that school boards and districts identify, test, control exposures from, and eventually remove and replace mercury-containing floors in every school in New Jersey.

Alert the school district: Make district administrators formally aware of the problems with mercury-containing floors by giving them the WEC, NJEA, HSN Alert: "Mercury Hazard to Staff and Students from Rubber-Like Floors in Schools."

Find and report rubber-like floors: Districts should undertake a systematic effort to identify the locations of rubber-like floors that may contain mercury in schools, tracks, administrative, garage, and other district buildings.

Request Bulk Sampling of Floors: Once suspicious floors have been identified, the district should hire a consultant to collect small, representative, full-thickness pieces of the floor for analysis at an accredited lab. Two square inch floor samples should be analyzed using EPA 7471A to determine the amount of mercury present that may vaporize into the air.

In addition, the district must have a mandatory toxicity characteristic leaching procedure (TCLP) Method 1311 performed on eight square inch floor samples to determine whether the floor must be disposed of in a hazardous waste landfill. Floors with leachate that exceeds the EPA maximum concentration of 0.2 ppm (mg/L) of mercury must be disposed of as hazardous waste. This is not the correct test, however, for deciding if a floor should be removed.

Appendix 3: Technical Resources has links for finding a consultant and an accredited lab and links to the analytical methods. The cost to analyze each bulk sample is about $50.

Interpret Bulk Floor Results: If the EPA 7471A test shows that mercury in a floor is less than 1 ppm, it can be assumed that the floor was not manufactured using a mercury-containing catalyst. **If mercury in floor levels are greater than 1 ppm, proper floor maintenance, adequate ventilation and cooling and initial worst-case air sampling should be immediately implemented.**

Measure Airborne Mercury: Once floor bulk sampling results are known, the district's consultant should be directed to conduct worst-case air sampling in each room with results over 1 ppm. Worst-case means under conditions of maximum temperature and minimum ventilation so that mercury vapor levels are as high as possible. Worst-case sampling is needed to decide if the floor should be removed. The results will also give a very rough estimate of how high past mercury vapor exposures to staff and students may have been.

One reason that worst-case sampling must be performed is that mercury exposures from floors increase dramatically as temperatures increase. They double for every 9 degrees F, as shown in this table. [3]

Room temp in degrees F	Temp increase in degrees F	Number of times airborne mercury vapor increases from the level at 68 degrees F
68	-	-
77	9	2x
86	9	4x
95	9	8x

A representative number of full-day air samples should be collected at children's breathing zone height (3 feet for up to eighth grade; 5 feet for higher grades) using either active sampling pumps or passive dosimeters for subsequent analysis by NIOSH Method 6009. The cost to analyze each air sample is about $50. The more samples taken, the more likely results are to be representative of actual exposures. Samples should also be taken in areas adjacent to a mercury-containing floor or track to see if mercury has been tracked away from it. These might include locker rooms, coach and PE offices, bathrooms, and hallways. Background samples should be collected outdoors in an area far from any mercury floor or track.

Real-time Mercury Vapor Analyzers: These can be used as a screening tool to collect additional mercury vapor in air readings. Such meters are well suited for taking many measurements at various heights off the floor and at any damaged areas of the floor. These meters must be sent to the manufacturer to be calibrated on a regular basis. Currently, the meter with the lowest limit of detection is the Lumex 915 M with a detection limit of 2 ng/m3. The next most sensitive is the Jerome J505 with a detection limit of 50 ng/m3. Note that only the Lumex 915 M is sensitive enough to measure average outdoor levels of mercury vapor of 2 to 10 ng/m3.

See Appendix 3: Technical Resources for analytical methods for mercury and sources for mercury vapor analyzers.

[3] *Mercury Flooring Testing and Mitigation: Guidance for Environmental Professionals, MN Dept. Health, http://bit.ly/2vYzuwl*

Before Air Sampling: Before air sampling, the consultant should first determine if there are operable windows and mechanical ventilation, heating and air conditioning. Then, to simulate a worst-case scenario during sampling, windows and doors should be closed, the ventilation system turned off for 24 hours, and the room heated as warm as it may get on a hot day. This may be above 90 degrees F. If the weather is cool, space heaters may be needed to heat the room to achieve such temperatures.

Wipe Sampling: Wipe samples of surfaces for mercury can help to determine whether there is mercury on surfaces such as furniture that are touched by staff and students. Items that should be wipe sampled include tables, chairs, bleachers, floor mats, balls and other recreation equipment. Walls, ceilings, and the outside and inside of ventilation ductwork should also be wiped sampled because mercury vapor may have condensed there.

Wipe samples of items will help assess the need for cleaning them to remove mercury. Cleaning may help reduce mercury levels and therefore hand to mouth ingestion and skin absorption from contact with the items. Wipe sampling results should be compared with background samples collected on similar clean surfaces far from the room with the mercury floor. There are no standards for their interpretation. Results should be ranked by severity to see where surface contamination is the worst. Contaminated items should be cleaned, if possible, or replaced. Porous materials such as cloth, cardboard, wood, concrete, ventilation ductwork lining, etc. may not be able to be decontaminated.

Interpret Air Sampling Results: It is very important that the district's consultant present air sampling results in written reports with all relevant information — dates, times, locations, heights, ventilation and temperature conditions, sampling methods, instrument calibration, etc. — so that the results can be correctly and fully understood by WEC industrial hygiene consultants.

Occupational exposure limits (OELs) apply only to adults at work and are not appropriate for interpreting the levels of mercury vapor in schools. They include the OSHA and PEOSH Permissible Exposure Limit (PEL) of 100,000 nanograms of mercury vapor per cubic meter of air (ng/m3) and the ACGIH Threshold Limit Value (TLV) (skin) of 25,000 ng/m3. More protective limits are necessary because children and fetuses are exposed. See the **Mercury Vapor in Air Guidelines** box for interpretation of air sampling results.

Mercury Vapor in Air Guidelines

WEC's industrial hygiene consultants recommend that the California reference exposure level (REL) of 60 ng/m3 for long-term, repeated, eight-hour inhalation exposures be used for interpretation of full-shift mercury in air samples involving mercury-containing floors before and after their removal. Note that this guideline is 6 to 30 times typical outdoor levels of 2 to 10 ng/m3.

The most recent and protective guidelines available are reference exposure levels (RELs) developed by the California Office of Environmental Health Hazard Assessment in 2008. An REL is an airborne level of a chemical that is not anticipated to present a significant risk of an adverse noncancer health effect. **There are three 2008 California RELs for mercury vapor inhalation, expressed in nanograms of mercury vapor per cubic meter of air (ng/m3):**

- **30 ng/m3 for long-term inhalation exposure.**
- **60 ng/m3 for long-term, repeated, eight-hour inhalation exposures.**
- **600 ng/m3 for short-term, acute, one-hour inhalation exposure.**

The Agency for Toxic Substances and Disease Registry (ATSDR) 1999 Minimum Risk Level (MRL) for chronic inhalation of mercury vapor is 200 ng/m3. It dates to 1999 so it is an older and less protective guideline. This level is the amount of mercury vapor in the air that ATSDR believes to be unlikely to produce adverse health consequences based upon continuous exposure over a person's lifetime. It has often been used in past state and federal investigations of mercury vapor exposures from floors, most of which predate the 2008 California RELs.

The U.S. Environmental Protection Agency (U.S. EPA) 1995 Integrated Risk Information System (IRIS) Reference Concentration (RfC) for chronic mercury inhalation exposure is 300 ng/m3. This is a lifetime exposure concentration not expected to result in appreciable adverse health effects to most people, including sensitive groups. It dates to 1995 so it is an older and less protective guideline.

The State of Minnesota August 2008 recommendation is 750 ng/m3 for staff during a 40-hour workweek and the same for children for 16 hours or less per week. This recommendation is based on the EPA RfC, an older and less protective guideline and assumes there no other ongoing sources of mercury vapor exposure such as amalgam dental fillings.

Action Levels for elemental mercury spills were set in March 2012 by ATSDR and include 1,000 to 3,000 ng/m3 for schools. The action levels are intended for deciding when it is safe to resume normal operations in schools, homes, businesses, vehicles, after liquid mercury is spilled then cleaned up. These guidelines are based on the older and less protective ATSDR MRL and EPA RfC noted above. WEC's industrial hygiene consultants do not believe the action levels are applicable to the evaluation of mercury-containing floors prior to or after their removal. This is because they were designed for use after a mercury spill clean-up, which is an entirely different situation. In addition, the levels listed as acceptable for schools to resume normal operations have the caveat "Pregnant workers and students should be offered temporary alternatives to working or attending the school."

See **Appendix 3: Technical Resources** for source documents on each of these exposure guidelines.

Solutions

Prevent installation of new mercury catalyst floors: Boards of Education and school district administrations should work with the New Jersey Schools Development Authority (SDA) and New Jersey Department of Education (DOE) and architects and contractors to prevent the installation of new mercury-containing floors. If a new rubber-like polyurethane floor is being considered for installation, a written statement should be requested from the manufacturer certifying that it does not contain PMA or other mercury catalysts. The statement should include the information the manufacturer is relying upon. Ideally, this will include analytical results of samples of the flooring materials.

Do not cover or seal floors: Attempting to encapsulate (cover or seal) a mercury-containing floor instead of removing it may not be effective and may create more contamination and cost. Mercury can penetrate and contaminate other materials, such as laminate, tile, or wood floors placed on top of them. These may then need to be disposed of as hazardous waste, which is expensive. Attempting to seal a floor with polyurethane will create other toxic exposures and may not reduce mercury emissions.

Limit mercury exposure: If removal is not going to take place in the near future, measures to limit mercury exposures should be implemented. These include cool temperatures, good ventilation, and ongoing air sampling. They also include floor maintenance, good housekeeping, restricting floor access, cleaning equipment and clothing, record-keeping, Hazard Communication and training, ventilation system documentation and training, and compliance with the PEOSH Indoor Air Quality (IAQ) Standard. These control measures should be used together to ensure average year-round mercury vapor concentrations are less than 60 ng/m3. Each is discussed in detail in **Appendix 2: Best Practices to Limit Mercury Exposure**.

Remove mercury-containing floors using precautions to protect workers and the school: The only way to permanently eliminate the hazard of a mercury-containing floor is to remove it. That may require long-term planning to raise the necessary funds and ensure the floor is removed when the school is not occupied. Prior to removing a mercury-containing floor, the district must call the N.J. Department of Environmental Protection (DEP) Hazardous Waste Program at 609-943-3019 for information on waste disposal, which varies by county.

The district should hire a contractor with proven experience in the effective and safe removal and disposal of mercury-contaminated materials, isolation of remediation areas, and qualification and protection of remediation workers. Mercury vapor and dust levels will be high during removal as the floor is being disturbed. Appropriate measures should be taken to assure that mercury does not contaminate the rest of the school or the ventilation systems. Removal workers must be protected from mercury with special training, air monitoring for respirator selection, respirator fit-testing, protective clothing, and by provision of decontamination facilities and procedures. Bid specifications from the contractor must describe mercury vapor and dust containment using physical barriers, pressure differentials, maintenance of negative pressure in the room, and filtration of exhaust air with high efficiency particulate arrestor (HEPA) and activated carbon filters.

Conduct clearance air sampling before new floor installation and reoccupancy: After floor removal and before installation of a new floor, the room should be thoroughly cleaned. All dust generated during the floor removal should be removed during the cleaning.

Clearance air sampling of the room should then be conducted. Samples should be collected and analyzed by the NIOSH 6009 method under worst-case temperature and ventilation conditions. Again, all sampling information should be made easily available to the school community.

If elevated mercury levels are still present, the source(s) of the mercury needs to be identified and removed. Possible sources include subflooring like concrete slabs, walls, ceilings, and the inside or outside of ventilation ductwork. Wipe and bulk sampling of suspect sources may be helpful in determining what needs to be cleaned. If the subfloor is contaminated and cannot be cleaned, it may need to be removed.

After the new floor has been installed and before the room is reoccupied by staff and students, it should be thoroughly cleaned and aired out for at least 24 hours with outdoor air. All dust generated during the installation of the new floor should be removed during the cleaning.

For More Information

(Note: Bit.ly links are case sensitive.)

New Jersey Work Environment Council (WEC)
https://njwec.org/2017/02/mercury/

New Jersey Education Association (NJEA)
https://www.njea.org/alert-mercury-hazard-staff-students-rubber-like-floors-schools/

Healthy Schools Now Coalition (HSN)
http://njwec.org/take-action/campaigns/healthy-schools-now/

Mercury Quick Facts for School Nurses, ATSDR, June 2012
http://bit.ly/2adwEwh

Organizing for Better Indoor Air Quality, NJEA, February 2011, 27-page booklet.
https://www.njea.org/issues/health-safety/health-safety-publications/

Mercury and Your Health, ATSDR Homepage
http://www.atsdr.cdc.gov/mercury/index.html

Health Effects of Mercury, ATSDR, June 2012
English: *http://bit.ly/2aIpnUo* Spanish *http://bit.ly/2aL1c9o*

New Jersey Hazardous Substance Fact Sheets
Elemental Mercury
English: *http://bit.ly/2aN6T3w* Spanish: *http://bit.ly/2aN6Dl9*
Phenyl Mercuric Acetate (PMA)
English: *http://bit.ly/2aE9ygb* Spanish *http://bit.ly/2aHpoZg*

Evaluating Mercury Exposure: Information for Health Care Providers, ATSDR, February 2009, *https://www.atsdr.cdc.gov/mercury/docs/physician_hg_flier.pdf*

Medical Treatment for an Elemental Mercury Exposure Incident, 3-pages, December 2012. Mt. Sinai Selikoff Centers for Occupational Health, *http://bit.ly/2vbHbkX*

Physicians in New Jersey specializing in occupational and environmental illness, New Jersey Department of Health listing. *http://bit.ly/2hgyrnT*

Pediatric Environmental Health Specialty Unit (PEHSU), Icahn School of Medicine at Mount Sinai, New York, NY, 866-265-6201, *http://icahn.mssm.edu/research/pehsu*
PEHSU can provide clinical consultation and education to families, health care professionals, public health officials, and community organizations that have concerns regarding children's environmental health.

Appendix 1

Background on Mercury Floors

Beginning in the 1960s, many schools, colleges, nursing homes, prisons, fitness centers and other institutions throughout the U.S. installed rubber-like polyurethane floor in multipurpose rooms, gyms, cafeterias, auditoriums, stages, and indoor and outdoor tracks. The floor material was first manufactured by the 3M Corporation under the name of Tartan® floors and Tartan® track, and then by more than 10 other manufacturers including American Biltrite Rubber Co. Inc., Athletic Polymer Systems, Crossfield Products (Dex-O-Tex®), Dynamic Sports Construction (Versaturf®), Mondo Rubber, Pitzer Inc., Robbins Sport Surfaces (Chem Turf® and Pulastic Systems®), Selby Battersby & Company, Surfacing Systems, and Whittaker Synthetic Surfaces (Chemothane®).

Although industry-wide data have not been collected, 2010 estimates from Athletic Polymer Systems (APS) claim they have installed over 25 million pounds of polyurethane floor product over the past 40 years.

According to 3M, mercury—usually as Phenyl Mercuric Acetate (PMA)—was used as a catalyst when mixing the polymer to form the floor covering, resulting in a finished product typically containing 0.1 to 0.2 percent PMA, which is 1,000 to 2,000 parts per million (ppm). Some manufacturers later adopted mercury-free formulations, but there is no evidence that they all did so or continue to do so. There is no legal prohibition against a U.S. chemical manufacturer using a mercury catalyst in floors.

The mercury-containing floors have life expectancies of 40 or more years before replacement. Damage can occur from the installation or movement of items such as bleachers and basketball posts. The floors can deteriorate and crack over time.

Polyurethane floors are made by combining two liquid resins to form a durable, rubber-like surface. This material can be factory produced in sheets and rolls or installed on site as a liquid to level and cure in place. Polyurethane surfaces are generally installed over Portland cement concrete substrates indoors, and over asphaltic concrete substrates for exterior tracks. Thickness of polyurethane floors ranges from one-quarter to 1 inch.

In poorly ventilated spaces, even in large spaces such as gyms, relatively high levels of mercury vapor have been found in the air. Results reported by state health departments in Ohio, Michigan and Minnesota varied greatly in concentrations of mercury vapor. In most cases, concentrations were found to be within older, less protective limits. However, there were instances where exposures exceeded these limits. Average mercury vapor levels in Minnesota gyms were about 200 times higher than typical outdoor background levels of 2 to 10 ng/m3 reported by ATSDR in their 1999 toxicological profile for mercury.

For more details, see **Appendix 4: ATSDR Mercury Floors in Schools Health Consultations in States.**

Appendix 2

Best Practices to Limit Mercury Exposure

If floor removal is not going to take place in the near future, measures to limit mercury exposures should be implemented. At a minimum, these include cool temperatures, good ventilation and ongoing air sampling. They should also include floor maintenance, good housekeeping, restricting floor access, record-keeping, Hazard Communication and training, ventilation system documentation and staff training, and compliance with the PEOSH Indoor Air Quality (IAQ) Standard. Each is described here. They should be used together to ensure average, year-round, full-shift mercury vapor concentrations are less than the California REL of **60 ng/m3 for long-term, repeated, eight-hour inhalation exposures** recommended by WEC industrial hygiene consultants and described earlier in this document under **Mercury Vapor in Air Guidelines**.

Cool temperatures: Mercury vaporizes much faster when it is hot than when it is cold. Temperatures should be kept as low as feasible yet comfortable, preferably about 68 degrees F. Central air conditioning is ideal for this purpose but window, wall, and portable AC units can also be employed. Heating in the winter will need to be minimized. Additional ways to help cool rooms with mercury-containing floors include:

- Solar film on windows, skylights, glass walls, etc.
- Exterior awnings and shades or shade trees.
- Reflective window shades and blinds.
- Replacement windows that block the heat ("low-e" windows).
- Replace/coat roof with bright white or shiny material.

Good ventilation: Good mechanical ventilation can help reduce mercury vapor to safe levels but is not always present in rooms with a mercury-containing floor. Providing natural ventilation by opening windows and doors, without an active system pulling in outside air, is unlikely to provide sufficient ventilation. A room with a mercury-containing floor should be actively ventilated by supplying clean outdoor air and removing contaminated indoor air, beginning at least two hours before it is occupied and continuing throughout the period of use. Unfortunately, many schools lack the mechanical heating, ventilation, and air conditioning (HVAC) systems that can accomplish this. Air movement within a space such as that provided by pedestal fans does nothing to reduce mercury levels. Fans in walls or placed at open doorways to bring in outdoor air or exhaust air from the room may help to slightly dilute mercury vapor. Ceiling fans do not cool a room and do not bring in outdoor air. However, they may mix and dilute mercury vapor at floor level with the rest of the air in a room.

Ongoing air sampling: Ongoing air sampling is the only way to ensure that mercury levels are being kept below harmful levels. Sampling should be done four times a year in different seasons. As in initial air sampling, a representative number of full-day air samples should be collected at children's breathing zone height (3 feet up eighth grade; 5 feet for higher grades) using either active sampling pumps or passive dosimeters for subsequent analysis by the NIOSH Method 6009.

This is a big and important undertaking, and the district will need to hire a competent and reliable industrial hygiene consultant to do the work. It is very important that air sampling results be presented in written reports with all relevant information—dates, times, locations, heights, ventilation and temperature conditions, sampling methods, etc.—so that the results can be correctly and fully understood. All results should be shared with school staff, students, parents and community.

Before sampling, all available ventilation and air conditioning should be checked to ensure it is in good repair. It should then be adjusted to run for two hours before the air sampling is begun and while it is being conducted. The ventilation should be run with the temperature and outside air exchange settings typical and customary for the season. In the same way, air sampling should be repeated during other seasons, preferably on the hottest days.

If air sampling in four seasons shows levels below this limit, the district should design and implement a written operations and maintenance plan for the ventilation and air conditioning equipment to ensure performance remains consistent in future years.

If ventilation and air conditioning adjustments do not reduce the school year average to below these limits, lowering temperatures and increasing outdoor air supply should be tried. If there are still overexposures, upgrading or replacing the ventilation and air conditioning should be considered.

If changes are made to the heating, air conditioning or ventilation in the school, or if there are changes to the room that may affect mercury emissions, mercury vapor concentrations in the room air should be measured again as soon as possible.

Floor maintenance: Mercury-containing floors should be regularly inspected and repairs made to cracks and holes using a least-toxic caulk. Buffing and resurfacing should not be done because they may abrade the floor, raise dust that is contaminated with mercury, and increase mercury vapor levels in the air.

Good housekeeping: Dust in rooms with mercury-containing floors may be contaminated with mercury. It should be regularly removed using methods that do not raise dust. These include wet wiping and mopping and microfiber mopping. Vacuuming using a regular vacuum or even one with a HEPA filter on the exhaust must not be used because it will heat and vaporize mercury and release it to the room. Special mercury vacuum cleaners that more safely collect liquid and particulate mercury are commercially available and can be considered. Walk-off mats should be placed at every exit from affected rooms. These measures will help prevent dispersion of dust to other areas of the school.

Clean equipment and furnishings: Mercury vapor can contaminate equipment and furnishings that have been in a room with a mercury floor, especially if in contact with the floor. Therefore, these items should also be cleaned regularly and wipe sampled to see if the cleaning was effective. Items that should be cleaned and wipe sampled include tables, chairs, bleachers, floor mats, balls and other recreation equipment. Contaminated items should be recleaned, retested, or discarded. The DEP Hazardous Waste Program at 609-943-3019 should be contacted for advice on proper disposal.

Restrict floor access: During periods such as heat waves when high levels of mercury in the air can be expected, close the room or restrict access to essential staff and students and restrict time in the room with the mercury-containing floor.

Record keeping: If removal of the mercury-containing floor will not occur for a number of years, it is important that records are maintained and that the institutional memory of the issues related to mercury-containing floors is preserved. Records must be kept for at least 30 years under OSHA and PEOSH regulation 1910.1020, Access to Employee Exposure and Medical Records.

Hazard communication and training: The district must clearly and regularly communicate mercury risks and control measures with all those affected—staff, students, parents and families, contractors, and visitors. Everyone should be educated about the health hazards of mercury-containing floors and how to minimize their exposures. Signs warning of the mercury hazard should be posted in all rooms with mercury-containing floors. Suggested language: MERCURY INHALATION AND SKIN ABSORPTION HAZARD COMING FROM THE FLOOR IN THIS ROOM. MERCURY VAPOR IS SUSPECTED OF DAMAGING THE UNBORN CHILD AND MAY CAUSE DAMAGE TO THE NERVOUS SYSTEM, LUNGS, AND KIDNEYS. MINIMIZE TIME IN THIS ROOM AND CONTACT WITH THE FLOOR. The Public Employees Occupational Safety and Health (PEOSH) Hazard Communication Standard (N.J.A.C. 12:100-7) requires such training and other protective measures for school staff potentially exposed to hazardous substances.

Ventilation documentation and staff training:

The district should implement these measures:

- Written documentation on the design of the school ventilation systems, including air supply and exhaust specifications.
- Written standard procedures for preventive maintenance of ventilation systems, doors, and windows with schedules and records.
- Written standard procedures for operation of the ventilation system with schedules and records.
- Adequate staffing and training for ventilation system operators.
- Occupant education on the ventilation system and its operation and maintenance.
- Written procedures for submitting and resolving ventilation-related complaints.

PEOSH Indoor Air Quality (IAQ) Standard requirements:

The district must do these things required by the PEOSH Indoor Air Quality (IAQ) Standard –

- Have a written plan to comply with the IAQ Standard.
- Have a designated person who is responsible for compliance.
- Provide proper preventive maintenance and repair of broken mechanical ventilation equipment, windows and doors.
- Make sure the heating and cooling systems are in proper operating order when indoor temperatures are outside of the desired range of 68 to 79 degrees F.
- Keep maintenance records for three years and make them available to employees and their unions.

Appendix 3

Technical Resources

(Note: Bit.ly links are case sensitive.)

Selecting an Indoor Air Quality Consultant
American Industrial Hygiene Association
http://bit.ly/2adwNzH

Accredited Laboratories
American Industrial Hygiene Association
http://bit.ly/2aq2vVn (Select IHLAP)

Analytical Methods for Mercury

- EPA 7471A Mercury in Liquid Waste *http://bit.ly/2aHpfF1*
- EPA TCLP Method 1311 *http://bit.ly/2aEa0et*
- NIOSH Method 6009 *http://bit.ly/2at6lAN*

Sources for Direct Reading Instruments for Mercury

- Lumex of Ohio, *http://bit.ly/2viFoe1*
- Arizona Instruments/Jerome, *http://www.azic.com/jerome/*
- Ion Science, *www.ionscience.com/products/mvi-portable-mercury-vapour-detector/*
- Nippon, *http://eng.hg-nic.com/index.html*

Sources of Mercury in Air Guidelines

California mercury RELs are listed in California Office of Environmental Health Hazard Assessment (OEHHA), All OEHHA Acute, 8-hour and Chronic Reference Exposure Levels (chRELs) as of June 2016." *http://bit.ly/2aIr0l1*

The documentation for the California mercury RELs is on pages 476-501 of Appendix D. Individual Acute, 8-hour, and Chronic Reference Exposure Level Summaries *https://oehha.ca.gov/media/downloads/crnr/appendixd1final.pdf.*

The risk assessment process used for the California mercury RELs is in the 2008 Hot Spots noncancer REL Technical Support Document
https://oehha.ca.gov/media/downloads/crnr/noncancertsdfinal.pdf

ATSDR Minimum Risk Level for Mercury
https://www.atsdr.cdc.gov/mrls/mrllist.asp#24tag

ATSDR Action Levels for Elemental Mercury Spills, March 22, 2012
http://bit.ly/2vfJPG5

EPA RfC, Integrated Risk Information System, Office of Health and Environmental Assessment, Environmental Criteria Office, U.S. Environmental Protection Agency. "Mercury, elemental." *http://bit.ly/2aKzAku*

Mercury Flooring Testing and Mitigation: Guidance for Environmental Professionals, Minnesota Department of Health, *http://bit.ly/2vYpxPh*

Other Technical Links

ATSDR Toxic Substances Portal for Mercury
http://bit.ly/2aY4sKO

State of Arizona School Rubber Flooring Project, *https://schoolflooring.az.gov/*

State of Minnesota Mercury in School Flooring webpage, Minnesota Department of Health, *http://bit.ly/2aN77rB*

Kiddie Kollege Mercury Investigation, N.J. Department of Health
http://bit.ly/2f1QFJ7

Mercury Educational Materials webpage, N.J. Department of Health
http://bit.ly/2uQUgxt

Mercury Emissions from PMA-Catalyzed Polymer Floors: Investigations, Mitigation, and Education, Christina R Bush MS, Marian L. Heyman M.P.H., Carl Herbrandson Ph.D., Thomas Baughman Ph.D., and Mark Johnson Ph.D. Year: 2011, Volume: 2, Conference: 12th International Conference on Indoor Air Quality and Climate 2011

Phenyl mercuric acetate (PMA): mercury bearing flexible gymnasium floors in schools – evaluation of hazards and controlled abatement, Beaulieu H.J., Beaulieu S., and Brown C. 2008. J Occupational Environmental Hygiene 5:360-366.
http://bit.ly/2ar5EaY

A Hazard in a Gym Floor; How the Burlington Township school district managed a crisis when it discovered flooring material contained mercury, Dr. Richard M. Lynch, Mary Ann Bell and Nicholas Bice. May/June 2017, Volume 47, 6. School Leader, NJ School Boards Association, *http://bit.ly/2vmeu5z*

Appendix 4

ATSDR Mercury Floors in Schools Health Consultations in States

(Note: Bit.ly links are case sensitive.)

Wisconsin

Agency for Toxic Substances and Disease Registry. Health Consultation:
"Evaluation of Health Concerns Associated with Mercury-Containing Polyurethane Gymnasium Floor in a Milwaukee Public School," Wisconsin Department of Health Services, December 2010. Atlanta, Ga.: U.S. Department of Health and Human Services.
http://bit.ly/2ani0zw

Minnesota

Agency for Toxic Substances and Disease Registry. Health Consultation:
"Mercury-Containing Polyurethane Floors in Minnesota Schools." September 2006, Atlanta, Ga.: U.S. Department of Health and Human Services.
http://bit.ly/2aIrd80

Bethel University, Health Consultation:
"Emissions from a Mercury-containing Gymnasium Floor: Mitigating exposures from mercury-containing polymer floors," February 2008.
http://bit.ly/2aHqKmS

Oregon

Agency for Toxic Substances and Disease Registry. Health Consultation:
Salem-Keizer School District 3M Flooring. Oregon Department of Human Services, Superfund Health Investigation and Education Program (SHINE), March 2006. Atlanta, Ga.: U.S. Department of Health and Human Services.
http://bit.ly/2aEavVR

Michigan

Agency for Toxic Substances and Disease Registry. Health Consultation:
"Mid-Michigan Mercury Floor." Middleton, Gratiot County, Michigan. Michigan Department of Community Health. May 6, 2004. Atlanta, Ga.: U.S. Department of Health and Human Services. *http://bit.ly/2aq3F3r*

Ohio

Agency for Toxic Substances and Disease Registry. Health Consultation:
"Mercury Exposures from 3M Tartan Brand Floors," Westerville Schools, Franklin County, Ohio. Ohio Department of Health, March 19, 2003. Atlanta, Ga.: U.S. Department of Health and Human Services.
http://bit.ly/2apXxOF

About the Authors

Eileen Senn, M.S. is an industrial hygiene consultant for WEC. She has performed occupational health work for government and unions in New Jersey and Pennsylvania for over 40 years. Her undergraduate degree is in chemistry from Duquesne University and her master's degree is in occupational health from Temple University.

Eileen was a research scientist for the New Jersey Department of Health in occupational health surveillance for 16 years. Earlier, Senn was a compliance officer for the Occupational Safety and Health Administration (OSHA) in Philadelphia and an industrial hygiene inspector for the Pennsylvania Department of Environmental Resources. She also worked for the United Auto Workers and Boilermakers unions providing technical assistance and conducting worker education.

Senn was a certified industrial hygienist (CIH), certified in the Comprehensive Practice of Industrial Hygiene, for almost 30 years.

Diana Crowder, M.S., CIH is an industrial hygiene consultant for WEC. She has performed occupational health work for government, unions, and a university in New Jersey for over 30 years. Her undergraduate degree is in biology from Boston State College and her master's degree is in environmental science from the University of Cincinnati.

Crowder was an industrial hygienist for the University of Medicine and Dentistry of New Jersey (UMDNJ) for 22 years. Earlier, she was an industrial hygienist for the Hudson County Regional Health Commission.

Crowder has been a CIH, certified in the Comprehensive Practice of Industrial Hygiene, for over 20 years.

Adrienne Markowitz, M.S. was an industrial hygiene consultant and healthy schools coordinator for WEC until her death July 24, 2017. She performed occupational health work for government and unions for over 30 years. Her undergraduate degree was in education from Queens College, City University of New York and her master's degree was in industrial hygiene from Hunter College, City University of New York.

Markowitz was the Director of Health and Safety for the Retail, Wholesale and Department Store Union (RWDSU) for 11 years. Earlier, she was a research scientist with the New Jersey Department of Health and Right to Know Coordinator for the Bergen County Department of Health Services. She also consulted for UMDNJ and the National Education Association providing technical assistance and conducting worker education.

New Jersey Education Association
njea.org

Healthy Schools Now Coalition
njwec.org/healthy-schools-now

New Jersey Work Environment Council
njwec.org/healthy-school-environments