Richard Beyer testimony, HB05100 February 18, 2014

This label informs me of my pillow's contents. It's a federal crime to remove it. I know what is in my pillows. I have no idea what is in the foam in my house. It made my family very sick.

Last year, the legislature **unanimously** passed the first version of this bill, HB5908, which actually protected consumers. The Department of Public Health opposed it, and the Governor vetoed. I spoke in favor, along with five industry representatives, and one from DPH opposed. Last year's bill was not perfect, this year's bill is terrible and I fully oppose it. It hands complete control over all spray foam installers in Connecticut to the American Chemical Council [ACC] . **This bill protects installers from consumers**. Not consumers from installers of toxic foam.

Follow the money. ACC solidly supports the bill. Their lobbyists are **Hughes & Cronin** and **Murtha Cullina**. They spray lots of cash around Washington too, including to Senator Chris Murphy. DPH supports the bill. They take marching orders from the Department of Health and Human Services. Who knows what it costs to buy a federal agency. Spray foam installers support the bill. Their industry group, Spray Polyurethane Foam Alliance, is an arm of the ACC, as is the Center for the Polyurethane Industry. The federal government has no jurisdiction inside homes, this falls to the states.

Spray foam has three problems:

1) It releases highly toxic fumes.
2) If improperly installed, it spontaneously combusts hours later.
3) In a fire, it releases **a soup of thick black smoke**[1] containing cyanide, which kills.

Foam insulation creates a toxic nightmare in homes. Foam leaches highly toxic gases. The higher the temperature, the more it releases. Attic temperatures reach over 150 degrees. This jar holds foam. If you open it, your lying nose reveals how dangerous these fumes are.

The bill contains no inspection or insurance provisions to protect consumers.

The insurance industry calls polyurethane spray foam insulation "**solid gasoline**." When it catches fire you have seconds to escape. The Station Nightclub fire involved foam.

In 1981, urea formaldehyde foam insulation [UFFI] was banned in the U.S. and Canada because of extreme toxicity, identical in health impacts to SPF. Will you ban it now, or later after too many have fallen ill or died?

---

[1]Madonna] Badger said she remembers being carried out of **a soup of thick black smoke** to safety. "My teeth were black and my mouth was black from the smoke," Badger said. "They took me away quickly because they were worried about smoke inhalation ... They said I had to go right away."

Read more:
http://www.nydailynews.com/news/national/madonna-badger-recalls-horror-christmas-fire-killed-daughters-parents-interview-nbc-matt-lauer-article-1.1098535#ixzz2tdZwMc4

THIS IS THE REAL WORLD OF SPRAY FOAM INSULATION

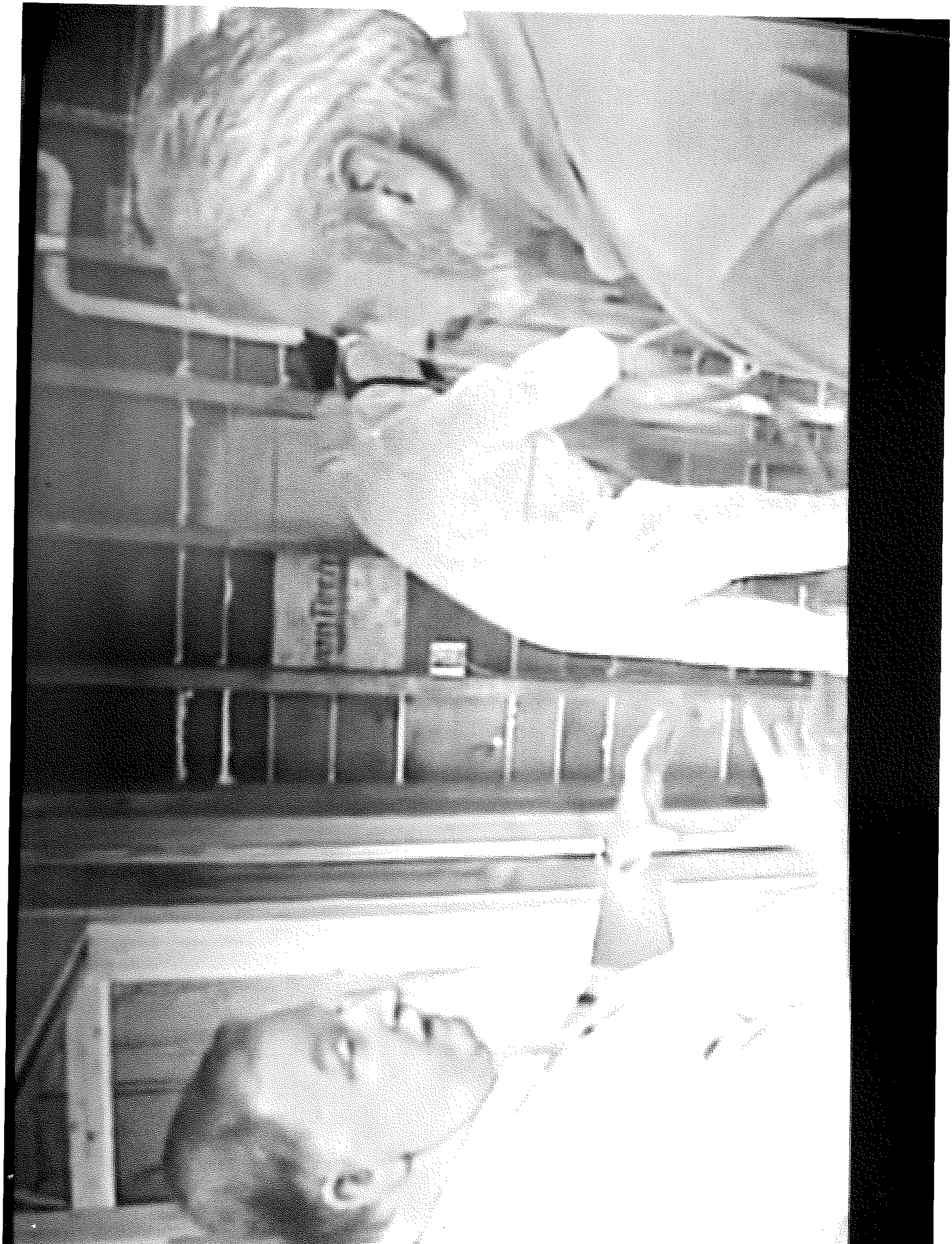
THESE PICTURES SHOW CONSUMERS ARE EXPOSED TO THE SAME LEVELS OF TOXINS AS INSTALLERS WHEN THEY ARE IN THE HOUSE AT THE TIME OF SPRAYING! THIS IS COMMON PRACTICE!

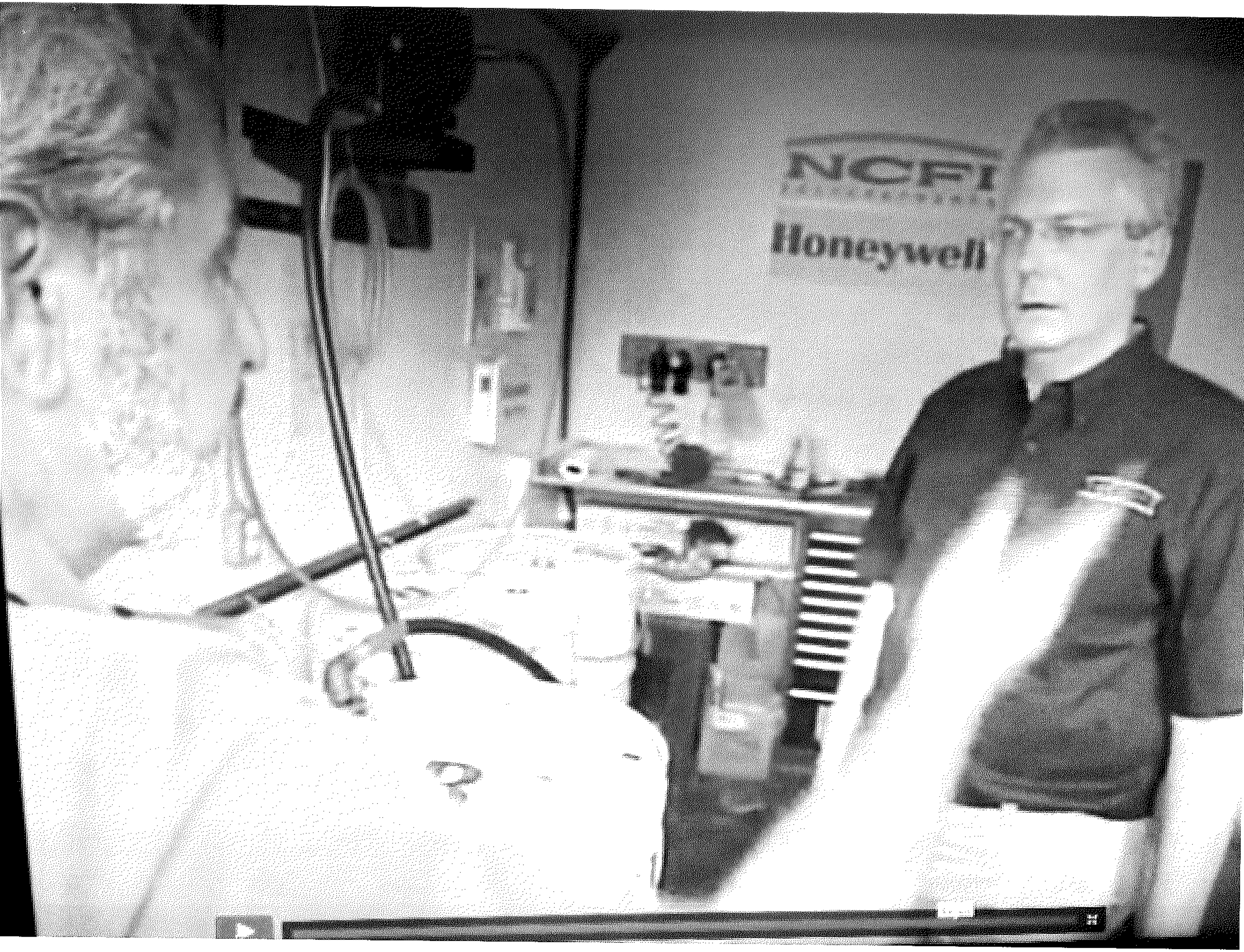
INDUSTRY TEST METHODS DO NOT TAKE INTO ACCOUNT

"CONSUMER EXPOSURE TO TOXIC CHEMICALS"

REASONS WHY THE CHEMICAL INDUSTRY SHOULD NOT BE ALLOWED TO CONTINUE PRACTICING IN HOMES UNREGULATED

- PICTURE 1 CLEARLY SHOWS AN INSTALLER SPRAYING SPF WHILE SMOKING A CIGARETTE AND WITH NO PERSONAL PROTECTIVE EQUIPMENT
-
- PICTURE 2 SHOWS BOB VILA AND THE SPRAY FOAM TECHNICIAN WITHIN A FEW FEET FROM ONE ANOTHER WHILE SPRAYING OCCURS. BY SHOWING BOB VILA STANDING WITHIN FEET OF THE INSTALLER IS IMPLYING THE CHEMICALS ARE "SAFE".
-
- PICTURE 3 CLEARLY ILLUSTRATES MANUFACTURER "OVERSIGHT" WITH BOB VILA!
-
- PICTURE 4 ILLUSTRATES NORM ABRAM FROM "THIS OLD HOUSE" STANDING WITHIN FEET OF THE INSTALLER WHO IS SPRAYING "HIGH PRESSURE" SPRAY POLYURETHANE FOAM INSULATION.
-
- PICTURE 5 ILLUSTRATES NORM ABRAM HANDLING A "USED" SPRAY FOAM GUN BARE HANDED WHILE THE INSTALLER WEARS PROTECTIVE GLOVES
-
- PICTURE 6 ILLUSTRATES A SPRAY FOAM CONTRACTOR HOLDING FRESHLY SPRAYED WATER BLOWN spfl (MDI CONTAINING) FOAM TO HIS FACE. (Note the vapor trail at finger tips)

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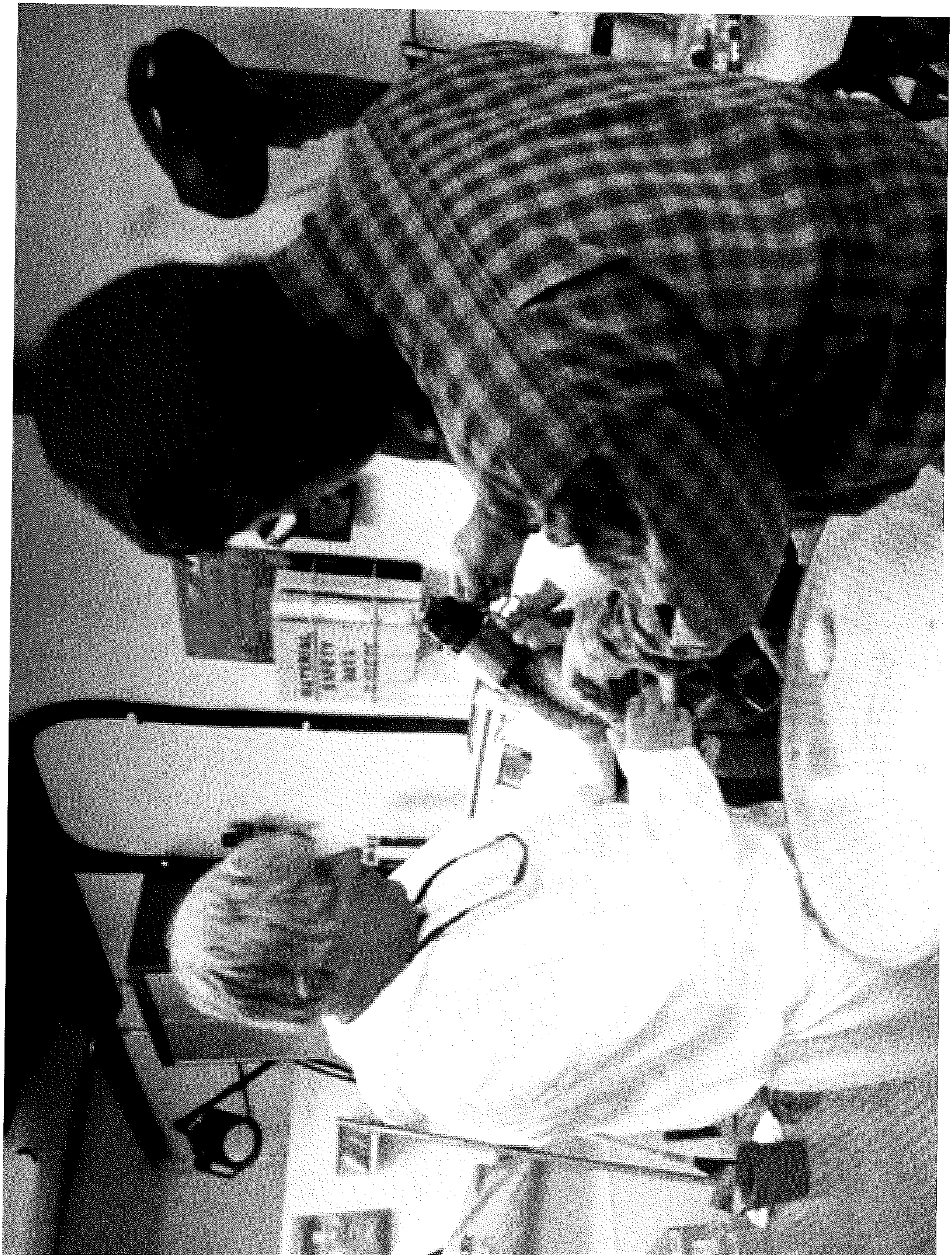

EACH DOCUMENT RAISES CONCERN ABOUT SPRAY POLYURETHANE FOAM INSULATION WITH THE EXCEPTION OF THE "FLUFF" AMERICAN CHEMISTRY COUNCIL PROVIDED TO THE EPA.

Health Consultation

SALEM-KEIZER SCHOOL DISTRICT SCHOOL BUSES

SALEM, OREGON

FEBRUARY 23, 2009

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR TOLL FREE at
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or
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HEALTH CONSULTATION

SALEM-KEIZER SCHOOL DISRICT SCHOOL BUSES

SALEM, OREGON

Prepared By:

Oregon Department of Human Services
Oregon Public Health Division
Environmental Health Assessment Program
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Foreword

The Environmental Health Assessment Program (EHAP) within the Oregon Public Health Division (PHD) has prepared this Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is part of the U.S. Department of Health and Human Services, Public Health Service. The mission of ATSDR is to prevent or mitigate adverse human health effects and diminished quality of life resulting from exposure to hazardous substances in the environment. This Health Consultation was prepared in accordance with ATSDR methodology and guidelines.

ATSDR and its cooperative agreement partners review the available information about hazardous substances at a site, evaluate whether exposure to them might cause any harm to people, and provide the findings and recommendations to reduce harmful exposures in documents called Public Health Assessments and Health Consultations. ATSDR conducts a Public Health Assessment for every site on or proposed for the National Priorities List (the NPL, also known as the Superfund list). Health Consultations are similar to Public Health Assessments, but they usually are shorter, address one specific question, and address only one contaminant or one exposure pathway. Another difference is that Public Health Assessments are made available for public comment, while Health Consultations usually are not. Public Health Assessments and Health Consultations are not the same thing as a medical exam or a community health study.

Public Health Assessments and Health Consultations include conclusions that categorize environmental contaminants and conditions according to the likelihood that they will harm people. These categories are called "Hazard Categories." The five possible Hazard Categories are:

Urgent Public Health Hazard: This category is used for sites that have certain physical features or evidence of short-term (less than 1 year), site-related chemical exposure that could result in adverse health effects and require rapid intervention to stop people from being exposed.

Public Health Hazard: This category is used for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Indeterminate Public Health Hazard: This category is used for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures. In other words, this category is used when there is not enough information to decide whether or not a condition at a site poses a public health hazard.

No Apparent Public Health Hazard: This category is used for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.

No Public Health Hazard: This category is used for sites where there is evidence of an absence of exposure to site-related chemicals.

Final Release

This is the final version of the Health Consultation titled "Salem-Keizer School District Buses." Prior to the current release, this Health Consultation was released for public comment. The public comment period was from September 9 – November 1, 2008. Comments from the public were incorporated into this final version of the report. Details about how comments were incorporated or otherwise addressed can be found in Appendix A. The most substantial revision in this final version following public comment was the addition of a recommendation that drivers or their union request a Health Hazard Evaluation from the National Institute of Occupational Safety and Health (See pages 22-23).

Table of Contents

Summary

The Oregon Public Health Division Environmental Health Assessment Program (EHAP) was asked by the Salem-Keizer School District to conduct this Health Consultation (HC). The purpose of this HC is to evaluate the public health risk for children who may have come into contact with contaminants found on several school buses in the Salem-Keizer School District (SKSD). Following a fire that destroyed and/or damaged several school buses parked in the SKSD Hawthorne Ave. bus barn, bus drivers began reporting health symptoms from driving affected school buses.

One parent of a child who rode one of the fire-affected buses during the 2007-2008 school year reported to EHAP that her child had experienced respiratory health symptoms, including asthma, during that year. Other children's health complaints were reported by bus drivers. In addition to concerns expressed by children or their parents to drivers, EHAP considers the complaints registered by the drivers about their own health as proxy for potential health effects in the children. Children spend much less time per day on the buses than drivers do, and so their exposure to contaminants on buses is also much less. However, EHAP recognizes that children may be more vulnerable from exposure to contaminants than adults.

All the data analyzed in this HC were collected by Oregon Occupational Safety and Health Division (OR-OSHA) in evaluating potential occupational exposures for the bus drivers.

In an attempt to characterize the nature and degree of the contamination that would impact children's health, the Environmental Health Assessment Program (EHAP) reviewed all of the data available from OR-OSHA's original complaint inspection, as well as from their follow-up health consultation. Several data collection and monitoring events over a 17–month period (see Appendix D); however the equipment used by OR-OSHA was intended to determine if certain chemicals were present, not to measure the concentrations of the chemicals.

EHAP determined that carbon monoxide, benzene, particulate matter, diesel exhaust, limonene, undecane, and phenol pose *no apparent public health hazard.* This was because the measured levels were either too low to cause health effect in children or, as in the case of limonene and undecane, they have low toxicity.

EHAP could not determine whether phosgene and sulfur dioxide are health hazards because we were unable to measure the levels of these contaminants. The instruments used for analysis could not accurately measure contaminants at the lower levels where health effects in children might occur, making this an *indeterminate health hazard.*

EHAP concluded that isocyanates and other fire-related residues pose an *indeterminate health hazard* to children who ride the affected school buses. This determination was due to uncertainties as to the amount of fire-residue substances, the length of time they could

potentially persist on the buses, and whether or not the children riding the buses could have been exposed to them.

EHAP recommends that the school district promote awareness of and adherence to the existing no idling policy to further reduce children's exposure to diesel exhaust. EHAP also recommends that drivers request a Health Hazard Evaluation (HHE) from the National Institute of Occupational Safety and Health (NIOSH) to gather more information about fire-residues in the soot on buses.

EHAP will be available to consult with the school district and NIOSH in developing sampling plans and interpreting results of future sampling. EHAP will also be available to help promote the no idling policy among drivers. EHAP will make every effort to ensure that the information in this report makes it to the parents of children who ride potential problem buses.

Purpose and Health Issues

EHAP is part of the Oregon Department of Human Services (DHS) Public Health Division. EHAP evaluates the human health risks of exposure to environmental contaminants throughout Oregon in cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). EHAP developed this health consultation to evaluate exposure to potential contaminants on specific school buses in Oregon's Salem-Keizer School District and to determine, based on available data, whether riding the buses poses a health hazard to children. The potential for past, current, and future exposure to residual contaminants in several school buses that were involved in a fire, is the concern that prompted the request for this consultation.

Background

Site Description and History

On December 17, 2006, a fire broke out in the main school bus facility in the Salem-Keizer School District, located at 998 Hawthorne Ave in Salem, Oregon. The fire destroyed seven buses and heavily damaged five more that were parked directly across from the destroyed buses. The metal canopy that sheltered the buses sustained heavy fire damage as well. At the time of the fire, the school district was closed for winter break. The cause of the fire has been labeled undetermined by the Salem Fire Department.

The school district's contracted industrial hygiene consultant, Wise Steps, Inc., oversaw the initial cleaning and repair of the buses between December 19 and December 29, 2006. ServiceMaster cleaned the interiors of buses that were located underneath the canopy at the time of the fire using HEPA-vacuums, detergents, and water. ServiceMaster also treated buses with ozone in order to eliminate odors. Salem Auto Body & Paintworks restored and cleaned the exterior of the five heavily damaged buses.

After returning from winter break, some of the bus drivers began reporting health problems including nausea, headaches, burning noses and throats, cough, and trouble breathing. Additional cleanings were conducted on specific buses on January 5, 8, and 26, 2007 based on drivers' complaints.

Site Investigations

The Environmental Safety Specialist from the SKSD contacted OR-OSHA because several bus drivers reported health problems. In February 2007, OR-OSHA opened a complaint inspection after several drivers filed formal complaints. During the investigation, OR-OSHA reviewed cleaning procedures, service reports, and MSDS sheets for cleaning products and deodorizers. They concluded that the school district took appropriate measures when cleaning the buses after the fire, and no further actions were recommended. The investigator's review did not identify any substances resulting from the fire that would cause the persistent health effects that the drivers continued to report.

Due to bus drivers' continued health complaints, the school district requested a consultation with OR-OSHA in November 2007. In response to this request, OR-OSHA agreed to conduct a health consultation that was based solely on current symptoms and current occupational exposures that may be responsible for the bus drivers' health effects. It was agreed that the consultation branch of OR-OSHA would not consider fire-related data in their report because the investigative branch had already reached a conclusion regarding the fire.

In December 2007, sample collection began for OR-OSHA's health consultation, which is detailed in the table of events (Appendix D). SKSD then contacted EHAP, in January 2008, to request that the program conduct a separate health consultation to review data collected by OR-OSHA and Wise Steps, Inc. EHAP agreed to conduct a health consultation for the SKSD that would address health concerns for children riding the school buses, although at this point in time no children or parents had directly voiced concerns to EHAP or the school district.

On April 1, 2008, EHAP conducted a site visit to the bus barn where the fire took place. Team members rode on one of the problematic buses, spoke with several bus drivers, and examined the area where the fire broke out. The barn lot itself is sandwiched between an interstate highway (I-5), and a busy city throughway. The entire facility is fenced in, with a one-way lane for vehicles to enter and exit the lot. Thirty-eight buses fit side to side, and nose to nose under a canopy. Several other buses are parked in an area outside the canopy. The driver's dispatch area and lunch room is located adjacent to the covered bus area at the far side of the canopy from the fire's point of origin. Drivers sit inside and wait between routes, eat lunch, and take care of business details.

While riding bus #11, EHAP staff noted a faint smoke odor and noticed that the ceiling was a metal mesh with holes approximately 0.5 cm in diameter. In the outdoor canopy area, EHAP staff noted a new section of canopy had replaced the fire-damaged portion. Streaks of black discoloration were still visible on the underside of original sections of the canopy, though it was evident that pressure washing had removed most of the soot.

EHAP had conversations with several bus drivers about their routes, their health concerns, and if they knew of any children who had health complaints. Their concerns are documented in the community concerns section of this report.

Community Concerns

Several school bus drivers indicated they had lingering health problems that they associated with driving certain school buses that had been on the lot at the time of the fire. At 17 months post-fire, some drivers characterized their health problems as stemming from a "past" exposure that had left them with multiple chemical sensitivities, allergies, and respiratory effects that included asthma. Some drivers said that as a result of developing chemical sensitivities, they could no longer walk down the cleaning supply aisle in the grocery store without experiencing symptoms. Some had given up their desired school bus routes and transferred to less desirable routes to avoid buses that brought out their symptoms.

Reported symptoms and health effects included fatigue; occupational asthma (medically diagnosed); bronchial & flu-like symptoms; a chemical taste and smell that persists; burning sore throat; itchy, burning eyes – as though grit and particles are in them; very dry mouth and nose; a persistent cough; sensitization to chemicals/smells/ perfumes; new allergies; dizziness; headache; and nausea. Drivers consistently reported that their acute symptoms dissipated after a few days/weeks away from problematic buses, but symptoms returned once they began driving those buses again. One driver reportedly had to pull over during his elementary school route and radio in to the dispatch for someone to come and get him because he was having difficulty breathing.

Many of the drivers felt that their symptoms were consistent with exposure to a class of chemicals known as isocyanates. Some drivers speculated that perhaps there was mold in the ceilings, heaters and defrosters that was causing their symptoms, while others thought the seat pads were the source of exposure. Many drivers reported that their symptoms were exacerbated when the bus heaters were on and kids were bouncing up and down on the seats. Heaters in many of the buses are under the seats, and drivers feel their symptoms were triggered when the seats heated up. Most of the affected buses had seats that contain post-1990's flame retardant seat material and the driver's seats were made of cloth, instead of vinyl, which was the predominant material before the 90's.

One driver indicated that "glass-like" particles fell from the holes in the bus ceiling and could be seen when the sun shone through the windows. The SKSD director of transportation indicated that the ceilings on most of the affected buses are a metal mesh with a vapor barrier and insulation on the inside.

Drivers had observed black soot when dusting and cleaning their buses, and said they had seen the roof-top vents dripping rain-soaked soot when left open. After wiping down their buses, some drivers said they returned the next day to find black soot covering everything again. One driver mentioned that he parked his car in the fenced-in bus lot while he worked, and continued to wipe down black soot inside his car every day, 17 months after the fire.

At the beginning of the 2008-2009 school year, all of the fire-affected buses were moved to different areas within the district. All of the drivers who had reported health effects are now driving buses that were not involved with the fire. Since that change, some of the drivers driving the fire-affected buses for the first time have begun to report health effects similar to those mentioned above. It has been reported to EHAP that one of the new drivers has been diagnosed with asthma since the current school year began.

A few drivers reported that children on their buses had complained about headaches, tight chests, "chemical" smells, coughs, sore throats, runny noses, fevers, vomiting, and asthma attacks. Drivers also reported that there were "a lot less kids riding the bus," and a lot of kids were newly diagnosed with asthma.

One driver indicated that she took some children on a swim trip and, after sitting on the seats in their swimsuits, the children developed itchy, red, and irritated skin. She said she saw glass-like particles on the seats – consistent with those she had seen falling out of the ceiling.

One parent contacted EHAP directly after recently learning that her daughter had been riding one of the fire-affected buses during the 2007-2008 school year. The parent reported that her daughter had been sick with a persistent respiratory infection through much of the 2007-2008 school year. The daughter's younger siblings, who did not ride the bus, never caught what she thought was an infection. During the course of the year, the daughter was diagnosed with asthma and was given an inhaler. This year, the girl's mother told EHAP that her daughter is riding a different bus and has not had to use her inhaler at all so far, and that her respiratory symptoms have disappeared.

The drivers had listed 27 buses as being problematic to drive, which included numbers 10-31 (except 17), 41- 43, 142 and 143.

Discussion

This section of the report describes the data collection that took place, the process used to identify contaminants of concern, and an evaluation of exposure pathways and public health implications. All data were collected by either OR-OSHA or Wise Steps, Inc. EHAP's evaluation and interpretation of the data is independent of the organizations that collected it.

Data Sampling & Analysis

Microscopic analysis of particles:
To determine if the air intake filters contained residual particulate matter from the fire that could be responsible for health symptoms, OR-OSHA removed the air intake filter from the school bus that was parked directly across from the fire's point of origin (# 22). OSHA was trying to determine if there was contamination inside the intake filter that may be responsible for the drivers' reported symptoms. It was thought that bus #22 was likely to have the most contaminated intake filter, and would be a good measure for the others. A microscopic analysis of particulate matter found inside the filter identified particles consistent with a fire, but did not identify any chemicals or specify the size of particles. EHAP concluded that this analysis was not useful in identifying the cause of symptoms, and did not use these data in this report.

Wise Steps, Inc. collected particles from the air inside of 10 buses, half of which had been in the fire and half of which had not. Air was sampled using personal air monitoring equipment that pulled air through a particulate-collecting filter at a rate of 2 liters per minute for about 10 and a half hours. Microlab Northwest (a third party laboratory) removed the filters and analyzed them under a microscope in order to determine how much of the debris in the filters could be attributed to the fire. The analysis identified some particles that were consistent with an uncontrolled bus fire and other particles that would be expected in any city roadway environment. When examining the amount of light being blocked by the particulate matter in the filters, the lab did not find a link between involvement in the fire and the amount of total particles in the filter. In fact, the bus that had the most light-blocking particles, bus # 17, was not on the lot when the fire occurred. Bus drivers had also identified bus #17 as a "non-problem" bus.

Because this method did not test for any chemicals or quantify particles with any size discrimination that is relevant to human health, it was not useful in identifying causes of health effects. Therefore, EHAP could not use these data in this health consultation.

Particulate-bound organics sampling
One potential source of chemical exposure on the buses could be from inhaling contaminated dust. In an attempt to identify particles that might be responsible for health effects, OR-OSHA collected dust from inside one bus (#16) in fiberglass filters while the floors were being swept. The collected dust particles were then washed with solvents to dissolve any organic chemicals that may have been bound to them.
The following chemicals were identified:

> Benzene, tetramethyl heptadecane, heptadecane, docosane, nonodecane, butyl palmitate, octadecyl acetate, butyl octadecanoate, eicosane, butyl hexadecanoate, tetratetracontane, heneicosane, 3-hydroxy-2,4,4-trimethyl pentyl 2-mthyl-propanoate, and 2,2-dimethyl-1-(2-hydroxy-1-methyl-ethyl) propyl 2-methyl-propanoate.

All of these chemicals fit within one or more of the following source categories:

- Diesel and gasoline fuels

- Food products
- Cosmetics
- Fragrances
- Food additives

Neither the chemicals nor the amount of dust collected were quantified (measured). Benzene is the only chemical identified that is associated with serious health effects, but because these data did not allow EHAP to determine the amount of benzene that a person would be exposed to via dust, EHAP did not use these data in the health consultation.

Wipe Test/Phenols

Some of the detergents used to clean the school buses after the fire, and on a regular basis by the bus drivers, contain phenols. Phenols can cause chemical sensitization in humans[2]. A person who becomes sensitized will experience negative health effects from exposure to phenol and other chemicals in the future, at lower exposure levels than are required by the average person[2].

One bus (#41) was tested for phenols. Air and seat surfaces were tested for phenols. Both the air sampling and seat-wipe data were used in this health consultation.

Real-Time Air Sampling

Particulate matter can contribute to symptoms similar to those experienced by some bus drivers, and may cause health problems for children who are exposed to it. OR-OSHA acquired real-time air monitors with the capacity to measure particulate matter 10 micrometers in diameter and smaller, without determining the exact size of particulates within that range. In addition to particulate matter, the real-time air monitors also measured temperature, humidity, carbon dioxide, carbon monoxide, and total volatile organic compounds (VOCs). The advantage of these real-time monitors was that they could measure multiple contaminants at the same time, and the data was immediately available online to drivers, OSHA, and school district staff.

These monitors were installed on buses 16, 17, 31, 41, 124, and 159. In addition, one outdoor reference monitor was placed at the Gaffin Road bus lot to measure ambient air, and one indoor reference monitor was placed in the bus driver's break room at the Hawthorne bus lot, which is the lot where the fire broke out. Temperature, humidity and carbon dioxide on school buses are expected to fluctuate over the course of the day depending on the use and outside weather and are not associated with symptoms matching those of drivers. However, some VOCs can act as respiratory irritants and have health effects that are particularly serious for children. VOCs were analyzed individually and quantitatively by another method (snap-shot sampling) that is more accurate. For this report, EHAP did not use the data on VOCs measured by the real-time monitoring system, but chose to use the more accurate snap-shot method (see below). In addition, carbon monoxide is a very toxic gas that reduces the blood's ability to carry oxygen, and EHAP used the carbon monoxide measurements from the real-time monitors in this health consultation.

Snap-shot air sampling
Certain gases cause respiratory irritation and symptoms matching those described by some of the bus drivers. The real-time monitoring equipment, mentioned above, was not able to measure all of these irritant gases. Therefore, OR-OSHA took snap-shot air samples on several buses and measured for several individual irritant gases. These included ozone, nitrogen oxides, phosgene, sulfur dioxides, and certain VOCs, including benzene, xylenes, toluene, limonene, and undecane. EHAP used these data in this health consultation.

Diesel Exhaust
Diesel exhaust has been linked to respiratory irritation, cancer, and other heart and lung problems[3]. Buses that run on diesel produce large amounts of diesel exhaust. To determine whether diesel exhaust was present in sufficient concentrations to cause adverse health effects, OR-OSHA collected air samples from buses and analyzed them for diesel particulate matter (DPM). OR-OSHA used the sampling and analytical method recommended by the National Institute of Occupational Health and Safety (NIOSH) known as the NIOSH 5040 method. These data include the concentration of DPM in the air, and EHAP used them in this report, comparing them to specific concentrations ("comparison values") known to be low enough that they are protective of children.

Identification of Contaminants of Concern
EHAP uses the following criteria to identify contaminants of concern:

- Contaminant concentrations (estimated dose in the case of phenol)
- Comparison of contaminant concentrations, limits of detection, or doses against health-based comparison values (CV)
- Community concern

EHAP uses comparison values (CVs) that were established by the Agency for Toxic Substances and Disease Registry (ATSDR). These values are used whenever possible because they are protective of the health of the most vulnerable of people, including children. In the absence of ATSDR comparison values, EHAP uses CVs established by the Environmental Protection Agency (EPA) that are based on human health effects among the general public.

In this HC, air contaminants were considered 'contaminants of concern' (COC) if their measured concentrations were above the CV levels on one or more of the school buses. In many instances, contaminants were not detected at all. In these cases, EHAP compared the equipment's limit of detection against the CVs. The limit of detection (LD) is the actual limitation of the equipment used when measuring a contaminant.

For example, we knew that sulfur dioxide was not detected on the school buses. However, upon closer examination, we noted that the equipment used did not measure anything below 100 ppb. Because we knew that health effects could occur near 100 ppb, we wanted to know whether sulfur dioxide levels were just below 100 ppb or far below. Because the equipments' detection limit was not adequate, we could not tell what the actual levels were, so we chose sulfur dioxide as a contaminant of concern and recommend obtaining a more accurate reading to use in our conclusions.

Other conditions that would cause us to identify a substance as a COC, are if there are no health-based standards that exist for that contaminant, (limonene and undecane were identified as COC for that reason). Also, if the community is concerned about a specific contaminant, EHAP chooses that contaminant to evaluate further, even if the contaminant does not exceed a CV. An example in this HC is isocyanates.

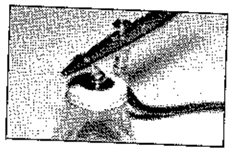
The contaminants of concern that EHAP identified for the SKSD school buses are:

- Benzene
- Phosgene
- Sulfur Dioxide
- Limonene
- Undecane
- Diesel exhaust
- Carbon Monoxide
- Particulate Matter
- Isocyanates and other fire-related residues
- Phenol

Table 1 summarizes the comparisons of chemical contaminants with their CVs. Contaminants that are bolded are contaminants of concern, and the concentrations or LDs that are bolded indicate numbers that exceed the health protective comparison values. All of the contaminants and measurements in Table 1 represent concentrations in the air.

In addition to air testing, phenol was also measured on the seat surfaces from wipe tests. Appendix C summarizes the method used to estimate a phenol dose to a child from contact with the seats. The estimated dose was 0.35 milligrams-phenol per kilogram-body weight per day (mg/kg/day). The CV for phenol is something known as a 'reference dose' (RfD) established by the EPA. The RfD is 0.3 mg/kg/day, so the estimated dose slightly exceeds the CV.

Isocyanates



Isocyanates are compounds containing the isocyanate group (-NCO). They react with compounds containing alcohol (hydroxyl) groups to produce polyurethane polymers, which are components of polyurethane foams, thermoplastic elastomers, spandex fibers, and polyurethane paints. Isocyanates are the raw materials that make up all polyurethane products. Jobs that may involve exposure to isocyanates include painting, foam-blowing, and the manufacture of many Polyurethane products, such as chemicals, polyurethane foam, insulation materials, surface coatings, car seats, furniture, foam mattresses, under-carpet padding, packaging materials, shoes, laminated fabrics, polyurethane rubber, and adhesives, and during the thermal degradation of polyurethane products.

Health effects of isocyanate exposure include irritation of skin and mucous membranes, chest tightness, and difficult breathing. Isocyanates include compounds classified as potential human carcinogens and known to cause cancer in animals. The main effects of hazardous exposures are occupational asthma and other lung problems, as well as irritation of the eyes, nose, throat, and skin.

Contents

Highlights

- National Emphasis Program - Occupational Exposure to Isocyanates [322 KB PDF, 48 pages]. OSHA Directive CPL 03-00-017, (June 20, 2013). Describes policies and procedures for implementing a National Emphasis Program to identify and reduce or eliminate the incidence of adverse health effects associated with occupational exposure to isocyanates.

Page last reviewed: 03/26/2012

OSHA Standards

Isocyanates hazards are addressed in specific standards for general industry, shipyard employment, and the construction industry. This section highlights OSHA standards and standard interpretations (official letters of interpretation of the standards) related to isocyanates. Twenty-five states, Puerto Rico and the Virgin Islands have OSHA-approved State Plans and have adopted their own standards and enforcement policies. For the most part, these States adopt standards that are identical to Federal OSHA. However, some States have adopted different standards applicable to this topic or may have different enforcement policies.

General Industry (29 CFR 1910)

- 1910 Subpart H, Hazardous materials
  - 1910.119, Process safety management of highly hazardous chemicals [related topic page]
    - Appendix A, List of highly hazardous chemicals, toxics and reactives (Mandatory)
- 1910 Subpart Z, Toxic and hazardous substances [related topic page]
  - 1910.1000, Air contaminants
    - Table Z-1, Limits for air contaminants
  - 1910.1450, Occupational exposure to hazardous chemicals in laboratories
    - Appendix A, National research council recommendations concerning chemical hygiene in laboratories (Non-Mandatory)

Shipyard Employment (29 CFR 1915)

- 1915 Subpart Z, Toxic and hazardous substances
  - 1915.1000, Air contaminants

Construction Industry (29 CFR 1926)

- 1926 Subpart D, Occupational health and environmental controls
  - 1926.55, Gases, vapors, fumes, dusts, and mists
    - Appendix A, Gases, vapors, fumes, dusts, and mists
  - 1926.64, Process safety management of highly hazardous chemicals
    - Appendix A, List of highly hazardous chemicals, toxics and reactives (Mandatory)

Directives

- National Emphasis Program - Occupational Exposure to Isocyanates [322 KB PDF, 48 pages]. OSHA Directive CPL 03-00-017, (June 20, 2013). Describes policies and procedures for implementing a National Emphasis Program to identify and reduce or eliminate the incidence of adverse health effects associated with occupational exposure to isocyanates.

Standard Interpretations

- Selection of air purifying respirators for gases and vapors with poor warning properties (diisocyanates). (2000, July 18). Clarification regarding OSHA's position on the selection of air purifying respirators (APR's) for gases and vapors with poor warning properties.
- Search all available standard interpretations.

Hazard Recognition

Many workers are unaware of the potential hazards that chemicals present in their work environment, which makes them more vulnerable to injury. The following references aid in recognizing and evaluating hazards associated with isocyanates in the workplace.

- OSHA Technical Manual (OTM). OSHA Directive TED 01-00-015 [TED 1-0.15A], (1999, January 20).
  - Polymer Matrix Materials: Advanced Composites. Deals with a segment of the polymer composite industry known as advanced polymer matrix composites, or advanced composites.
- Chemical Hazard Communication. OSHA Publication 3084, (Revised 1998). Also available as a 248 KB PDF, 31 pages. Addresses the need for chemical hazard communication and explains why a standard is necessary to minimize workplace hazards.
- Documentation for Immediately Dangerous to Life or Health Concentrations (IDLHs). National Institute for Occupational Safety and Health (NIOSH), (1994, May).
  - Methyl isocyanate
  - Methylene bisphenyl isocyanate (MDI)
  - Toluene-2,4-diisocyanate
- TOXNET (Toxicology Data Network). National Library of Medicine.
  - Methyl Isocyanate
  - 4,4'-Methylenediphenyl Diisocyanate
  - 2,4-Toluene Diisocyanate
- Report on Carcinogens (RoC). US Department of Health and Human Services (DHHS), National Toxicology Program (NTP). Identifies and discusses agents, substances, mixtures, or exposure circumstances that may pose a health hazard due to their carcinogenicity. *The listing of substances in the RoC only indicates a potential hazard and does not establish the exposure conditions that would pose cancer risks to individuals.*
  - 2,4-Toluene diisocyanate [166 KB PDF, 3 pages]. NTP classification: *Reasonably anticipated to be human carcinogens*
- International Agency for Research on Cancer (IARC) Monographs on the Evaluation of Carcinogenic Risks for Humans. World Health Organization (WHO).
  - 4,4'-Methylenediphenyl Diisocyanate (MDI) [88 KB PDF, 10 pages]. IARC Classification: *Not classifiable as to its carcinogenicity to humans (Group 3).*
- ToxFAQs™ for Methyl Isocyanate. Agency for Toxic Substances and Disease Registry (ATSDR), (2002, April). Summarizes the properties and health effects for methyl isocyanate.
- Integrated Risk Information System (IRIS). Environmental Protection Agency (EPA). Discusses the health effects.
  - Methyl isocyanate (CASRN 624-83-9)
  - Methylene Diphenyl Diisocyanate (monomeric MDI) and polymeric MDI (PMDI) (CASRN 101-68-8, 9016-87-9)
  - 2,4-/2,6-Toluene diisocyanate mixture (TDI) (CASRN 26471-62-5)
- Health Effects Notebook for Hazardous Air Pollutants. Environmental Protection Agency (EPA).
  - Hexamethylene Diisocyanate. CAS No. 822-06-0.
  - Methyl Isocyanate. CAS No. 624-83-9.
  - 4,4'-Methylenediphenyl Diisocyanate (MDI). CAS No. 101-68-8.
  - 2,4-Toluene diisocyanate. CAS No. 584-84-9.
- Hazardous Substance Fact Sheets. New Jersey Department of Health and Senior Services. Includes detailed reports on specific chemicals, covering hazard summaries, identification, exposure routes, health hazards, and ways of reducing exposure. The following fact sheets cover isocyanate compounds.
  - 3-Chloro-4-Methyl Phenyl Isocyanate [105 KB PDF, 6 pages]. (1997, April).
  - Hexamethylene Diisocyanate [1 MB PDF, 6 pages]. (1999, April).
  - Isophorone Diisocyanate [109 KB PDF, 6 pages]. (1986, January).
  - Methylene Bisphenyl Isocyanate [362 KB PDF, 6 pages]. (1998, June).
  - Methyl Isocyanate [157 KB PDF, 6 pages]. (1996, April).
  - Toluene-2,4-Diisocyanate [155 KB PDF, 6 pages]. (1996, February).
  - Toluene-2,6-Diisocyanate [154 KB PDF, 6 pages]. (1996, February).
- International Chemical Safety Cards (ICSC). National Institute for Occupational Safety and Health (NIOSH). Summarizes essential health and safety information.
  - Hexamethylene Diisocyanate
  - Isophorone Diisocyanate
  - Methylene Bisphenyl Isocyanate
  - Methyl Isocyanate
  - Toluene-2,4-Diisocyanate
- Preventing Asthma and Death from Diisocyanate Exposure. US Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH) Publication No. 96-111, (1996). Discusses the recognition, evaluation, and control of diisocyanate exposures.
- *Evaluation of the Effectiveness of Air-Purifying Respirator Cartridges in Removing MDI Aerosols from Air.* The Dow Chemical Company, (1997). Shows that organic vapor cartridges without a particulate filter were not effective at removing Methylene bisphenyl isocyanate (MDI) aerosols from air, while organic vapor cartridges with dust/mist (DM) or high efficiency (HEPA) filters effectively removed greater than 99 percent of MDI aerosol and vapor in all test atmospheres.
- The following studies indicate that respiratory sensitivity to isocyanates may be related to previous dermal exposure.
  - Kimber, I. "The Role of the Skin in Development of Chemical Respiratory Hypersensitivity." *Toxicology Letters* 86(1996): 89-92.
  - Bickis, U., and K. Nakatsu. "A Single Skin Contact with Toluene Diisocyanate (TDI) Causes a One-Year Persistence of Airway Sensitization, Demonstrable in Vivo and in Vitro." (1996). Abstract of platform presentation No. 310 presented at the 1996 American Industrial Hygiene Conference and Exposition.
  - Bickis, U. "Investigation of Dermally Induced Airway Hyperreactivity to Toluene Diisocyanate in Guinea Pigs." Ph.D. thesis, Department of Pharmacology and Toxicology, Queen's University, Kingston, Canada, (1994).
  - Karol, M. H., et al. "Dermal Contact With Toluene Diisocyanate (TDI) Produced Respiratory Tract Hypersensitivity in Guinea Pigs." *Toxicol. Appl. Pharmacol* 58(1981): 221-230.
  - Rattray, N. J., et al. "Induction of Respiratory Hypersensitivity to Diphenylmethane-4,4'-Diisocyanate (MDI) in Guinea Pigs; Influence of route of exposure." *Toxicology* 88(1994): 15-30.
  - Deschamps, F., et al. "Mechanisms of Occupational Asthma Induced by Isocyanate." *Ann. Occup. Hyg.* 42(1998): 33-36.
  - Cole, K. C., et al. "Flexible Polyurethane Foam. I. FTIR Analysis of Residual Isocyanate." *Applied Polymer Science* 34(1987): 395-407.

Exposure Evaluation

- Chemical Sampling Information. OSHA. Presents, in concise form, data on a large number of chemical substances that may be encountered in industrial hygiene investigations. Basic reference for industrial hygienists engaged in OSHA field activity.
  - Butyl Isocyanate
  - 2,6-Diisopropylphenyl isocyanate
  - Hexamethylene Diisocyanate
  - Hexamethylene Diisocyanate Biuret
  - 1,6-Hexamethylene diisocyanate homopolymer
  - Isophorone Diisocyanate
  - Methyl Isocyanate
  - Methylene-bis (4-Cyclohexylisocyanate)
  - Methylene bisphenyl isocyanate

  - 1,5-Naphthalene Diisocyanate
  - Phenyl Isocyanate
  - o-Tolyl Isocyanate
  - Toluene-2,4-diisocyanate (TDI)
  - Toluene-2,6-diisocyanate
- Occupational Chemical Database. OSHA maintains this chemical database as a convenient reference for the occupational safety and health community. It compiles information from several government agencies and organizations. This database originally was developed by OSHA in cooperation with EPA.
  - Hexamethylene Diisocyanate
  - Isophorone Diisocyanate
  - Methyl Isocyanate
  - Methylene Bisphenyl Isocyanate
  - 1,5-Naphthalene Diisocyanate

Analytical Methods

OSHA

- Diisocyantes (HDI, 2,4-TDI, 2,6-TDI). Method 42, (1989, March).
- Methylene bisphenyl isocyanate (MDI). Method 47, (1989, March).
- Aromatic Isocyanate Surface Contamination Sampling and Evaluation Techniques. (1997, August 21). Describes sampling procedures for using direct reading (colorimetric) wipes and collecting wipe samples for laboratory analysis.

For additional information, see OSHA's Sampling and Analysis Safety and Health Topics Page.

National Institute for Occupational Safety and Health (NIOSH)

- NIOSH Manual of Analytical Methods (NMAM). US Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH) Publication No. 2003-154, (2003). Provides individual analytical methods, listed by chemical name or method number.
  - Isocyanates [35 KB PDF, 6 pages]. Method No. 5522.

Other

- U.K. Health and Safety Executive Method 25/2
- The following are analysis methods for specific isocyanate compounds. It is often desirable to determine the amount of free isocyanate, not just the specific compound. Several methods have been suggested to accomplish this. However, all have had serious problems when applied to field sampling.
  - Streicher, RP, et al. Investigation of the ability of MDHS method 25 to determine urethane-bound isocyanate groups. *American Industrial Hygiene Association Journal.* 1995;56(5):437-42.
  - Key-Schwartz, RJ. Analytical problems encountered with NIOSH method 5521 for total isocyanates. *American Industrial Hygiene Association Journal.* 1995;56(5):474-9.
  - Maitre, A., et al. Biological monitoring of occupational exposure to toluene diisocyanate. *Int. Arch. Occup. Environ. Health.* 1993;65:97-100.
  - Documentation of the threshold limit values and biological exposure indices. American Conference for Government Industrial Hygienists (ACGIH). 1991;6:1581-9.

Possible Solutions

- Use of portable air compressors as a source of air supply for supplied air respirators. OSHA Hazard Information Bulletin (HIB), (1985, January 25). States that under current policy, supplied air respirators are not to be used in an atmosphere that is immediately dangerous to life or health (IDLH) unless the respirator is equipped with a self-contained air supply for escape.
- NIOSH Pocket Guide to Chemical Hazards. US Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH) Publication No. 2005-149, (2007, September). Provides a physical description, exposure limits, measurement method, personal protection and sanitation, first aid, respirator recommendations, exposure routes, symptoms, target organs, and cancer sites.
  - Hexamethylene diisocyanate
  - Isophorone diisocyanate
  - Methyl isocyanate
  - Methylene bis (4-cyclohexylisocyanate)
  - Methylene bisphenyl isocyanate
  - Naphthalene diisocyanate
  - Toluene-2,4-diisocyanate
- Occupational Health Guidelines for Chemical Hazards. US Department of Health and Human Services (DHHS), National Institute for Occupational Safety and Health (NIOSH), (1981, January). Contains information on identification, physical and chemical properties, health hazards, exposure limits, exposure sources and control methods, monitoring, personal hygiene, storage, spills and leaks, and personal protective equipment.
- Health Hazard Evaluations. National Institute for Occupational Safety and Health (NIOSH). Performs Health Hazard Evaluations (HHE's) for a wide variety of industries that use isocyanates to determine whether any substance normally found in the workplace contains potentially toxic concentrations. NIOSH also provides specific control recommendations. To access the online database, follow the link and then search the site using the term "isocyanate." Some HHE's that focus on isocyanates are listed below.
  - Isocyanate Exposures From Polyurethane Foam Packaging Operations, General Motors Corporation, Allison Transmission Division, Indianapolis, Indiana [1 MB PDF, 16 pages]. Report No. HETA 99-0065-2780, (1999, December).
  - Isocyanate-Containing Compounds During Spray Painting Operations, Lockheed Martin Aeronautical Systems, Marietta, Georgia [2 MB PDF, 21 pages]. Report No. HETA 99-0122-2798, (2000, June).
  - Worker Exposure To Methylene-bisphenyl-diisocyanate (MDI) From Foam Spraying Operations In an Adjacent Building, Twin City Fruit, F.L. Thorpe Co., Deadwood, South Dakota [1 MB PDF, 17 pages]. Report No. HETA 89-0278-2035, (1990, April).
  - Isocyanates Used In Some Powder Coatings, Modern Materials Incorporated, Rochester, Indiana [3 MB PDF, 56 pages]. Report No. HETA 90-0174-2231, (1992, July).
  - Possible Isocyanate and Polyamide Imide Resin Exposures Occurring During Brazing and Welding Operations, Square D Company, Oshkosh, Wisconsin [1 MB PDF, 23 pages]. Report No. HETA 94-0312-2512, (1995, June).
  - A Summary of Health Hazard Evaluations: Issues Related to Occupational Exposure to Isocyanates, 1989 to 2002 [1 MB PDF, 42 pages]. Report No. HETA 99-0039, (1999, April). Presents some background information about isocyanate exposures, health effects, analytical methods, and general recommendations for most isocyanate-related HHE's. The major portion of this document presents the titles and summaries of the site visits related to isocyantes conducted between 1989 and 2002.

Additional Information

Related Safety and Health Topics Pages

- Autobody Repair and Refinishing
- Carcinogens
- Dermal Exposure
- Occupational Asthma
- Personal Protective Equipment (PPE)
- Plastics Industry

Training

- Isocyanates in Paints [193 KB PDF, 2 pages]. Workplace Safety and Health Division of the Manitoba Labour and Immigration Bulletin 143, (2008, December). Includes a short summary of hazards and protective measures for workers spraying isocyanate-containing paints.

Accessibility Assistance: Contact the OSHA Directorate of Technical Support and Emergency Management at (202) 693-2300 for assistance accessing PDF materials.

Centers for Disease Control and Prevention
CDC 24/7: Saving Lives. Protecting People.™

May 1994

Documentation for Immediately Dangerous To Life or Health Concentrations (IDLHs)

Methylene bisphenyl isocyanate (MDI)

CAS number: 101–68–8

NIOSH REL: 0.05 mg/m3 (0.005 ppm) TWA,

0.2 mg/m3 (0.020 ppm) 10-minute CEILING

Current OSHA PEL: 0.2 mg/m3 (0.02 ppm) CEILING

1989 OSHA PEL: Same as current PEL

1993-1994 ACGIH TLV: 0.051 mg/m3 (0.005 ppm) TWA

Description of substance: White to light-yellow, odorless flakes.

LEL: . . Unknown

Original (SCP) IDLH: 100 mg/m3

Basis for original (SCP) IDLH: The chosen IDLH is based on an analogy with toluene diisocyanate, which has an IDLH of 10 ppm. [Note: A concentration of 10 ppm methylene bisphenyl isocyanate is equivalent to about 100 mg/m3.]

Short-term exposure guidelines: None developed

ACUTE TOXICITY DATA:

Lethal concentration data:

Species	Reference	LC_{50}	LC_{Lo}	Time	Adjusted 0.5-hr LC (CF)	Derived value
Rat	Bunge et al. 1977	369 mg/m3	-----	4 hr	738 mg/m3 (2.0)	74 mg/m3
Rat	Bunge et al. 1977	380 mg/m3	-----	4 hr	760 mg/m3 (2.0)	76 mg/m3
Rat	Woolrich 1982	178 mg/m3	-----	?	?	?

Lethal dose data:

Species	Reference	Route	LD_{50} (mg/kg)	LD_{Lo} (mg/kg)	Adjusted LD	Derived value
Mouse	Izmerov et al. 1982	oral	2,200	-----	15,400 mg/m^3	1,540 mg/m^3
Rat	Woolrich 1982	oral	-----	31,690	221,830 mg/m^3	22,183 mg/m^3

Human data: None relevant for use in determining the revised IDLH.

Revised IDLH: 75 mg/m^3
Basis for revised IDLH: The revised IDLH for methylene bisphenyl isocyanate is 75 mg/m^3 based on acute inhalation toxicity data in animals [Bunge et al. 1977].

REFERENCES:

1. Bunge W, Ehrlicher H, Kimmerle G [1977]. Medical aspects of work with surface coating systems using the spraying technique. Zentralbl Arbeitsmed Arbeitsschutz Prophylaxe *4*(spec. ed.):1-46 (in German). [From ACGIH [1991]. Methylene bisphenyl isocyanate. In: Documentation of the threshold limit values and biological exposure indices. 6th ed. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, pp. 978-980.]

2. Izmerov NF, Sanotsky IV, Sidorov KK [1982]. Toxicometric parameters of industrial toxic chemicals under single exposure. Moscow, Russia: Centre of International Projects, GKNT, p. 63.

3. Woolrich PF [1982]. Industrial hygiene and medical control of TDI, MDI and PMPPI. Am Ind Hyg Assoc J *43*(2):89-97.

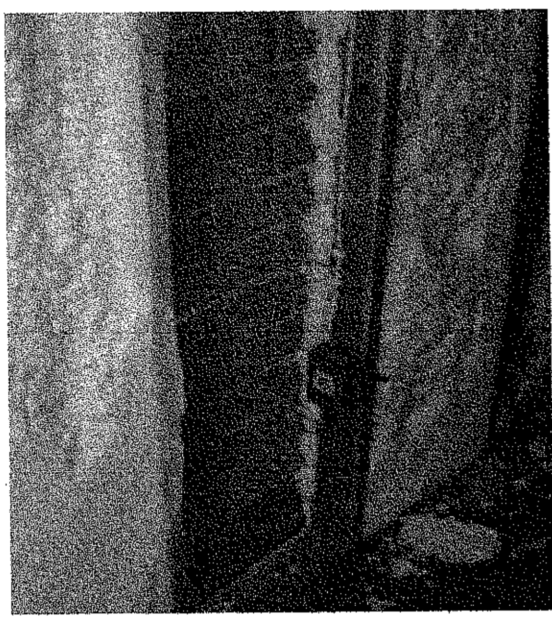
NIOSH Science Blog

Safer Healthier Workers

Help Wanted: Spray Polyurethane Foam Insulation Research (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/)

Categories: Chemicals (http://blogs.cdc.gov/niosh-science-blog/category/chemicals/) , Construction (http://blogs.cdc.gov/niosh-science-blog/category/construction/) , Engineering Control (http://blogs.cdc.gov/niosh-science-blog/category/engineering-control/) , Exposure (http://blogs.cdc.gov/niosh-science-blog/category/exposure/) , Green (http://blogs.cdc.gov/niosh-science-blog/category/green/) , Personal Protective Equipment (http://blogs.cdc.gov/niosh-science-blog/category/personal-protective-equipment/)

March 21st, 2012 1:55 pm ET - **David A. Marlow, BS**



(http://blogs.cdc.gov/niosh-science-blog/files/2012/03/spf.jpg) Environmentally friendly doesn't necessarily mean worker friendly. In many cases, new "green" technologies and products have reached the market without being adequately evaluated to determine whether they pose health or safety risks to workers in manufacture, deployment, or use. Spray polyurethane foam—commonly referred to as SPF—is a case in point. Its use as insulation has been on the upswing because of the laudable aim of builders and property owners to improve energy efficiency. As popular as it has become, however, much remains unknown about spray polyurethane foam—specifically the health implications of its amines, glycols, and phosphate upon workers.

Polyurethane foam has a high R-factor (or R-value), so it resists the flow of heat and, when used as insulation, increases a building's energy efficiency. Because of this, it has become a favorite in the world of energy-conscious construction and renovation. While better insulation clearly means less energy consumption, what's not clear is the level of protection and ventilation workers need so that they remain safe during the installation process.

MDI: The known hazard

Spray polyurethane foam is applied as a liquid but expands as it dries. The product itself is a two-component system. The first chemical in the mixture is methylene diphenyl diisocyanate (MDI). The hazards of MDI (http://www.cdc.gov/niosh/topics/isocyanates/) are well-documented and their exposure limits have been established However, the known hazards for spray polyurethane foam only take into account the first part of the mixture—the MDI.

Amines, glycols, and phosphate: Unknown risks

The other half of the mix has not been studied for worker safety. It is a chemical question mark with no toxicology or health information. This part contains amines, which act as a catalyst; glycols—blowing agents that react with the foam; and phosphate, a flame retardant. This half of the spray polyurethane foam equation raises several questions:

- What is the concentration of the fumes and vapors from these chemicals when spray foam is applied?
- Are the workers who are applying the spray foam adequately protected?
- What about others on site who are not applying the spray foam and who are not wearing the same personal protective equipment?
- How long does it take to ventilate the area after application?
- Are there cost-saving methods for isolating and venting the fumes?

A need for real-world air sampling

We are currently researching these issues. In our labs we've done tracer gas studies, simulating potential exposures to spray polyurethane foam components, but to make the science useful for SPF installers, we need partners to help us collect on-site air samples. At the worksite, we will collect personal breathing-zone air samples and set up five tripods with air-sampling pumps to obtain readings in a variety of sampling areas. We would like to gather samples during the spray foam application, and again at intervals afterwards. The data we collect will help us gauge:

- The true level of personal protective equipment needed by the worker applying the spray foam and by those who are elsewhere on the worksite.
- The actual amount of time before the area is void of harmful levels of vapors. The idea that the area needs to be clear for 24 hours is anecdotal and has no scientific underpinning.
- Proper ventilation and cordoning of the spray foam work area. Some contractors go to great lengths to tape and plastic the room; others do nothing at all. Our air sampling will clarify what the best practice is.

Additionally, we are working on a portable spray booth that will contain overspray fumes and improve ventilation—a cost-saving intervention.

A need for solid science

It's difficult for even the most conscientious employers to protect their workers because limited data exist on the second part of the spray foam mixture. The popularity of the product and the number of companies using it demands that there be some scientific background informing its use.

Help wanted

Please contact NIOSH to advance the science behind spray polyurethane foam insulation. You can reach us through this blog. While foam insulation may be green, with your help, our research can ensure that spray foam is sustainable for your workers as well.

—David A. Marlow, BS

Mr. Marlow is an industrial hygiene engineer in the NIOSH Division of Applied Research and Technology.

25 Comments (#comments)

Public Comments

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1. March 26, 2012 at 12:54 pm ET - Rachel White

   I work with Byggmeister [http://www.byggmeister.com], a residential remodeling firm in Newton, MA, that has been using SPF as an insulation material for some now. Your call for help is timely for us: we have recently begun to take a closer look at the existing guidelines on SPF safety in an effort to better protect our crew and our clients (most of whom are living in their homes during construction). So, we are thrilled that you are doing this research and would very much welcome the opportunity to participate in your study. Please let me know if we can be of help.

   Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3499)

2. March 28, 2012 at 4:14 am ET - Emlyn Ó Troighthigh

   This topic should be of interest to health and safety professionals, trades and regulatory bodies in Ireland as at the moment, there are incentive schemes in place for home owners to improve insulation in their homes. As a health and safety consultant, I closely follow such topics in the media, online etc. and am not aware of any concerns to date in this field.

   It would be interesting to hear the views of users of this material or trade representative bodies in respect of the extent of use and any research done on the application of spray polyurethane foam in Ireland.

Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3514)

3. March 29, 2012 at 12:20 am ET - greenwashed

   I think it is great you are going to research the effects of SPF on the workers, but what about the occupants. We have a year of testing that indicates our oc SPF continued to offgass. What about all of us who cannot live in our homes or the Icynene homes that are breaking down and off gassing after 6 yrs of being 'stable' in the home. The homeowners have no guidelines for chronic exposure to the large amount of chemicals from 'inert' SPF.

   Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3533)

   - AUTHOR COMMENT April 12, 2012 at 1:21 pm ET - David Marlow

     Thank you for your comment. The research we are planning will look at exposures to workers during the application process. The EPA addresses homeowner concerns. You may want to visit the Spray Polyurethane Foam page (http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html (http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html) (http://www.cdc.gov/Other/disclaimer.html)) on the EPA website.

     Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3716)

4. March 29, 2012 at 6:17 am ET - yoyo

   We should change our lifestyle, try to live a green life

   Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3536)

5. March 29, 2012 at 6:54 am ET - Poisoned Homeowner

   It's not just the workers that face health problems. When spray foam is not installed properly (A-B ratio is off or chemicals sprayed cold) or when it is exposed to the high heat of an attic environment it causes off-gassing of chemicals that can cause health effects after prolonged exposure. My family and I have been living this nightmare and only recently paid a large sum of money to remove our spray foam. Even following removal we cannot live in the home as we have become sensitized to the chemicals.

   Be aware that spray foam has the potential to go very wrong and when it does manufacturers and installers will use this lack of science to leave the homeowner responsible for everything.

   Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3538)

6. March 29, 2012 at 3:10 pm ET - greenwashed

   A few blogs are popping up explaining spray foam problems, [www.sprayfoamsucks.com] and [www.toxicsprayfoam.com] are good places to start.

   Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3542)

7. March 29, 2012 at 5:05 pm ET - Kevin

I just wanted to send a quick thanks regarding this posting on SPF. Glad to hear you're looking into SPF some more. The unintended consequences of "environmentally friendly" products is quite interesting to me, mainly in how products can be "environmentally friendly" but so bad for employees using them.

I have worked in the maritime industry quite a bit and we run into SPF there also. An added hazard of SPF in shipyards is its combustibility. Once they start, foam fires are VERY difficult to put out and emit HCN plus lots of other nasty products of combustion. Very careful protocol must be in place in order to do repair/retrofit work on ships which contain this foam. Fishing vessels commonly have SPF insulating their fish holds. This might be another industry to examine in your study.

Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3545)

8. March 31, 2012 at 12:39 pm ET - Jane

   A very informative article and a good reminder that sometimes the end result does not always justify the means, even in the world of "green."

   Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3578)

9. May 8, 2012 at 9:11 am ET - Darren

   Like all things if the installer is not certified or been properly trained then you risk to have problems.The SPF industry has come along way in taking out the poor quality workmanship we have seen in the past. The fact remains that the two part chemical reaction between part A and B must be given 48 hours to finish it`s reaction in a good ventilated area, all installers should be wearing air supplied apparatus during the installation. the grey area does not exist in this process and when you use quality products and installers then you do not have a problem. The agressive market should not dictate the price of this product and I believe short cuts will disappear, that should eliminate fly by night companies giving false advice to home owners and design officials a like.

   Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3978)

10. May 9, 2012 at 10:20 pm ET - Fred

    I worked in the theatrical scenery industy for 25 years for a company with no respiratory protection program, where urethane spray foam was used constantly. The thing about spray foam is that is doesnt really have an overpowering odor, which makes one less concerned about breathing the vapors. Stronger labeling by manufacturors right on the canisters such as a big red WARNING sign would be helpful for people who are not instructed properly and the employer does not provide MSDS. In my last year at that company I developed chest pains and breathing problems so severe I thought I was going to die and did not suspect it was urethane vapors making me so ill. I can tell you for a fact that improper mixing will also somtimes emit liquids that will never solidify and leak into wood and other porous materials. Spray foam is used commonly in the theatrical industry for such things as texture,large sculpture, and other applications that it is not intended for. This might be an area for you to advertise your study.

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-3998)

11. May 12, 2012 at 1:17 pm ET - Michael

"what's not clear is the level of protection and ventilation workers need so that they remain safe during the installation process."

I disagree and think it's very presumptuous of you to say this. There is already plenty of documentation about the safety and precautions one must take when using spray foam insulation. In fact, one might argue that it is safer to use than fiberglass insulation.

Fiberglass insulation has been used for ever, but it is made of fibers. Fibers that disintegrate over time and can float in the air, being breathed in by people if exposed to the area that it is found in. This can get into the lungs.

Spray foam, on the other hand, dries solid, and therefore does not have that attribute. Additionally, those applying spray foam wear a lot of safety equipment, including suits and respirators that one would expect a scientist to be wearing if dealing with a chemical spill or radioactive material.

I have been in the spray foam industry for over 20 years, and can honestly say that I find your claims unfounded. You do know that polyurethane foam has been used since the 1940's, right? It was first used by the military for planes and other aviation technology. So we have years of evidence already.

In regards to warning labels mentioned by Fred, most, if not all packaging and cans already have the warnings. Additionally, they have manuals and videos that highlight these warnings as well. I would assume that most people using spray foam insulation would already be reading these materials.

Honestly, I think people should be more concerned about Radon than spray foam fumes. If you don't already know about Radon, look it up. This is much more a concern and is often not known about or discussed. This is the true silent killer!

Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4040)

- AUTHOR COMMENT June 19, 2012 at 7:36 am ET - David Marlow

  Thank you for your comment. Although employers have taken steps over the years to reduce occupational exposures in the application of spray polyurethane foam, our present knowledge about the potential risks relates only to one component of the spray foam mixture, methylene diphenyl diisocyanate (MDI), as our blog noted. As we stated, "It's difficult for even the most conscientious employers to protect their workers because limited data exist on the second part of the spray foam mixture." As builders and facilities managers increasingly use spray polyurethane foam for insulation, this new knowledge will help support the safe growth of this industry.

  Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4547)

12. May 27, 2012 at 12:13 pm ET - Don Morgan

    Spray foam insulation has so many advantages over conventional insulating methods now used in home construction. I would like to see it used especially in mobile homes where I have found that many times the batt type insulation has fallen down inside of walls due to transport.

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4251)

13. June 9, 2012 at 5:35 pm ET - Nicole

Greenwash it all you like, 3 percent soy doesn't make sprayfoam "green". As a consumer I can no longer live in my home as it is offgassing chemicals. Not to mention my family is sensitized to everyday things in the environment and almost have to live in a bubble now. Isocyanates comprise 50 % of this toxic foam and are odorless. We had it installed by a reputable company and have visited respirologists ever since. To top it off if this foam catches on fire it releases cyanide gas. Nice. Will be interesting to see in the future what lawsuits arise from this nasty invention. Sure it works well, it insulates my home, but to what cost? More research needs to be done on this. We have been in touch with experts in the US EPA and it is astounding how many families have been affected by this. Our first hand experience trumps anything that a contractor can write here... shame, shame, shame.

Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4415)

14. July 5, 2012 at 3:14 pm ET - Tra

    Foam insulation helps gets into hard to reach places.

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4738)

15. July 5, 2012 at 3:39 pm ET - DAN SYMES

    CLEANSEAL GLOBAL TOXIC INSULATION REMEDY

    Recently our firm was engaged to assist in remediating off-gassing of toxins (including confirmed Isocyanates) in a structure which had been retro fitted with SPF insulation. We implemented a two-part protocol which consisted of using an all 'green' toxin sealant on all exposed insulation combined with the installation of zero ozone producing bi-polar ionization device inserted into the HVAC system to terminate odors and toxins, and to circulate negative ions throughout the structure and behind the wall cavities.

    The results were a reduction in toxins brought to below regulatory standards of less than .20 ppb Formaldehyde and reduction in MDI below 5 ppb without removal of any drywall. As a result we are now working with some manufacturers of SPF to solve the problem in order to address the concerns of customers. Our product and this protocol also come with a warranty against reoccurrences.

    Contact us if you wish to discuss employing our methods and protocols.

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4739)

16. July 9, 2012 at 2:53 pm ET - CHARLES MARTINE

    My wife and I have been experiencing severe respiratory problems and skin irritations after I had spray foam insulation installed in my NC home last year. Out of desperation and after doing some research I hired a company to come and treat my house to handle this toxic odor which began right after the insulation was foamed in.

    The company sprayed a white chemical coating called Clean Seal "DTOX" on the foam insulation and then installed a very small air purifying machine in my heat-air conditioning ductwork which runs constantan. Not sure what the little thing is they put in the ductwork but I can tell you the results are unbelievable! One day there's a strong paint "odor" and in less than 24 hours after the company finished treating the house the odor is gone, my eyes don't sting and my wife and had the first good night's sleep in 6 months.

After reading about other people having problems with similar types of foam insulation I can tell you that this treatment I had done got rid of the problem and we are very very pleased with the results. They even gave me a warranty! I recommend this procedure to everyone having the same problems with insulation.

Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4780)

- AUTHOR COMMENT July 9, 2012 at 3:17 pm ET - Blog Coordinator

  References to products or services do not constitute an endorsement by NIOSH or the U.S. government.

  Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4781)

17. July 11, 2012 at 11:30 am ET - Lee Price

    Foam is becoming less and less useful as a wall insulator. Sure, it's still great for lofts but newer forms of insulation exist for cavity walls that are much more effective than foam. Home Insulation is still extremely important... just make sure your get the right type fro your property.

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4800)

18. July 11, 2012 at 8:54 pm ET - Boudewijn Heylen

    The extremely bad news: Polyurethane Foam (PUF) contains a chemical, TCEP, which has flame-retardant properties and has been shown to cause cancer. You can find more about this on the following location : [http://www.epcdiensten.be/downloads.asp] .

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4806)

19. July 14, 2012 at 7:36 am ET - Danny

    Boudewijn, what you say is the same thing i rode somewhere else on the internet recently.
    I thought it was on [http://cancerinfobase.com].
    They said that as long as it is untouched and stable it can do no harm, but as soon at the material becomes dust due to physical change like breaking it, the particles cause cancer within a short period of time.
    I don't know if it is true but it sounds like the same problem asbestos carries, when it becomes dust it becomes dangerous, but in an untouched stable form it can do no harm.

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4833)

20. July 22, 2012 at 12:28 pm ET - Epoksi Boya

    (Polyurethane Foam (PUF) contains a chemical, TCEP, which has flame-retardant properties and has been shown to cause cancer.) Exactly so........

    Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-4892)

21. August 22, 2012 at 5:03 pm ET - Debbie

Please feel free to study my house, me and my cats for your research. My attic was sprayed with SPF, I was not told to vacate nor get my pets out the day they sprayed, I ended up with horrendous chemical vapors/odors throughout my house, including on my clothing in the closet, and later learned there was a lot of off ratio foam sprayed. My pets and I were in the house the day they sprayed; that day and for 12 days after I sat paralyzed in my house because the vapors and odors were terrifying but the contractor kept telling me that everything was OK. I finally had some neutral parties who had experience with spray foam come in to examine the foam in my attic, and was told it was a sloppy job most likely done by inexperienced sprayers and that there was a lot of off ratio foam.

I had to move out because it was causing me to have headaches, very serious eye irritation, burning in my nasal passage and sinuses and I was becoming forgetful and spaced out. Unfortunately I can't afford to board all of my cats so there is one left in the house, and I have to keep going back in the house to feed him and get him outside for some fresh air. Needless to say, this has been about the most traumatic experience I've ever had; I'm afraid of my house, scared my cats have been harmed and scared of my own potential long term health problems from this exposure.

So I'll be glad to participate in your research.

Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-5430)

22. August 27, 2012 at 10:25 am ET - David Marlow

I wanted to thank all of you who volunteered to assist us on this project. Because of your willingness to assist in this research, we have been able proceed with our measurements of worker exposures to spray foam fumes. I look forward to sharing the results of the study when it is complete.

Link to this comment (http://blogs.cdc.gov/niosh-science-blog/2012/03/21/sprayfoam/#comment-5528)

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Pg 2 for testimony

EDF Health

Gasping for breath: Asthma-inducing diisocyanates enter our homes and schools

By JENNIFER MCPARTLAND | BIO | Published: JULY 21, 2011

Johanna Katz is a Cornell Iscoll intern at EDF. Jennifer McPartland, Ph.D., is a Health Scientist.

Toxic chemicals called diisocyanates are long-established as occupational hazards known to cause severe respiratory problems to workers who use or are otherwise exposed to them (see here). In fact, diisocyanates are the number one cause of workplace-induced asthma (see here and here). Recently, potential exposure of the general public to diisocyanates has grown, as these chemicals are increasingly used in consumer products. This is certainly a troubling trend considering that the primary health effect of these chemicals, asthma, is a massive and growing public health problem, especially among children. And some of the newest uses of diisocyanates are in products to which children are quite likely to be exposed.

Asthma is at an all-time high, affecting more than 24 million Americans, and creating astronomical health and productivity costs upwards of $20 BILLION each year. And while diisocyanates are but one of many contributors to the increasing rate of asthma in the general population, we surely don't need to be bringing more products containing such chemicals into our homes, schools, and workplaces. That will only make matters worse.

So what exactly are diisocyanate chemicals, where are they found, and what's the federal government trying to do about them? Read on to find out.

A diisocyanate is any of several chemical compounds that has two reactive isocyanate groups (N=C=O) in its structure. Isocyanates react with another group of chemicals called polyols to form a family of polymers commonly known as polyurethanes. Products containing polyurethanes are numerous, varied and found everywhere: from couch cushioning to roller blade wheels to deck sealant.

Waiting for the cure

Not all of these products are necessarily hazardous. Their potential toxicity is dependent on whether and to what extent the product is *cured* or *uncured.* In fully *cured* polyurethane products, the reactive diisocyanates have been incorporated into polyurethane polymers and virtually no unreacted diisocyanates remain. These products – a good example is a bowling ball – contain *cured* polyurethanes and can be considered essentially non-toxic.

In contrast, products containing diisocyanates that are not yet incorporated into polyurethane polymers are *uncured* (i.e. still reactive) and remain toxic until and unless the curing process is complete. And herein lies the problem. Without complete curing, exposure to toxic diisocyanates continues to be possible through inhalation and skin absorption. Uncured polyurethane products include adhesives, sealants, coatings, paints, craft materials and insulating foams. Among other uses, uncured diisocyanate products are used in the manufacture and repair of cars, boats, furniture, appliances and electronics.

So how long can it take for curing to complete? Well, the answer is not simple. Polyurethane cure time is influenced by a number of factors, including what other ingredients are contained in a polyurethane product (e.g., oil-based vs. water-based polyurethane floor finish), the product's mode of application (e.g., painted by brush or roller versus sprayed), the amount of surrounding air flow during and after application, and other environmental conditions during and after application (like temperature and humidity).

While it is difficult to make generalizations about cure time, some studies suggest that curing can take a long time. For example, a recent paper showed that the cure time for aliphatic isocyanates-containing autobody spray paint varies between 48 minutes and 32 days, depending on drying conditions and the paint formulation. This study also found unbound isocyanate-containing particles on the painted surfaces days or weeks after drying. Hence, there can be substantial variability in polyurethane paint curing times.

Occupational exposure to diisocyanates

Diisocyanates are a known cause of occupational asthma. Annually, over 280,000 workers in the US are exposed to diisocyanates and it is estimated that between 1-20% of these workers develop asthma or other respiratory conditions from diisocyanate exposure. Occupational data has also shown a link between diisocyanate exposures and hypersensitivity pneumonitis (inflammation of the lungs) and pulmonary edema (fluid in the lungs).

Asthma can develop from a single high-dose exposure or from continued exposure to lower levels of the chemicals. Diisocyanates are chemical *sensitizers*, whereby over time exposure to lower and lower concentrations of the chemicals can elicit an asthmatic response. In addition, asthmatic reactions can be delayed by up to 12 hours following exposure.

Several cases of occupational and bystander diisocyanate exposure and consequent detrimental effects are detailed in the Center for Disease Control and Prevention's (CDC) publication on "Preventing Asthma and Death from Diisocyanate Exposure." Included in the report are descriptions of illness caused from *single* exposure to toluene diisocyanate (TDI) at high concentrations, like this incident:

> Two police officers developed asthma-like illness after a single exposure to TDI in the immediate vicinity of a tank car that had overturned on the highway. After briefly directing traffic at the accident scene, both officers received medical care for severe symptoms, including burning eyes, throat irritation, cough, chest tightness, and difficult breathing. Treatment

included steroids and a bronchodilator.

Both police officers developed a chronic bronchospastic disorder after their relatively brief exposure to high concentrations of TDI. Though considerable improvement has occurred in both cases, symptoms have persisted for more than 7 years.

Also included in the report are descriptions of occupational exposure that have even resulted in death, like this case of exposure to methylene diphenyl diisocyanate (MDI):

A homeowner present in the area during spray is the same as the worker but worse! Homeowner is not protected by the proper PPE!

> A maintenance worker became ill after repairing an MDI foaming system at a plant that manufactured artificial plants with polyurethane foam bases. The worker later suffered recurrent bouts of respiratory illness (diagnosed as isocyanate- induced Hypersensitivity Pneumonitis).
>
> After showing further respiratory symptoms associated with isocyanate exposure, the worker quit his job but continued to experience coughing and progressive loss of lung function. His illness was eventually complicated by productive cough, weakness, sweats, muscle aches, and shortness of breath. Ultimately, he died.
>
> Worksite evaluations found detectable air concentrations of MDI and inadequate ventilation systems in the foaming areas. Vapors and aerosols were observed rising into the faces of employees working with the foam. Skin contact with the curing foam was also noted during the survey.

Cases in which bystanders are exposed to commercial or institutional uses of polyurethane products are also a concern. The CDC describes a case in which teachers were unknowingly exposed to diisocyanates from roofing materials used at their school:

> The management of a large metropolitan school district contacted NIOSH for assistance after a university study documented asthma in 13 of approximately 85 staff members from a middle school. The report further suggested that as many as 34 staff members might be asthmatic.
>
> NIOSH investigators determined that large quantities of polyurethane foams and isocyanate coating materials had recently been applied to the school roof on several occasions. School staff members reported odors during roofing application, suggesting possible exposures to roofing materials that included isocyanates. Later air sampling during a test pour of the roofing materials at another location indicated the release of isocyanates during roofing and a potential for exposure.

This report amply illustrates the strong link between diisocyanate exposure and respiratory illness. For even more information on the occupational hazards of diisocyanates check out these links, which discuss exposures in different industries: spray on truck bed lining, automobile foam production, automobile paint, upholstery, bathtub refinishing, electroplating, and paraoccupational exposure from a machine shop and from wood varnish.

Public exposure to diisocyanates

Despite overwhelming epidemiological evidence of the harms of diisocyanates to workers and bystanders, they continue to be used widely with little regulation. In one exposure incident, children at an elementary and junior-high school were exposed to MDI through inhalation. The source? Workers were paving an athletic track with a polyurethane artificial surface containing diisocyanates (MDI) dissolved in a solvent (xylene).

Within 20 minutes of a change of wind direction, students in nearby buildings reported sickness. Of the 2700 students in buildings near the track, 203 students complained of ailments that were likely a result of contaminant exposure. Students suffered eye and throat irritation, nausea, headache, vomiting, cough and dyspnea (shortness of breath), with nearly half of the exposed students complaining of at least four of those symptoms. Hospitalized students required inhaled bronchodilators to relieve symptoms of irritant-induced asthma, also known as reactive airways dysfunction syndrome.

The incidence of affected students was plotted on a graph against distance from exposure and showed a clear linear relationship between the two variables. While incidence decreased further away from the exposure site, **symptoms were still reported by students up to 150 meters away** (that's nearly 500 ft or roughly 1.5 football fields)! Those exposed might also have become sensitized to diisocyanates and could be at a higher risk of developing asthma in the future. Read the entire study of this incident here.

Physiological data indicate that children are generally more vulnerable to environmental health hazards for a number of reasons. Their surface-area-to-body-weight ratio is larger than adults, and they breathe in more air per pound of body weight than do adults. Children are especially susceptible to inhalation of diisocyanates because these chemicals are heavier than air and thus lie closer to the ground where children spend more time relative to adults. In a nation in which one in 10 children is diagnosed with asthma, we think uncured diisocyanates have no business being used around children.

Consumers' and children's exposure to diisocyanates

Despite clear hazards, diisocyanate-containing consumer products are widely available for purchase.

For example, "IdeaPaint" is a new polyurethane-based dry-erase board paint. This product has recently been picked up by Lowes, making it widely available to consumers. One of the paint's main ingredients is hexamethylene diisocyanate (HDI), which has been linked to asthma in occupational studies.

The company defends the safety of its product by stating "Once it is dry it emits no harmful chemicals." Yet the company acknowledges that its product takes an estimated **seven days** to cure, or at temperatures below 60°F, up to **28 days**. For the integrity of the paint finish, the product instruction manual advises against writing on the freshly coated area for one week after application; however, no warnings are presented on potential inhalation hazards during cure time.

The product's safety information is mainly found on the material safety data sheets (MSDS) posted on the company's website. This kind of data sheet is typically used for reference in science labs and industry. And while decipherable by chemists, MSDSs are largely inaccessible to the average product user.

The MSDS for the company's CRE-8 brand product lists the chemical components of the paint and associated hazards, including a number of known or suspected toxic chemicals in addition to HDI: styrene, dibutyltin dilaurate, and 2-butoxyethanol. (Note: The identities of 10 of the product's 25 ingredients are not listed because they are claimed to be "trade secret").

The MSDS lists the PEL, TWA and STEL values for the chemical components, all various measures of acceptable air concentrations of compounds as determined by OSHA for worker exposure. We'd wager a guess that the typical consumer is clueless as to what these values means and is incapable of testing for compliance with these air levels. Moreover, general worker exposures limits to chemicals set by OSHA are typically much higher than levels that are acceptable for the general public, especially children, who are virtually certain to experience exposure as bystanders as products are used.

Perhaps realizing that its MSDS is not very user-friendly, the company has posted to its website a letter issued by a scientist it hired to review the MSDS. Because they were not disclosed on the MSDS, the trade secret chemicals contained in the product were not specifically evaluated, just the general class to which they belong. Indeed, the identities of these ingredients are blacked out and replaced with the term "proprietary component" in the letter.

The letter asserts, without providing any documentation, the safety of the proprietary components mainly based merely on the fact that it is used in a lot of other products. It briefly acknowledges a concern for product inhalation while drying, and separately mentions that curing needs to proceed to completion in order to remove the hazard – but then fails to acknowledge or distinguish between the drying time (about 2-hours) versus the subsequent and often much longer curing time.

That's hardly a basis for being able to conclude with any confidence that this or similar products are safe.

Despite the abundance of safety concerns raised by a product containing diisocyanates, "IdeaPaint" markets its product as "green." The company explains that its product eliminates the need for a wooden board (therefore saving energy in shipping), as you can simply paint right on your kitchen wall, your child's bed frame or kids' school desks – all uses suggested on the company's website.

Think back to the case study involving school children exposed to diisocyanates from track sealant fumes. Students suffered from asthma-like symptoms at distances of up to 500 feet away from the track, where sealant was applied in open air. Now consider your own home or your child's schoolroom. Where would 500 feet away from the application site place you or your kids?

What's needed

Concerns about the increased availability of diisocyanate-containing products have been raised by the Environmental Protection Agency (EPA). The agency recently issued chemical action plans for two of the most commonly used diisocyanates, methylene diphenyl diisocyanate (MDI) and toluene diisocyanate (TDI). We applaud the agency for scrutinizing the widespread use of these toxic chemicals.

These examples illustrate a much broader problem and need: Diisocyanates are among hundreds of chemicals we know are toxic that are in widespread use without adequate demonstration of their safety (see reviews of other toxic chemicals here). And there are thousands more chemicals about which we know too little to determine their hazards, uses or exposures.

That's why EDF and hundreds of other health and environmental groups representing more than 11 million Americans are demanding that our main chemical safety law be brought into the 21st century.

Companies that make and use chemicals we know can cause or exacerbate asthma should be required to show that they're safe before selling us products containing them that we bring them into our homes and schools.

Otherwise, they may literally leave us *gasping for breath*.

Health Consequences of Exposure to "Green" Polyurethane Spray Foam

Download: PDF

Summary Statement: This PowerPoint from a presentation at a 2012 CPWR meeting by Carrie Redlich MD reviews the main findings of a NIOSH-funded study looking at health effects from exposure to spray polyurethane foam as part of green construction. The results point out the strong relationship between this work and occupational asthma and addresses the medical evaluations needed. Case studies are presented of workers who developed sensitivity.
March 27, 2012

Exposure to "Green" Polyurethane Spray Foam

- What's in it
- Potential health effects - isocyanate asthma
- Challenges
- Biomonitoring - Isocyanate-specific IgG / IgE
- CPWR study – preliminary data
- Questions

Chemical Composition of SPF

Part A – Isocyanates

- **Methylene diphenyl diisocyanate (MDI) /pMDI**

Part B – variable / proprietary

- Polyols (petroleum or soy based)
- **Amine catalysts**
- Flame retardants
- Blowing agents
- Surfactants

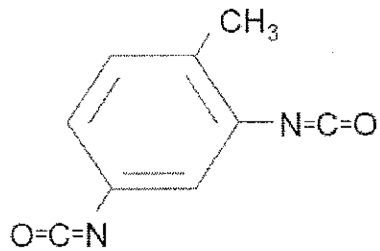
Mix A + B = POLYURETHANE FOAM (exothermic reaction)

Major Commercial Isocyanates

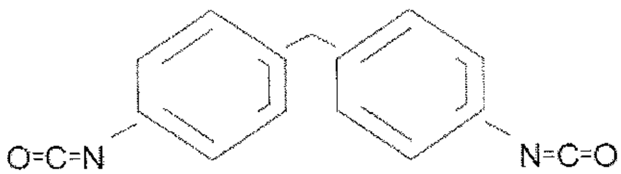
HDI - hexamethylene

$O=C=N(CH_2)_6N=C=O$
Paints, Coatings Light resistant

TDI - toluene



MDI - diphenylmethane or methylene diphenyl



Less volatile – "safe"
Foams, adhesives Coatings, wood products

Uses Isocyanates / Polyurethanes in Construction - Growing

- Foams – soft / hard
  - *Insulation – spray foam*
  - Simulated wood – doors, posts
- Adhesives
- Roofing materials
- Caulking
- Sealants
- Elastomers / coatings
- Woodbinder – composite wood

Health Effects Isocyanates

- Potent sensitizer / allergen
- **Occupational asthma**
- One of the most commonly identified causes of occupational asthma
- Rash / skin irritation - less common, but occurs
- Hypersensitivity pneumonitis – less common.

Isocyanate asthma – key features

- Clinically similar to "ordinary" asthma
- Timing- onset months to years after onset exposure
  - Delayed symptoms 6-8 hours after exposure
- Once sensitized, exposures to very low levels trigger asthma
- Diagnosis can be missed – (by patient and doctor)
- Asthma commonly persists after away from exposure
- Poor socioeconomic outcomes – unemployment, reduced income
- Extent problem unknown – especially in end-user settings

Health effects from exposure to other components PU Foam ?

- **Amine catalysts**
  - Sensitizers, irritants – asthma, rash
  - **Blurry vision (halo vision)**
- Flame retardants
- VOCs
- Blowing agents
- Polyols

Routes of exposure / forms

- **Inhalation**
- **Skin** – likely contributes to sensitization and asthma

- Liquid, aerosol, vapor
- Exothermic reaction
- Cut & shave foam → dust, particulates

Case

Healthy 36 y/old construction worker / insulator 1 yr ago started use PU spray foam. Past 5 months -- cough after work / evening – wife concerned. Chest tightness, SOB, wheeze. Better on weekends. Symptoms progress – goes to ER.

Initial Medical evaluation
No h/o asthma, allergies. Improves with asthma inhalers. Continues to work, wears PPE, but progressive symptoms.

Further work-up
Spirometry – airflow obstruction - positive BD response MDI-IgG, MDI-IgE positive. Told to avoid isocyanates.

Health Effects of Exposure to "Green" Polyurethane Spray Foam

- What's in it
- Potential health effects - isocyanate asthma
- **Major challenges**
- **Biomonitoring - Isocyanate -specific IgG / IgE**
- CPWR study – preliminary data
- Questions

Limitations isocyanate exposure assessment and regulation

- Multiple formulations and forms– vapor / aerosol / particulates
- Sampling and laboratory analysis can be challenging
- All methods depend on free NCO – timing critical
- "Snapshot" of exposure - end-user settings esp problematic
- Air sampling does not assess effectiveness personal protective equipment (gloves, respirator)
- Skin exposure assessment methods limited

- Current OELs – Not protective

Limitations diagnosis isocyanate asthma

- Asthma common condition - connection to work frequently missed – especially once asthma more chronic.
- No simple specific test for isocyanate asthma. Frequently other work (and environmental) triggers.
- Most clinicians focus on treatment more than cause / prevention
- Worker may leave causative job / work before diagnosis made, but asthma frequently persists.
- No mandatory medical surveillance or reporting for isocyanate asthma

Biomonitoring Approaches

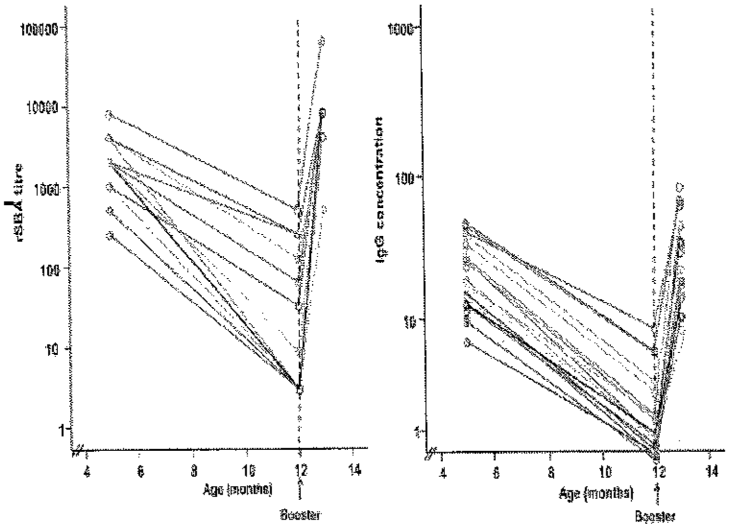
- Direct measurements of isocyanate derivative or metabolite in urine - *currently not useful*

- **Measurements of physiologic response to exposure (antibodies in blood)**

Principles Guiding Isocyanate Serology

Isocyanate chemicals are "man-made" - don't exist naturally.

Humans don't normally make antibodies to isocyanate modified albumin; they are triggered by exposure.



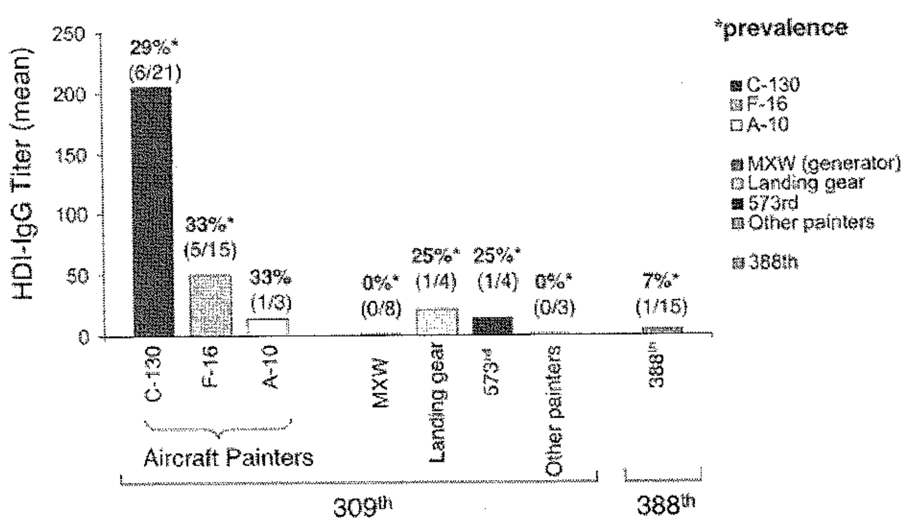
Without ongoing exposure, specific antibodies are cleared from blood in a time dependent manner.

Isocyanate Immunoassays

Measures human response to exposure

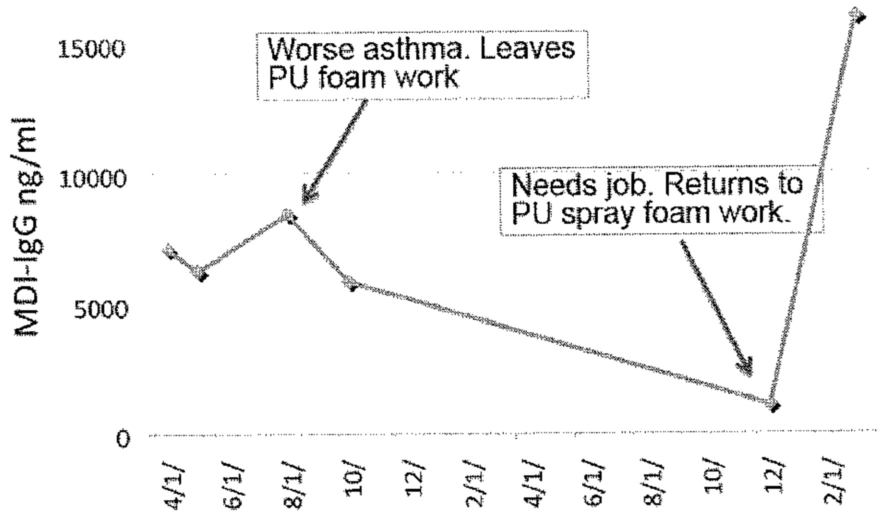
- Detect in human serum
- Isocyanate-specific IgG and IgE responses
- Integrated measurement over time
  - IgG serum1/2 life = 30 days
  - IgE serum 1/2 life ~ 2 days
- Response highly specific for isocyanate
- Can vary depending upon form of isocyanate used as the "antigen"

Biomonitoring hexamethylene diisocyanate (HDI) exposure based on serum levels of HDI-specific IgG



Wisnewski. Ann Occup Hyg 2012; 10: 1-10

Case: PU spray foam sprayer MDI-IgG over time



Assessment and Prevention of Isocyanate Exposures in the Construction Industry Funded by NIOSH / CPWR

Aim 1) Assess respiratory and skin isocyanate exposures in the construction industry

Aim 2) Implement a surveillance program for construction workers who work with or around PU products.

Aim 3) implement an intervention program to reduce isocyanate exposures in construction workers.

Characteristics Construction Workers Recruited who use Isocyanate Products (n= 60) *Preliminary Data*

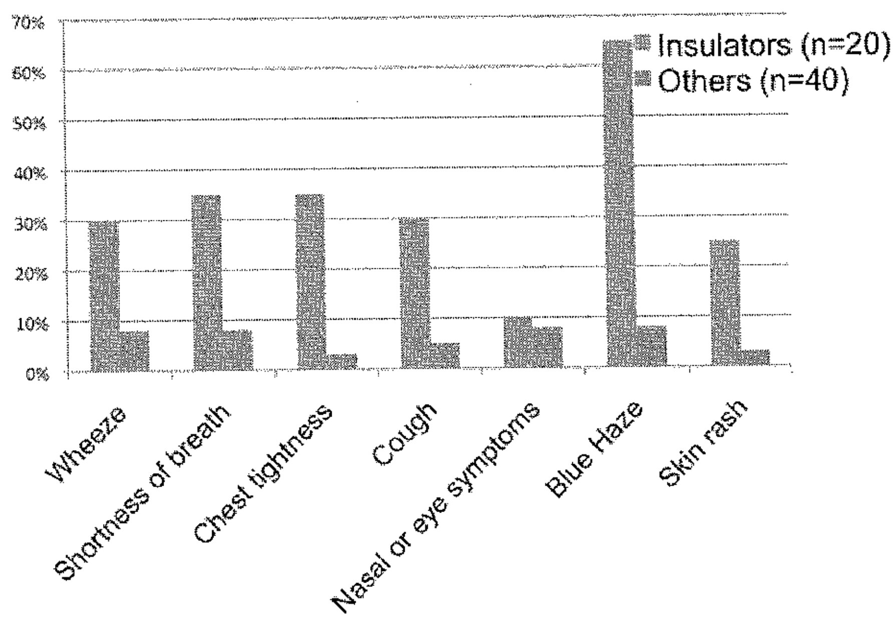
Gender: Male	58 (97%)
Current smoker	22 (37%)
Job Category	
Insulator	20 (33%)
Other	40 (67%)
Glazier / taper	9 (15%)
Energy conservation	7 (12%)
Other construction	24 (40%)
Symptoms	
None	19 (32%)
Non-specific	24 (40%)
Asthma, work-related	15 (25%)
Spirometry - airflow obstruction	16 (27%)

Worker Self Reported Exposure (n= 60) *Preliminary Data*

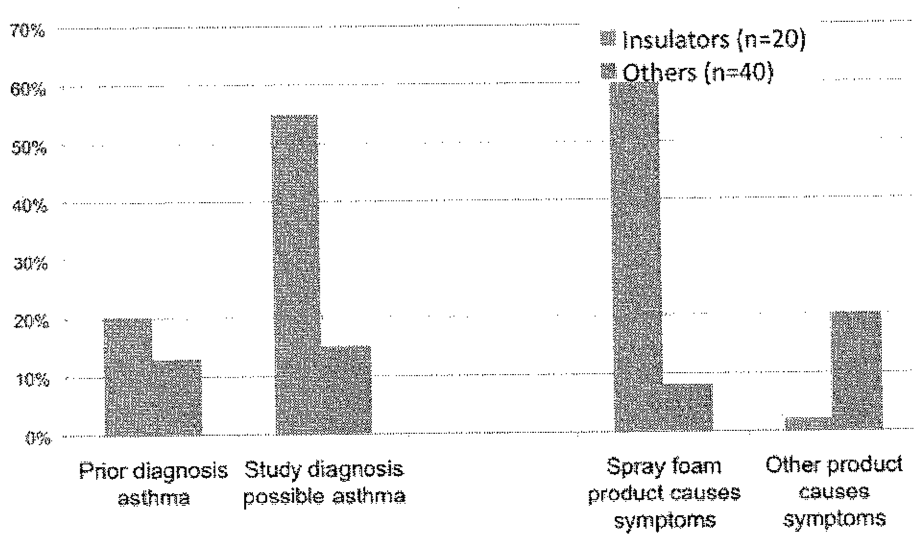
Other spray near you	
No	7 (12%)
Monthly or less	14 (23%)
Daily / weekly	39 (65%)
Get Isocyanate product on skin	

Never	4 (7%)
Occasionally	22 (37%)
Frequently	**34 (57%)**
Where on skin	
Hands, arms, wrists	24 (40%)
Head, neck, face	15 (25%)

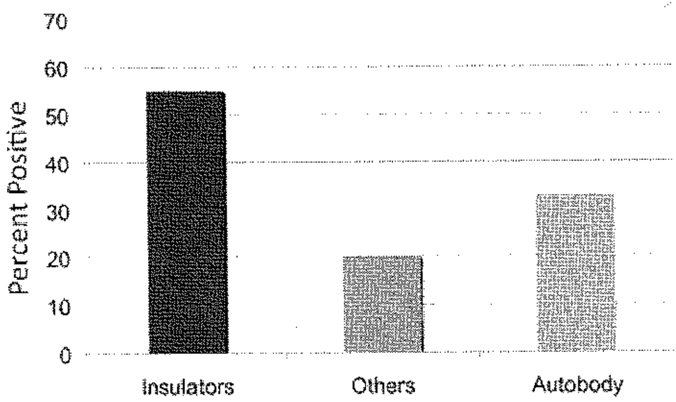
Work-related symptoms *preliminary data* (n = 60)



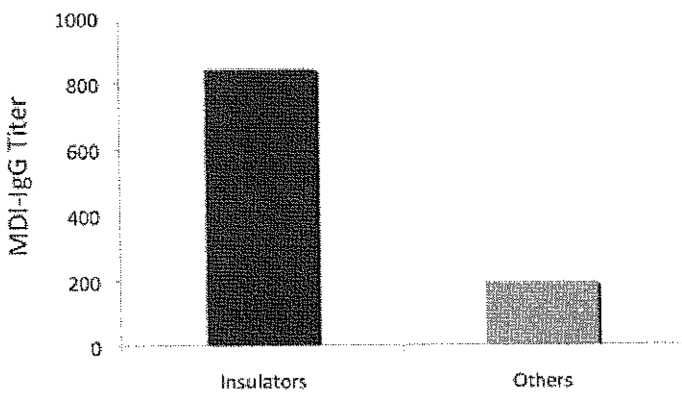
Possible Asthma: prior diagnosis vs study diagnosis *preliminary data* (n = 60)



Prevalence of isocyanate-specific-IgG Comparison to autobody workers *preliminary data*



MDI specific-IgG titres (mean) *preliminary data* (n = 60)



PU Construction Worker Project – Initial *Preliminary* Conclusions

- Work-related asthma symptoms are common in the PU spray foam workers – may represent isocyanate asthma
- High prevalence MDI-IgG positive titers in PU spray foam workers
- MDI skin exposure is commonly reported
- Traditional IH monitoring does not appear to be adequate

Health Effects of Exposure to "Green" Polyurethane Spray Foam

- What's in it
- Potential health effects - iIsocyanate asthma
- Major challenges
- Biomonitoring - Isocyanate-specific IgG / IgE
- CPWR study – preliminary data
- **Questions**

Acknowledgements

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Asthma Induced by Exposure to Spray Polyurethane Foam Insulation in a Residential Home

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Spray polyurethane foam (SPF) has recently become a popular "green" solution for insulation systems in residential homes and office buildings in the United States because of its high efficiency, low cost, and eligibility for federal energy tax credits in 2011. All SPFs contain isocyanates that are known to cause occupational asthma,1 but the occurrence of asthma in occupants of homes and building in which SPF is used for energy retrofits has not been reported.

Back to Top

CASE

A 36-year-old man and a 38-year-old woman living in the same household presented to the pulmonary clinic for evaluation of persistent cough and dyspnea upon exertion. They had moved into a home 18 months previously and had SPF installed in the attic. The patients followed the recommended precautions by evacuating the home for 4 hours. On returning, the patients noted a strong noxious odor, and almost immediately they developed cough, dyspnea, dizziness, nausea, headache, and watery eyes. Several attempts were made to abate the odor by venting the attic, keeping the windows open, and eventually removing the SPF, but the symptoms persisted. After 3 months, the family finally vacated the home. Neither patient had significant medical history. Both were nonsmokers and worked in office-based professions with no exposure to occupational hazards. Both had normal physical examinations, normal routine laboratory tests, including complete blood count and metabolic panels, and normal pulmonary function tests. Both patients showed a positive methacholine challenge test with the methacholine concentration that causes a 20% decrease in forced expiratory volume in 1 second (PC_{20}) of 8 mg/mL for the male patient and 1 mg/mL for the female patient (Fig. 1). The SPF used in our patients' home was a two-component SPF system (Sealection® 500; Dimilec USA, LLC, Arlington, TX) that contained polymeric diphenylmethane diisocyanate (MDI) (50% to 60%), 4,4'-MDI (35% to 45%), and 2,4'-MDI (1% to 5%) in side A. Both patients were diagnosed with asthma or reactive airway dysfunction syndrome induced by exposure to isocyanates and were treated with bronchodilators and inhaled steroids.2

Figure 1

Back to Top

DISCUSSION

Isocyanates are traditionally used in the automotive, aerospace, metal-working, and wood-working industries.3 They are the most common cause of new onset work-related asthma.4 The use of isocyanates in nonoccupational settings has increased recently, primarily because of the popularity of SPF as an insulation material for residential homes. The home occupants may unknowingly be exposed to isocyanates residential homes. The home occupants may unknowingly be exposed to isocyanates and be at increased risk for adverse health effects.

The "curing" rate of SPF, that is, the time for chemicals in the product to react to produce polyurethane foam, is an important determinant for health effects and varies from 7 to 72 hours depending on the type of SPF product, applicator technique, foam thickness, temperature, and humidity. This curing rate will impact the "re-entry time." Our patients were told to return 4 hours after the application was completed, and thus were likely exposed to high concentrations of MDI. The clear exposure history, symptoms/signs of asthma, and positive methacholine challenge test established the diagnosis of isocyanate-induced asthma.

To our knowledge, this report is the first to describe asthma associated with household exposure to isocyanates contained in SPF. The use of SPF in residential homes likely will continue to increase. This new source of exposure potentially puts a large population at risk for adverse health effects. In response to a growing number of complaints about adverse health effects from homeowners and occupants of office buildings, the US Environmental Protection Agency has recently published an action plan to control exposure to MDI for homeowners and "do-it-yourselfers."5 Clinicians should be vigilant about this novel exposure scenario to isocyanates when managing patients with new-onset or worsening asthma.

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Back to Top

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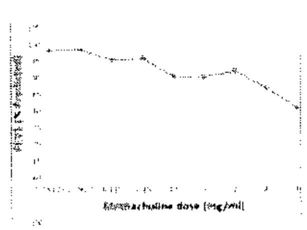


Number of chemicals linked to autism and other disorders doubled in past 7 years, study shows

By Amanda Woerner / Published February 15, 2014 / FoxNews.com

A chemical commonly used in dry cleaning was included in a new list of neurointoxicants known to cause problems in children.

The number of industrial chemicals with known links to neurodevelopmental disabilities like autism has more than doubled in the past seven years, according to new research published in *The Lancet Neurology*.

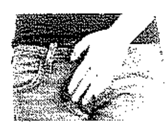
As rates of autism and attention deficit-hyperactivity disorder (ADHD) increase worldwide, researchers believe widespread exposure to these chemicals among children may be contributing to a "silent epidemic" of people with neurodevelopmental disabilities.

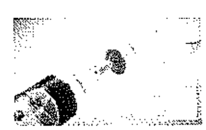
Based on an analysis of previous studies, researchers added six new toxins to a list of chemicals believed to pose a threat to the brains of fetuses and young children: manganese, fluoride, chlorpyrifos, dichlorodiphenyl-trichloroethane (DDT), tetrachloroethylene, and the polybrominated diphenyl ethers.

While chemicals like manganese and fluoride, common in drinking water, are rarely found in high enough concentrations in the U.S. to pose a health threat, other chemicals on the list are much more pervasive.

"Chlorpyrifos is an organic pesticide … 10 years ago it was banned for household use, but it is still extensively used in agriculture and can be found in lots of fruits and vegetables," study co-author Dr. Philip Landrigan, of the Icahn School of Medicine at Mount Sinai in New York City, told FoxNews.com.

And the list gets scarier: Tetrachloroethylene, which has been linked to deficient neurological function and increased risk of psychiatric diagnosis, is a common solvent used in dry cleaning. Another chemical on the list, polybrominated diphenyl ethers, is a type of flame retardant frequently found in couches. And while the





pesticide DDT is now banned in the U.S. due to human health risks, it's still found in imported fruits and vegetables, as well as in soil and water throughout the country.

These six chemicals have been added to a list of five other neurointoxicants – lead, methylmercury, polychlorinated biphenyls, arsenic, and toluene – first identified by Landrigan and his co-author, Dr. Phillipe Grandjean of the Harvard School of Public Health, in 2006.

How chemicals harm the developing brain

Industrial chemicals pose a far greater threat to the neurological health of a developing fetuses, infants and young children than to adults, Landrigan noted.

During the early weeks of pregnancy, an embryo forms the cells that eventually go on to become the brain and spinal cord. Those cells divide, multiply and migrate, forming millions or even billions of connections with surrounding cells – and build up the pathways that form the body's central nervous system.

"If some chemical gets in to the developing brain, whether lead or methylmercury, and either kills brain cells or disrupts cell division or cell migration, those connections are lost and the brain is not as complete as it should have been," Landrigan said. "And the consequence is a child whose intelligence is reduced and attention span shortened, etc. The human brain is a wondrous creation, and extremely complex, but the price of that complexity is vulnerability."

Though the researchers acknowledge that increasing rates of conditions like ADHD and autism are partially due to increased awareness about these conditions, they argue that other factors are also at play.

"We note the increase of later diagnoses of these disorders tracks very nicely with increased production and release into environment of synthetic chemicals over last 40 or 50 years," Landrigan said. "And then on top of that, there's the direct evidence we present in [the] paper showing these particular chemicals have been linked to these problems in children."

How to curb the effects of industrial toxins

Currently, the United States has no system by which to screen the potential health effects of industrial chemicals before they enter the marketplace – a problem which must change in order to reduce the levels of dangerous toxins in the environment, according to Landrigan.

"That's the first thing, calling for proper chemical testing," Landrigan said. "There is bipartisan legislation currently in Congress introduced by the late Senator Lautenberg and Senator (David) Vitter and they said, 'This is a nonpartisan issue, we all have children, we should do something about it,' and it's currently being debated."

Secondly, Landrigan and Grandjean propose setting up an international agency dedicated to studying the toxicity of chemicals, similar to organizations like the International Agency for Research on Cancer. Landrigan said he believes efforts like these could slowly curb increasing rates of autism and other neurodevelopmental disorders in the United States.

"The short answer is yes [it could curb rates of autism and other disorders], and the longer answer is it would take time," Landrigan said. "These chemicals are out there, some of them are quite persistent. They aren't going to disappear overnight, but I think it's entirely worthwhile for the government to take action."

However, concerned parents can also take action to reduce exposure in simpler ways – for example, by eating organic or eliminating wall-to-wall carpeting in homes, which can trap chemicals and pesticides.

"Lastly, I talk with parents about what to buy and even in the case of chemicals where evidence for toxicity is not yet solid, like phthalates and BPA, it makes sense to buy products free of chemicals," Landrigan said. "I say to people, 'Why take a chance? Why risk your health and your child's health with exposure to a chemical [with] at least some toxicity when there are safe alternatives available?'"

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Are you ingesting these 'Dirty Dozen' toxic chemicals?

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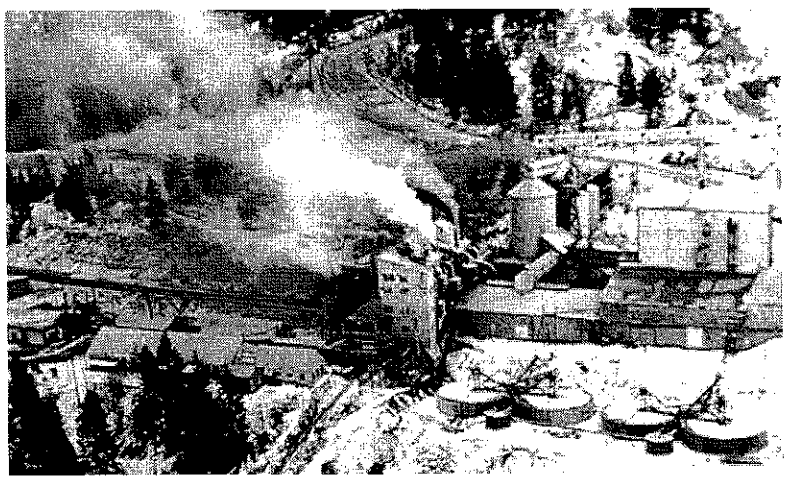
HEALTH & WELLNESS

Life / Health & Wellness

Lawsuit deadline looms for homes insulated with Zonolite

Canadians with the asbestos-contaminated insulation Zonolite in their homes are due a meagre settlement compared to their U.S. counterparts.



LINCOLN COUNTY DISTRICT COURT / AP FILE PHOTO

Asbestos dust from the mill stack at the W.R. Grace vermiculite mine at Libby, Mont., would powder the area.

By: Jennifer Wells Feature Writer, Published on Sun Aug 23 2009

As with myriad marketing come-ons, this one held out the promise of a little bit of magic.

"Actually snuffs out flames," was the sell line in one advertisement. "Easy as pouring popcorn from a bag," was another.

It was a light-as-a feather, do-it-yourself product ideal for homeowners eager to keep their houses snug in winter and help repel the sweltering heat of summer.

What was not to love?

In fact, the popcorn-light insulation, carrying the brand name Zonolite, proved so popular that the substance was poured into the attics of thousands of Canadian homes. How many thousands has never been precisely determined: a report prepared in June 2006, for Health Canada, which had struck an interdepartmental scientific committee on Zonolite, came up with an estimate of 242,000.

We do know that Zonolite's insulating properties were deemed impressive enough to qualify for the country's Canadian Home Insulation Program. CHIP, which was launched at the height of the energy crisis in 1977 and terminated in 1986, extended grants to assist Canadians in making their homes more energy efficient.

There would have been little reason then for the average Canadian homeowner to know that the insulating miracle came from a single source: a deposit of vermiculite mined from the Disneyesque sounding Zonolite Mountain in Libby, Mont.

Nor would the average homeowner have been attuned a decade ago to the breaking tragedy that the vermiculite was contaminated with tremolite, an especially toxic form of asbestos that has taken a terrible toll on Libby. Declared a Superfund site for environmental cleanup in 2002, the Environmental Protection Agency took the unprecedented action this June of declaring a public health emergency there.

And to many it will come as a surprise to learn that legal efforts in Canada to financially assist homeowners in the containment or removal of Zonolite from their attics has resulted in a frail settlement that is just a fraction of what U.S. homeowners are in line to receive. The deadline for Canadian homeowners to submit a claim for slight compensation is 5 p.m., Aug. 31.

It has been such a long and tortured journey, with a story line tricky to plot.

That once upon a time there was an outfit called the Zonolite Company, whose "Warmer in Winter – Cooler in Summer" sales pitch dates at least as far back as 1928. That the Zonolite Co. was purchased by W.R. Grace & Co. in 1963. That processing plants, where the vermiculite was exfoliated through a heat process that literally popped the mineral into shape, dotted the American landscape and Canada's too, with plants in Vancouver, Calgary, Regina, Winnipeg, St. Thomas, Ont., and one in Ajax that today recycles Styrofoam into commercial fireproofing.

The people in Libby grew sick. And though the mine was closed in 1990, they grew sicker. In November 1999, Pulitzer Prize-winning journalist Andrew Schneider penned a two-part series for the *Seattle Post-Intelligencer*, marking the deaths of 192 miners from asbestos-related diseases and at least 375 cases of asbestosis, mesothelioma and other cancers. The asbestos dust from the dry mill stack was such, Schneider wrote, that it did not have to snow for Zonolite Mountain to be white: "Some days, when the east wind blew, sheets on the clotheslines of Libby would be covered in the dust, and children would write their names in the dust on their parents' cars."

Given the latency period for asbestos-related diseases, a period that can last as long as 40 years, the ultimate toll is still not known. "So in Libby," Schneider wrote, "the dying goes on." In April 2001, facing more than 100,000 personal injury lawsuits related both to Zonolite and other asbestos products manufactured elsewhere in its corporate operations, W.R. Grace filed for bankruptcy protection. (The company remains financially robust, with pre-tax income of $300 million (U.S.) on revenues of $3.3 billion last year.)

As the tragedy in Libby became clearer, the effects of the fatally flawed mineral that was shipped, processed, bagged and sold to consumers across North America was much less transparent.

In Spokane, Wash., Darrell Scott became the first lawyer to take legal action, in December 2000. The property damage suit sought, says Scott, the establishment of a homeowner program to both notify residents of the product's potential dangers and fund the removal or abatement of the asbestos contamination where it occurred, and that Grace pay for it. "Our argument before the court had always been that very few homeowners would recognize Zonolite if they ran into it," says Scott, not anticipating then that Grace would end up in one of the longest bankruptcies in U.S. history.

But what *were* the product's dangers?

In December 2006, U.S. bankruptcy judge Judith Fitzgerald released a key opinion: there is no dispute, Fitzgerald concluded, that Zonolite is contaminated with asbestos fibres and that disturbance of the product can release those fibres into the air. However, she added, in the absence of any epidemiological studies, Zonolite posed no "unreasonable risk" of harm.

The finding echoed health advisories posted by the EPA in the spring of 2003 and Health Canada a year later that the best course of action for homeowners is to leave the material thoroughly sealed, secured and undisturbed. That view is supported by experts in the home inspection industry and in the medical community. "We say the same thing here – don't disturb it, leave it alone," says John Graff, co-director of the National

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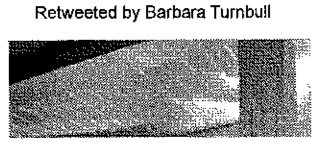

Center for Vermiculite and Asbestos-Related Cancers at the Barbara Ann Karmanos Cancer Institute in Detroit. "We wish we had a better answer to that, but we don't."

That presumes an awareness on the part of homeowners, an awareness that a young Raven Thundersky and her family on Manitoba's Poplar River First Nation Reserve in Manitoba did not possess. The 520-square-foot home, built by the federal government in 1964, was a tight fit for Thundersky and her seven siblings. The children would, she said in a sworn affidavit in the spring of 2005, access the attic as additional play space. Documents dating to the time of the home's construction reveal that 46 bags of Zonolite were used for insulation. In fact, hundreds of reserve homes, largely in Manitoba and Saskatchewan, were constructed with Zonolite. In her affidavit, Thundersky testified that four of her siblings, and one or more of her parents, had died from asbestos-related disease. In September 2005, Thundersky sued Grace and the Canadian government. That suit, which briefly drew the story of Zonolite into the headlines, has been stayed pending completion of the bankruptcy proceedings.

Under settlement terms in the Grace bankruptcy, two trusts have been established: a personal injury trust to address all present and future asbestos-related claims against the company, which admits no liability; and a property damage trust, to address claims related to Zonolite. "The U.S. plan will have an actively managed fund that runs for at least 20 years, potentially 25 years that will both encourage people to remove it when necessary and pay for most of the cost of removing it," says Darrell Scott. "That's what we sought to do 10 years ago."

Should Grace's reorganization plan be approved – hearings are scheduled for early next month – U.S. claimants can expect to receive 55 per cent of a payment cap of $7,500.

The Canadian plan is far more meagre. "We were able to at least negotiate some compensation, though nominal," says David Thompson at Scarfone Hawkins LLP, one of two law firms representing Canadian claimants. Those who can prove the presence of Zonolite and additionally prove costs incurred to contain the insulation can expect to see $300. Those who undertook major remedial measures – i.e., removal – will receive just $600. The average cost to remove the product: $7,000 to $8,000.

Unlike the U.S., there will be no opportunity beyond Aug. 31 for Canadian homeowners to make any claim at all. Should the presence of Zonolite become apparent five or 10 years from now, the homeowner can count him or herself out of luck.

Thompson says a main objective was a $1 million notification program rolled out last fall through print and television advertisements as part of the claims process. "We felt that was absolutely key here," he says of commercials that ran on TSN and HGTV and others. "There are perhaps thousands of Canadians out there who do not realize they have this insulation and don't realize that by disturbing it they may be exposing themselves and their families to harm."

Clearly the EPA feels that more must be done on the notification front in the U.S. In late June, it announced a public awareness campaign "to ensure that the general public, and those individuals whose jobs routinely put them in attic spaces, such as electricians, plumbers and other contractors, are aware of the potential risks of exposure."

Has enough been done here at home? David Thompson ponders those old CHIP grants, and the way the federal government bore the cost of the removal of urea formaldehyde foam insulation, or UFFI, back in the early '80s, and suggests the federal government could "do the right thing" this time by extending similar financial aid to homeowners.

In Detroit, John Graff is leading a pilot study, funded by the EPA, analyzing insulation for asbestos fibre content; interviewing homes owners; estimating cumulative exposures. "We want to make sure that the public has all the facts that they need," he says, adding that it's too early to draw any conclusions. "I wish we had a magic wand and we could wave it and make it go away. ... I think we're going to be telling this story for an awfully long time."

UREA-FORMALDEHYDE FOAM INSULATION: HEALTH EFFECTS AND REGULATION

MINI BRIEF NUMBER MB82228

AUTHOR:

Michael M. Simpson

Science Policy Research Division

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ISSUE DEFINITION

Urea-formaldehyde foam insulation (UFFI), a synthetic substance which when new is an excellent thermal insulator, has been installed in hundreds of thousands of commercial and residential buildings as a means of reducing heating and cooling costs. At the present time, however, some residents of these buildings are complaining of a variety of health-related discomforts; research indicates that exposure to UFFI may have serious health effects.

Four U.S. Federal agencies and several foreign governments have taken different actions in relation to controlling potential human health effects resultant from exposure to UFFI; these actions range from use bans and compensation programs to refusal to regulate in the absence of evidence of significant risk to humans. Public policymakers' concerns currently focus on compensatory relief programs and congressional reviews of UFFI regulations and regulators.

BACKGROUND

General Information

Rising energy prices, shortages of other insulating materials, and the low cost and ease of installation of UFFI encouraged a dramatic increase in the second half of the 1970s in the number of buildings insulated with UF foam. As a way to reduce energy consumption and dependence upon foreign suppliers of energy, the U.S. Government extended thousands of tax credits to encourage the insulation of buildings; UFFI qualified as a tax creditable way to insulate a building. (Please see MB83210 -- The Residential Energy Tax Credits; also, IP0033 -- Energy Conservation.)

Building codes in the United States rate UFFI as a combustible material; as a result, when installed inside buildings, a thermal barrier of fire-resistant material was required. Installation involved mixing and injecting under pressure, behind the thermal barrier, partially polymerized UF resin with a foaming agent and an acid catalyst. The foam hardened in minutes and cured within days. But a number of factors in this process could allow excessive formaldehyde gas from the UFFI to be emitted into the building:

excessive formaldehyde in the initial resin solution,
excessive acid catalyst in the foaming agent,
excessive foaming agent,
installation in high heat or humidity,
installation with chemicals at sub-optimal temperatures,
improper use of vapor barriers, and
installation in ceilings or other improper places.

Even when properly installed, UFFI will emit formaldehyde in decreasing quantities over time (one monitoring study found 10 to 100 times greater emission levels with newly installed UFFI relative to UFFI installed 3 to 5 years before measurement). And UFFI tends to shrink with age, reducing its value as a thermal insulator.

While formaldehyde gas in measurable amounts has been detected in homes with UFFI, gaseous formaldehyde can also be emitted by plywood, particleboard, carpeting, draperies, gas stoves, tobacco smoke, paper products such as grocery bags and tissues, wrinkle-resistant and/or water-repellent materials and clothing, and other products held together by UF resins.

Health Effects

Several studies using young, healthy adults exposed for short durations in clean and controlled atmospheres to formaldehyde gas in concentrations as small as 0.2 parts per million (ppm) have shown irritant effects of the eye, nose, and throat. Many occupational and residential studies have shown formaldehyde gas levels of 0.03 to 4.15 ppm to be associated with eye, nose, and throat irritation, nausea, vomiting, diarrhea, headaches, irritability, and skin rashes. The Committee on Toxicology of the National Academy of Sciences has reported that it found no population threshold for the acute effects of formaldehyde gas. Studies indicate that formaldehyde

- can react readily with other chemicals in humans and animals;
- is mutagenic in bacteria, viruses, fungi, insects, and mouse lymphoma cells with or without metabolic activitation;
- induces chromosomal recombination in yeast, insects, cultured mammalian cells and rats;
- induces cellular transformation in certain mouse cells;
- induces cancer in rat nasal tissue; and
- may be carcinogenic in other species and other tissues.

(For further information on health effects of indoor air, please see IB83074 -- Indoor Air Quality and Health Impacts of Energy Conservation: Some Congressional Options.)

CONSUMER PRODUCT SAFETY COMMISSION

On Mar. 2, 1982, the U.S. Consumer Product Safety Commission (CPSC) proposed a regulation to ban the future installation of UFFI in non-mobile residences and schools. The proposed regulation was based upon the unreasonable risks to consumers from the irritation, sensitization, and possible carcinogenic effects of formaldehyde potentially emitted by UFFI, the availability of alternative insulating materials for nearly all applications, and the lack of alternative approaches to eliminate or adequately reduce the risks. The proposed ban was thus deemed necessary and in the public interest. It was not to apply to mobile homes (see "Department of Housing and Urban Development" hereafter) nor to offices, warehouses, stores, or similar commercial buildings (see "Occupational Safety and Health Administration" hereafter). It was also to have no effect upon UFFI already installed in buildings. The proposal included a provision for granting exemptions to any company which could demonstrate that it could consistently manufacture a UFFI product which does not pose an unreasonable risk to consumers. The CPSC published the regulation in the Federal Register (47 FR 14366) on Apr. 2, 1982. Following 10 days of judicial review, the regulation was sent on for congressional review. Congress had 90 days in which to veto or otherwise modify the rule. CPSC planned to enforce the regulation, using the authority in sections 19 to 21 of the Consumer Product Safety Act. CPSC plans to react to consumer complaints of illegal installations by inspecting UF manufacturers' and UFFI installers' sales records, then assigning civil or criminal penalties against violators. By Apr. 23, 1982, court cases in several jurisdictions had been filed, challenging the validity of the ban, its wording, its proposed effective date, and its inapplicability to commercial building installations. Despite these, the ban became effective on Aug. 10, 1982. (The ban was lifted on Aug. 24, 1983). Under provisions of the ban, any installer of formaldehyde-emitting UFFI was subject to a civil fine ranging from $2,000 to $500,000 per installation. Any installer knowingly and willfully continuing to install UFFI after being notified by the CPSC that he was in noncompliance with the law was to be subject to criminal penalties of up to one year in jail and/or fines up to $50,000.

CPSC found that approximately 500,000 non-mobile homes in the United States are presently insulated with UFFI, or 0.59% of the total number of non-mobile homes in the United States today. Approximately 1,750,000 people presently reside in UFF-insulated homes. This is 0.80% of the U.S. population. On average then, 3.5 persons live in each UFF-insulated non-mobile home.

As of 1980, the CPSC received from residents of UFF-insulated homes one complaint of physical effects for every 200 installations -- the physical health-effects complaint rate was 0.5%. Today, with 500,000 installations, assuming the health-effects complaint rate is unchanged, there could be 2,500 UFFI-installation complaints. And with 3.5 persons per installation, this means there could be 8,750 persons nationwide potentially being exposed to UFFI in their homes to the point of complaining to the CPSC. And the CPSC has not been alone in handling UFFI-related complaints. A university-based environmental health department in the Pacific Northwest monitored 244 homes and found 409 residents (158 adult males, 122 adult females, and 139 children) exhibiting at least one symptom of formaldehyde exposure. The same department handled 2080 telephone complaints in the past year. These data suggest that CPSC may have underestimated the number of people exposed to formaldehyde at a level sufficient to evoke a complaint.

According to CPSC, the average cost of a UFFI installation was $1,500. The average cost of removing the UFFI is from $6,000 to $20,000. This may include replacement of the UFFI with another type of insulation depending on the preferences of the consumer as to who performs the service. Nationally, the cost of UFFI removal could cost as much as $3-10 billion.

The effect of UFFI in residential walls on non-mobile home resale value is inconsistent: the resale value may be increased (due to improved thermal insulative properties), may be reduced (due to negative value of UFFI publicity and potential health effects), or may be unchanged. The Commission has estimated the possible property value reductions at $6,000 to $20,000 per house, i.e., the cost of removal of the UFFI. There does not now appear to be solid evidence from which to assess the consistent direction or magnitude of effect upon house prices due to UFFI. There are currently no national laws requiring sellers to disclose whether their houses have UFFI. But the National Association of Realtors has issued a directive to all realtor boards nationwide suggesting that: (a) the seller complete a form stating the "Yes," "No," or "Maybe" presence of UFFI, and; (b) the purchaser complete a second form acknowledging receipt of this information prior to tendering an offer to buy. Of crucial legal concern are the adherence to the real estate agents' Code of Ethics, and the implied warranty of habitability (wherein an agent must disclose information of any known health hazard).

The CPSC stated that complaints of health effects from UFFI exposure occur with installations of any age, from recent to several years prior; 1977 was a notable year for the dramatic increase in the number of UFFI installations.

CPSC estimates the following number of residential UFFI installations:

YEAR	CPSC-ESTIMATED NUMBER OF RESIDENTIAL INSTALLATIONS
1975	20,000 - 30,000
1976	41,000 - 75,000
1977	146,000 - 221,000
1978	68,000 - 125,000
1979	60,000 - 150,000
1980	25,000 - 30,000
1981	8,000 - 10,000

While the number of installations has been steadily declining, the number of health-effects complaints has been proportionately increasing.

The CPSC also stated its position that formaldehyde concentrations found in homes are sufficient, in its opinion, to cause harmful health effects. The Commission's upper value of risk was estimated to be 89 malignant cancers developing among the estimated population of 1,750,000 persons currently exposed in 500,000 UFFI homes, using the data from actual measurements in residences. The 89 cancers represent 0.005% of the 1,750,000 persons currently exposed to UFFI in their homes, and 0.00004% of the U.S. population. The CPSC estimates the cost of avoiding one UFFI-caused malignant cancer to be $164,000 to $292,000. The Commission pointed out that these ratios considered only the reduced risk of malignant cancer, and did not include other health benefits, reduced medical and related costs, and benign tumors.

Under certain conditions, certain States will take formaldehyde measurements in homes on request. Using the National Institute for Occupational Safety and Health (NIOSH) procedure are Iowa, Kentucky, Massachusetts, Michigan, Minnesota, New Hampshire, New Jersey, New York, Ohio, and Washington. Using the Drager system are Connecticut and Texas. The two procedures are chemically slightly different but yield similar results with comparable accuracy; some scientists maintain that the Drager system is less reliable.

Formaldehyde can be filtered out of the air, extracted onto a chemically treated wick-bottle or gel, sealed in the walls, or vented. Costs and effectiveness of these methods were not presented in the CPSC regulation (see "The Canadian Situation" hereafter).

On Jan. 12, 1983, the CPSC announced that it is collecting information on formaldehyde released from pressed-wood products. One possible result of this investigation could be a product standard requiring that pressed-wood products emit no more than a specified amount of formaldehyde. Such a standard may be met through carefully controlled and monitored manufacturing and curing techniques. (The CPSC concluded that such a standard could not be met by UFFI owing to the excessive number and magnitude of uncontrollable variables involved in the installation and curing of UFFI.) A ban on pressed-wood products is another possible, but less likely, outcome of the CPSC investigation. The CPSC investigation was prompted by consumer complaints involving 3700 people. In August 1982, the Consumers Federation of America requested the CPSC to limit formaldehyde emissions from pressed-wood products to 0.05 ppm. The CPSC plans to make an announcement about the findings of its investigation in the third quarter of FY83.

On Apr. 8, 1983, a three-judge panel of the 5th Circuit Court in New Orleans ruled that the CPSC ban of UFFI is illegal; the decision was based upon their finding that the Commission did not present sufficient evidence to support the ban action. On May 5, 1983, the CPSC filed for a rehearing.

On Apr. 20, 1983, 23 Members of Congress sent a letter to CPSC Chairman Nancy Steorts stating that "Formaldehyde insulation is a dangerous substance that must be kept out of homes." The letter urged the chairman to "Please do all you can to prevent this ban from being lifted."

The Insulation Contractors Association of America's Executive Director, R. Hartly Edes, commented on the Fifth Circuit court's decision by saying "I don't see that there's going to be any new effect on the industry by its (the CPSC ban on future UFFI installations) being overturned." Edes added that members of the association "questioned (UFFI's) efficacy as insulating material because of its shrinkage (after installation). When you leave up to a 4% void in insulation, you can have heat loss of up to 50%."

Ed Stana of the Formaldehyde Institute commented that the UFFI industry "is down to just about zero," but that "it's too early to tell" if the New Orleans ruling would likely revive the business.

On May 9, CPSC released a draft discussion paper ranking 17 known carcinogens. Formaldehyde was the seventh most potent carcinogen. The paper discussed the major disadvantages and limitations of potency comparisons, including nonconsideration of human exposure information, and reduction of risk assessment ranges to single values. The paper is receiving peer review.

By mid-June 1983, the CPSC petition for a re-hearing had been denied. In a letter dated Aug. 24, 1983, the Solicitor General notified the CPSC that he would not issue a writ of certiorari to send the case to the Supreme Court. Also, the ban was lifted on that date.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

The U.S. Department of Housing and Urban Development (HUD) has prohibited the installation of rigid formaldehyde insulation in mobile homes since 1976 (based upon common knowledge of the fire hazard of the insulation), and it is currently considering whether a rule is needed to regulate formaldehyde in particleboard, draperies, carpeting, and other products in mobile homes (Aug. 28, 1981 Federal Register).

On Mar. 22, 1983, HUD disapproved further use of UFFI in its mortgage insurance and low-income Public Housing program pursuant to the CPSC ban.

OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION

In 29 CFR 1910.1000 Table Z-2, the Federal Occupational Safety and Health Administration (OSHA) states that employees may be exposed to formaldehyde at a level of 3 ppm as an 8-hour time-weighted average (this is the Permissible

Exposure Limit, or PEL), with an acceptable ceiling concentration of 5 ppm, and that the acceptable maximum peak above the acceptable ceiling concentration for an 8-hour shift is 10 ppm for less than 30 minutes; this applies only to States administered by Federal OSHA. State-administered programs have a PEL of 2 ppm.

Some labor unions have petitioned OSHA to reduce its allowable exposure concentration, and the National Institute of Occupational Safety and Health (the research arm of OSHA) has proposed the PEL be reduced to 1 ppm, but OSHA has responded that it does not recognize sufficient evidence to warrant a tightening of the standard. Currently, an employee can file a health complaint and an OSHA inspector can respond by equipping the employee with a personal dosimeter to measure the worker's exposure to formaldehyde. OSHA has received reports of rare nasal cancers in workers exposed to formaldehyde; these reports are being investigated.

ENVIRONMENTAL PROTECTION AGENCY

On Feb. 12, 1982, John A. Todhunter -- then the U.S. Environmental Protection Agency's (EPA) assistant administrator for pesticides and toxic substances -- announced the agency's official position on formaldehyde, saying that the chemical should not be regulated under section 4(f) of the Toxic Substances Control Act because it does not cause "significant risks of serious or widespread harm of cancer," and that the EPA"s tentative decisions in 1980 to regulate formaldehyde were "incomplete and flawed." Despite the agency's conclusion not to regulate formaldehyde under section 4(f) of TSCA, the EPA continued in its 5-step workplan for evaluating formaldehyde. The workplan schedule began Jan. 4, 1982, and was planned to take 8 months to complete. The first step was almost complete as of Feb. 12, 1982. The entire study was to include evaluations of the applicability of animal data to potential human carcinogenicity, human exposure levels and resultant risks, coordinated interagency and outside group data-gathering, and outside peer review of hazard, exposure, and risk data. On Apr. 30, 1982, EPA Pesticides and Toxics Assessment Division Director Joseph Merenda said that a major revision of the schedule was to be announced when ready; a date was not given at that time.

On May 18-19, 1982, the House Subcommittee on Commerce, Consumer and Monetary Affairs of the House Government Operations Committee held hearings on the effects of exposure to formaldehyde, with emphasis on formaldehyde emissions from UFFI. On May 20, 1982, the House Subcommittee on Investigations and Oversight of the House Committee on Science and Technology held a hearing on the specific topic of EPA's position to not regulate formaldehyde under section 4(f) of TSCA, and on the more general topic of EPA's current position on the level of risk and scientific certainty necessary to trigger regulatory action. In connection with these hearings, the EPA announced its negotiation with the National Center for Toxicological Research (NCTR) for further formaldehyde research using project-specific funds from EPA; the EPA signed the agreement in July 1982. EPA said NCTR will:

Establish expert review panels in the areas of formaldehyde, toxicology, epidemiology, exposure, and risk.

Establish a clearinghouse to identify ongoing studies and to coordinate the exchange of scientific data on formaldehyde exposure and health effects studies.

Develop coordinated data bases of reviewed and validated scientific knowledge in the areas of each of the panels listed above, to be supplemented by new data as they are developed through various ongoing studies.

Hold an international consensus building workshop in which the panels and other scientists will discuss the available data, reach conclusions as to their interpretation, and identify any remaining gaps requiring further research.

Complete and submit for publication a peer-reviewed report of the workshop's conclusions concerning formaldehyde health risks.

EPA said the NCTR program will be "supplemented by a limited number of additional Office of Toxic Substances projects aimed at supporting the efforts of the expert review panels or at filling certain data gaps; the specific nature of those activities will be defined as the panels are established and begin reviewing the available data bases." EPA at that time did not say if discussions to be held in connection with the NCTR project would be open to the public or other scientists. Coordinating the EPA-NCTR project is an Executive Panel composed of 2 representatives each from industry, academe, government, and public interest groups. The first meeting of the Panel was held on Oct. 29-30, 1982; discussion topics included the desirability and workability of opening meetings to the public. The Panel concluded that public input is needed and will be sought via announcements in the Federal Register (the first of which appeared Dec. 7, 1982), and in relevant journals (one advertisement appeared in the Dec. 17, 1982, issue of Science magazine). The Panel also planned to hold consensus workshops, focusing entirely upon the scientific (and not the policy) issues relating to formaldehyde from approximately June through October 1983.

On Jan. 7, 1983, the Natural Resources Defense Council (NRDC) sent a letter to the EPA Administrator (then Anne Gorsuch Burford) notifying the Agency that the NRDC intends to sue the government for failing to list formaldehyde under section 4(f) of TSCA; the suit will be filed after the required 60-day period following receipt of the notification letter.

On July 12, 1983 President Reagan signed the HUD and Independent Agencies Appropriations Act of 1984 which included $2 million for a multi-agency task force on indoor air quality; the task force is co-chaired by the EPA, CPSC, and the Department of Energy.

THE CANADIAN SITUATION

The use of UFFI in residences was banned in Canada in December 1980, as the result of tremendous public pressure in response to media coverage of the potential health effects of UFFI. The Canadian Mortgage and Housing Corporation (CMHC) instituted a response program which has undergone modification over time.

The first step of the program was an information campaign, to notify the citizenry of the UFFI response program.

Originally, homeowners had to demonstrate that they had experienced medical problems due to UFFI and/or had homes with indoor formaldehyde levels exceeding 0.1 ppm in order to be eligible under the UFFI response program. The homeowners had to perform preliminary testing to determine if full-scale testing was required. Full-scale testing cost $100, reimbursed through the program. Now, preliminary testing is optional and full-scale testing, if required, is free.

Further, homeowners originally had to implement corrective measures recommended by CMHC to be eligible for financial assistance. Now, the kind of corrective measures undertaken is the choice of the homeowner, with CMHC providing technical information and estimates for all possible corrective measures, and a current list of registered contractors who have successfully followed the government training course on corrective measures.

Homeowners originally had to pay $100 to attend a training course on corrective measures, with no choice of location of study. Now, the course is free, is available in more areas more often (including evening and weekend courses), and even includes a home study program. This is the same training course required of registered contractors. Upon successful completion of the course, a homeowner may perform his own corrective measures and be eligible for assistance through the UFFI program. Topics covered in the course include the relative advantages and disadvantages of different remedial measures in different circumstances; the remedial measures are: caulking compounds and vapor barriers; ventilation; chemical absorption filters; ammonia gas; removal; and treatment of contaminated material remaining after removal and prior to rebuilding.

Advance payments up to $2,500 are presently available if needed to undertake corrective work. Up to $5,000 per dwelling will be given, tax-free, to registered homeowners for expenses incurred in the course of corrective measures, including removal. There is a maximum of 3 dwellings per homeowner. Eligible houses must be located in Canada, and may be detached, link, semi-detached or part of a row, duplex or triplex, or prefabricated, or a condominium, or a mobile home on a permanent foundation.

Homeowners must apply for assistance by Sept. 30, 1983, although corrective work can begin later.

The CMHC will test for formaldehyde levels after corrective measures are completed, and a Statement of Test Results will be issued to the homeowner.

As of June 1, 1983, more than 43,000 homeowners were registered with the Program.

In the autumn of 1981 the CMHC tested 2,400 homes for formaldehyde levels; 2,000 of those homes had UFFI, and 400 lacked UFFI. Of the 400 without UFFI, 11 (around 3%) had formaldehyde levels exceeding 0.1 ppm, the highest level deemed acceptable for homes by Health & Welfare Canada. Of the 2,000 with UFFI, 198 (9.9%) had levels exceeding the 0.1 ppm standard. From these data, the CMHC estimated that about 8,000 houses (10% of the housing stock) in

Canada will require some remedial work.

Canada is presently spending about $1 million for medical research into UFFI health effects, and for further research on UFFI, its reaction with other materials, the characteristics of gases and particles associated with UFFI, corrective measures to reduce or eliminate effects of UFFI in living spaces, and testing methods for formaldehyde and other potential emissions.

There is also the Canadian Home Insulation Program (CHIP) intended to assist homeowners to improve the insulation of their homes. A special retroactive CHIP grant has been made available to homeowners whose eligible costs under the UFFI program exceed $5,000. The program may reimburse 60% of eligible costs of re-insulation, up to a maximum of: $500 for a detached, semi-detached, row, or mobile home; $285 for a unit in an apartment building of three stories or less, and of six units or less (includes duplexies); $215 for a unit in an apartment building of three stories or less, having more than six units (these are not eligible for assistance under the UFFI program).

THE INTERNATIONAL SITUATION

Australia

Approximately 45,000 structures in Australia have been insulated with UFFI since 1971. Some adverse health effects have been reported where the foam was not properly installed; these health effects were considered minimal. The concentration of formaldehyde deemed acceptable in private housing is 0.1 ppm.

Austria

UFFI was first marketed in Austria about fifteen years ago but is seldom used today in either the industrial or the private sector. Where it is used, owing to slow construction, possible health problems from formaldehyde emissions are minimized because most residential buildings are not occupied until a year after the insulation has been installed.

Belgium

Common use of UFFI began in 1975 in the industrial and private sectors. UFFI is used only to insulate conventional buildings with hollow walls, although tests are in progress examining prefabricated structures. There have been reports in Belgium of medical problems attributed to UFFI. The Belgian government has not yet decided whether to ban UFFI or to impose standards and controls.

Denmark

UFFI has been used in Denmark since the early 1950s. It has been used in very reduced quantities since 1981. From 1976 to 1981, between 1,300 and 1,800 residences and commercial buildings were insulated each year with UFFI. About 100 buildings a year are currently insulated with UF foam. Medical problems have been reported. Some homeowners have removed the UFFI from their homes. The Danish government is currently preparing rules and regulations regarding UFFI, specifying that the concentration of formaldehyde in room air must not exceed 0.12 ppm.

Finland

Although available for the last ten years, UFFI has seen only limited use in Finland. Only old houses built of wood and a few schools have been insulated with UFFI. Very few medical problems have been reported.

France

Though in common use in France since the 1970s, UFFI appears to have caused few complaints. The installation of UFFI in houses is regulated by the "Centre scientifique et technique des batiments"; performance of the insulation has been reported as satisfactory when the guidelines are followed.

Germany

UFFI was first used in industry in the 1950s and later in the private sector. There is a government standard for emission levels and the standard is well enforced, although it is reported that the installers have a great deal of difficulty in meeting the emission standard. The public appears to have been informed of the problems with UFFI emissions. The German government is drafting UFFI product and installation standards (Canada did the same in 1978).

The Netherlands

The Netherlands has an acceptable formaldehyde concentration standard of 0.1 ppm. The government will test any house claimed to exceed the standard. If the air inside the house exceeds the standard, the UFFI installers are required to remove the insulation at their own expense. UFFI has been widely installed in the Netherlands. There has been very little basic research on UFFI conducted by government researchers; they are enthusiastic about forming a cooperative research program with Canada. In the Netherlands, formaldehyde emissions from particleboard receive much more attention than those from UFFI.

Norway

UFFI was first marketed in Norway in the 1960s yet has hardly been used since 1975 because of its ineffectiveness as a thermal insulator.

Sweden

UFFI was first used on a limited basis in the 1950s in Sweden but was banned in some regions in 1974 because of its strong odor and the damage that it can cause to construction materials. The use of UFFI is presently subject to very strict standards. The recommended formaldehyde level in UFF-insulated housing ranges from 0.1 to 0.7 ppm depending upon the type of building.

United Kingdom

While UFFI was introduced twenty years ago to the United Kingdom, wider use of the product has occurred only in the last ten years. More than a million homes are currently UFF-insulated. A few complaints have been reported in recent years concerning formaldehyde emissions from UFFI. It is recommended that UFFI be installed only in masonry buildings in accordance with established standards.

Italy, Japan, Spain, Switzerland

UFFI has been in limited use in these countries for about fifteen years. These countries appear to have no restrictions on the installation of UFFI, and few significant problems resulting from it. It should be noted that the UFFI used in Spain and Switzerland are improved products, though still capable of emitting formaldehyde.

POINTS FOR FURTHER CONSIDERATION

Public policymakers' concerns currently focus on 1) the question of need for and the mechanics in establishing Federal programs to compensate those persons suffering adverse health effects from exposure to UFFI in their homes; 2) the question of need for and the mechanics in establishing Federal programs to compensate those homeowners whose property values may be adversely affected by having UFFI; and 3) legislative oversight of those Federal agencies whose responsibilities include the assessing of risk, setting of standards, and enforcement of regulations relating to UFFI. It is presently a matter of controversy as to whether the actions taken by the various Federal agencies are premature, inadequate, unnecessarily restrictive or intrusive, or scientifically defensible.

H.R. 3819 in the 98th Congress seeks to assist homeowners in taking corrective measures to reduce the indoor concentration of formaldehyde in dwellings with UFFI exceeding 0.1 ppm by authorizing the Secretary of Housing and Urban Development to grant up to $10,000 per dwelling to homeowners, for no more than three dwellings, for corrective measures taken. The bill has been referred to the House Committee on Banking, Finance and Urban Affairs.

H.R. 2533 in the 98th Congress seeks to amend the Internal Revenue Code to allow a refundable income tax credit to individuals for expenditures to remove UFFI from their homes. The bill also provides for testing formaldehyde levels in homes, and surveying the extent of UFFI in public schools. The bill has been referred to the House Committee on Banking, Finance and Urban Affairs, and to the House Committee on Ways and Means.

The House Small Business Committee in the 97th Congress held hearings on the topic of UFFI on Aug. 4, 1982. H.R. 6389, 6390, 6391, 6437 and 6524 and S. 2763 were bills in the 97th Congress aimed at providing financial assistance to homeowners for removal of the UFFI.

UFFI and market value

The Canadian Appraiser / Spring 1985

By B.J. (Ben) Lansink

Urea formaldehyde foam insulation (UFFI) has become the centre of controversy in the Canadian real estate industry during the last years. Many buildings have been insulated with this product and its effect on the inhabitants and market value of these properties is just now being seen

Urea formaldehyde foam insulation is a low-density foam prepared at the installation site from a mixture of urea formaldehyde resin and a propellant, usually compressed air. The mixture is pumped into the cavities of a wall, where it hardens. Deterioration of the foam with time results in the release of formaldehyde gas. In addition, a high moisture content may cause fungus to grow. Spores of the fungus may also find their way into the living area of a home. Formaldehyde gas and fungus spores can result in irritation to the eyes, nose and throat.

In 1980, a lab test indicated a relationship between cancer and UFFI. A temporary ban was put in place by Health and Welfare Canada in 1980. The ban was confirmed permanently in April 1981.

UFFI's presence in Canada goes back to 1969, but is a new phenomenon for the real estate industry. Approximately 80,000 to 100,000 Canadian homes were insulated with this controversial product. The installation of UFFI was subsidized through the Federal Government's C.H.I.P. program.

Insulation is a hidden item. Usually it is located in the frame cavities of the exterior walls between the exterior and interior finish, and in the attic area; it is not readily visible to an individual. In the majority of cases the type of insulation in the wall cavity and attic differs. Therefore, confirmation of the attic insulation does not necessarily mean wall-cavity insulation is the same. Exterior walls in the same house may have different types of insulation, and one wall could be insulated with two or more insulation types.

If a home has been insulated with UFFI and the insulation has been removed, the property may still have unacceptably high levels of UREA formaldehyde gas.

Since 1980 many articles have been published about UFFI – most of them negative in their findings. I consulted *The Canadian Newspaper Index* (CNI) at the University of Western Ontario in October of 1984. CNI indexes seven daily Canadian newspapers including the *Calgary Herald, Globe & Mail, Halifax Chronical Herald, Montreal Gazette, Toronto Star (Sunday Star), Vancouver Sun*, and the *Winnipeg Free Press*. The Index does not cover every article published, but seems to provide an excellent cross-section of subjects. The subject index concerning UFFI fell under "Insulation." I noted the following number of articles in the various seven newspapers:

YEAR	# OF ARTICLES
1978 -	none
1979 -	none
1980 -	2
1981 -	136
1982 -	121
1983 -	95
1984 -	not available

Ninety-six to ninety-eight % of the articles concerned UFFI. There were, of course, numerous articles in magazines such as *McLeans* and special purpose papers such as the *Financial Post*. It is noteworthy that the amount of press concerning UFFI appears to be declining.

In one article written for *McLeans Weekly Magazine*, a physician who is professor of medicine at a Canadian university stated that a careful search for affected patients was conducted. He and other Toronto-area physicians did not find a single documented case of UFFI-related illness. He and his family live in a UFFI home.

Other articles state that UFFI type gases could come from a recently-purchased laminated coffee table, or from plywood found in a home's sub-floor. Some examples of press headlines follow:

"Foam Leaves Legacy of Nose-Bleeds and Nausea"
"Ottawa Faces class Action Over Insulation"
"Liberals Sued Over Urea Foam"
"Urea Formaldehyde 'Foam-Linked' Deaths Claimed by 2 Families"
"Study Confirms Urea Foam Hazard"
"UFFI Scare Overblown – Hudac"
"Urea Good For You, Former Seller Insists"
"Pair Burns House to Get Rid of Foam"
"Cancer From Banned Foam Unlikely – Scientist"

On October 5, 1984, the Toronto Star headline read "Feds Approved Insulation Knowing Of Health Risk." A study obtained by the Star says that thousands of Canadians suffered health problems and structural damage to their homes because of the actions of two federal civil servants. The article further states that the two officials could be liable to criminal prosecution because of their acts and omissions.

An article by the Ontario Real Estate Association in *Education Update* (August 15, 1984) indicates that a Woodbridge area man pleaded guilty in county court to fraud. He was convicted for lying about UFFI to the buyer of his Etobicoke home.

Other evidence about the effect on market value if submitted by a 1982 Notice of Assessment mailed to all property owners in Elgin and Middlesex Counties by M.C. Quinn, Regional Assessment Commissioner, in 1983. I quote in part:

"If your residential property is insulated with Urea Formaldehyde Foam Insulation (UFFI) you may qualify for a reduction to you property assessment. A 35% reduction will be applied to the residential building portion of the property assessment. This percentage reduction has been determined based on an analysis of those properties in Ontario which sold over the past year, where purchasers were aware of the presence of UFFI."

An article in *Ontario Lawyers Weekly* (page 2, March 23, 1984), by Paul Truster, indicates that the analysis concluding the 35% was a "fake" as charged by Toronto lawyer, C. Ruby.

Does UFFI cause health problems? Will it cause structural problems by deteriorating a building's wood framing? As an appraiser, I am not qualified to say. As a real estate appraiser, I can attempt to measure the market value of a UFFI-insulated house to versus an exact duplicate without UFFI insulation. In other words, will a home offered on the open market fetch less when insulated with UFFI than an exact duplicate not insulated or insulated with a product other than UFFI?

The evidence since the ban of UFFI by the Federal Government in 1980 suggests "yes," a UFFI-insulated home will be subject to buyer resistance and will probably sell for less.

I am aware of the following nine properties that have sold and are reported to be UFFI insulated:

No.	*Location*	*Sold*	*App/Price*	*Resold*	*Resale Price*	*Loss*
1.	Base Line Road.	1975	$42,700	1982	$25,000	41%
2.	Commissioners Road	1981	$56,900	1982	$42,000	26%
3.	Highbury Avenue	1976	$23,000	1981	$12,000	47%
4.	Base Line Road	1982	$185,000	1983	$94,000	49%
5.	Con. 4, Lobo	1979	$50,000	1983	$31,000	38%
6.	Con. 12, Lobo	1981	$110,000	1984	$60,000	46%
7.	Hope Street	1978	$52,000	1981	$22,000	58%
8.	Oakdale Avenue	1978	$45,500	1982	$36,500	20%
9.	Wilson Avenue	1976	$39,500	1983	$18,000	54%

Sale 1. sold power of sale for $ 25,000. The foam was removed, certain improvement were made, and the home resold in May 1983 for $ 65,100.

Sale 2. Sold power of sale. It is my understanding the purchasers removed the foam.

Sale 3. Sold power of sale. The purchaser has rented the home, having purchased it as an investment.

Sale 4. Involved an appraisal of $ 185,000 in 1982. It sold power of sale in August 1983. It is my understanding that the purchaser removed the foam at a cost of $12,000 to $ 15,000.

Sale 5. Had been owned since 1971. It was appraised for a mortgagee in 1979. A first mortgage was placed for $ 37,500 at 11.5%. It was insulated with UFFI early in 1979. With interest, payment arrears, and other costs, the debt amounted to $ 41.000 when sold for $ 31,000 in September of 1983.

Sale 6. Was the purchase of a contemporary-design home. It was purchased in 1982 by a local brewery to assist a corporate transferee for $ 59, 478, the amount of the mortgage. The brewery resold the home in 1984 for $ 60,000 after disclosing that it was insulated with UFFI.

Sale 7. Is located in the hamlet of Tavistock. It was sold by CMHC power of sale.

Sale 8. Involved the transfer of the owners to the Ottawa area. In my opinion, the market value of the 30-year-old detached single-family brick dwelling was closer to $ 55,000 assuming no UFFI therefore, the loss is closer to 34%.

Sale 9. Sold by CMHC power of sale, after disclosing that it was insulated with UFFI.

I personally inspected each property on the exterior and Sales 1, 3, 4, 5, 6 and 9 on the interior. All except Sales 5, 6 and 7 are located in the City of London. All are detached single family dwellings. None of the examples considers the resale-date market value assuming no UFFI, thus complicating the true loss measurement.

My conclusion concerning the estimated market value of a UFFI residence versus a non-UFFI residence is that the UFFI home is worth substantially less.

Based on many negative press articles causing buyer resistance and the future homeowners' concern over possible health consequences, I suggest that a range of 35% to 50% less than the estimated market value is supportable.

Bear in mind that the 35% to 50% reduction would be based on the total property value of land and building(s). If we assume a market value estimate of $ 100,000 assuming no UFFI, the indicated value of a UFFI-insulated house would be as follows:

$100,000 - 35% = $ 65,000
$100,000 - 50% = $ 50,000
Final estimated mid-range estimated: $ 57,500

While the indicated range may be significant, it is not unrealistic in view of the many complexities involved in a UFFI home.

Will a home which has had UFFI removed and has been re-insulated with an acceptable insulation product sell for less than a similar home never having been insulated with UFFI?

With some evidence, I suggest there is in fact some buyer resistance, and in a market with an abundant housing supply, buyer resistance must result in a lower value. In other words, when shopping for a home a typical buyer will probably not attempt to purchase a home formerly UFFI-insulated versus a non-UFFI home unless the price is substantially less.

I am aware of the following sales:

Property	Sold	Price	Resold	Resale Price
1. Kenneth Avenue	1981	$48,500	1984	$47,500
2. Bow Street	1981	$55,900	1983	$52,750
3. Victoria Street	1982	$66,500	1983	$60,000

All three sales involve detached single family dwellings located in the City of London.

Sale 1 was purchased in 1981, with the purchaser unaware of the insulation type. The UFFI was removed at a cost of $10,500 late in 1983, and the property sold early in 1984 for $47,500. The loss is approximately $11,500 excluding possible removal grant. This property was listed MLS in 1984 after disclosing its former UFFI. The supportable loss is 24% once UFFI was removed. When purchased in 1981, this home had original brick. When sold in 1984 it had replaced brick, one rebuilt fireplace, and a new second fireplace. In may opinion, it had a market value of $55,000 in 1984. Therefore, it sold at 10% to 15% less than market value.

Sale 2 sold for 5.6% less than its 1981 price. Assuming it increased by 5% between April 1981 and September 1983 when sold, the selling price would be approximately 10% less than market value, because of the former UFFI insulation.

Sale 3 had UFFI removed between 1982 and 1983 and sold for 11% less than its unadjusted 1982 price.

It must be remembered that some government grant assistance may have occurred. The grants did not exceed $5,500. Most UFFI removals cost in excess of $10,000.

I am professionally involved in four lawsuits concerning UFFI. Being situated in Canada's eleventh's largest city, they probably represent a fraction of the litigation involving UFFI. I understand there is a group court action before the Federal Court of Canada, claiming $20 million in damages from the Federal Government.

To conclude: the final chapter has yet to be written on the UFFI story. It will be necessary for appraisers to monitor UFFI and market value on an ongoing basis.

***B.J. Lansink**, AACI, SRA has been a fee appraiser with Knowles, Lansink & Associates Limited since the company was formed in 1974. Prior to that, he had been the Mortgage Manager for Royal Trust. As well as being active in real estate appraisal, Mr. Lansink is a certified instructor in the Principles of Mortgage Financing for Ontario colleges.*

Five-Hundred Life-Saving Interventions and Their Cost-Effectiveness

Tammy O. Tengs,[1] Miriam E. Adams,[2] Joseph S. Pliskin,[3,6] Dana Gelb Safran,[4] Joanna E. Siegel,[5,7] Milton C. Weinstein,[6,7] and John D. Graham[6,7]

Received July 26, 1994

We gathered information on the cost-effectiveness of life-saving interventions in the United States from publicly available economic analyses. "Life-saving interventions" were defined as any behavioral and/or technological strategy that reduces the probability of premature death among a specified target population. We defined cost-effectiveness as the net resource costs of an intervention per year of life saved. To improve the comparability of cost-effectiveness ratios arrived at with diverse methods, we established fixed definitional goals and revised published estimates, when necessary and feasible, to meet these goals. The 587 interventions identified ranged from those that save more resources than they cost, to those costing more than 10 billion dollars per year of life saved. Overall, the median intervention costs $42,000 per life-year saved. The median medical intervention costs $19,000/life-year; injury reduction $48,000/life-year; and toxin control $2,800,000/life-year. Cost/life-year ratios and bibliographic references for more than 500 life-saving interventions are provided.

KEY WORDS: Cost-effectiveness; economic evaluation; life-saving; resource allocation.

1. INTRODUCTION

Risk analysts have long been interested in strategies that can reduce mortality risks at reasonable cost to the public. Based on anecdotal and selective comparisons, analysts have noted that the cost-effectiveness of risk-reduction opportunities varies enormously, often over several orders of magnitude.[1–5] This kind of variation is unnerving because economic efficiency in promoting survival requires that the marginal benefit per dollar spent be equal across investments.

Despite continuing interest in cost-effectiveness, we could find no comprehensive and accessible data set on the estimated costs and effectiveness of risk management options. Such a dataset could provide useful comparative information for risk analysts as well as practical information for decision makers who must allocate scarce resources. To this end, we report cost-effectiveness ratios for more than 500 life-saving interventions across all sectors of American society.

2. METHODS

2.1. Literature Review

We performed a comprehensive search for publicly available economic analyses of life-saving interventions.

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[2] Simmons College, School of Social Work, Boston, Massachusetts.
[3] Industrial Engineering and Management, Ben-Gurion University of the Negev, Israel.
[4] The Health Institute, New England Medical Center, Boston, Massachusetts.
[5] Maternal and Child Health, Harvard School of Public Health, Boston, Massachusetts.
[6] Health Policy and Management, Harvard School of Public Health, Boston, Massachusetts.
[7] Center for Risk Analysis, Harvard School of Public Health, Boston, Massachusetts.

0272-4332/95/0600-0369$07.50/1

"Life-saving interventions" were defined as any behavioral and/or technological strategy that reduces the probability of premature death among a specified target population. To identify analyses we used several on-line databases, examined the bibliographies of textbooks and review articles, and obtained full manuscripts of conference abstracts. Analyses retained for review met the following three criteria: (1) written in the English language, (2) contained information on interventions relevant to the United States, and (3) reported cost per year of life saved, or contained sufficient information to calculate this ratio. Most analyses were scientific journal articles or government regulatory impact analyses, but some were internal government memos, reports issued by research organizations, or unpublished manuscripts.

Two trained reviewers (from a total of 11 reviewers) read each document. Each reviewer recorded 52 items, including detailed descriptions of the nature of the life-saving intervention, the baseline intervention to which it was compared, the target population at risk, and cost per year of life saved. The two reviewers worked independently, then met and came to consensus on the content of the document.

Approximately 1200 documents were identified for retrieval. Of these 1200 documents, 229 met our selection criteria. The 229 documents contained sufficient information for reviewers to calculate cost/life-year saved for 587 interventions.

2.2. Definitional Goals

To increase the comparability of cost-effectiveness estimates drawn from different economic analyses, we established seven definitional goals. When an estimate failed to comply with a goal, reviewers attempted to revise the estimate to improve compliance.[8] In general, reviewers used only the information provided in the document to revise estimates. The seven definitional goals were:

1. Cost-effectiveness estimates should be in the form of "cost per year of life saved." Cost/life saved estimates should be transformed to cost/life-year by considering the average number of years of life saved when a premature death is averted.
2. Costs and effectiveness should be evaluated from the societal perspective.
3. Costs should be "direct." Indirect costs, such as foregone earnings, should be excluded.
4. Costs and effectiveness should be "net." Any resource savings or mortality risks induced by the intervention should be subtracted out.[9]
5. Future costs and life-years saved should all be discounted to their present value at a rate of 5%.
6. Cost-effectiveness ratios should be marginal or "incremental." Both costs and effectiveness should be evaluated with respect to a well-defined baseline alternative.
7. Costs should be expressed in 1993 dollars using the general consumer price index.

2.3. Categorization

Interventions were classified according to a four-way typology. (1) Intervention Type (Fatal Injury Reduction, Medicine, or Toxin Control), (2) Sector of Society (Environmental, Health Care, Occupational, Residential, or Transportation), (3) Regulatory Agency (CPSC, EPA, FAA, NHTSA, OSHA, or None), and (4) Prevention Stage (Primary, Secondary, or Tertiary).

Interventions we classified as primary prevention are designed to completely avert the occurrence of disease or injury; those classified as secondary prevention are intended to slow, halt, or reverse the progression of disease or injury through early detection and intervention; and interventions classified as tertiary prevention include all medical or surgical treatments designed to limit disability after harm has occurred, and to promote the highest attainable level of functioning among individuals with irreversible or chronic disease.[6]

3. RESULTS

Cost-effectiveness estimates for more than 500 life-saving interventions appear in Appendix A. This table is separated into three sections according to the type of intervention: Fatal Injury Reduction, Toxin Control, and Medicine. The first column of Appendix A contains the reference number assigned to the document from which the cost-effectiveness estimate was drawn (references are in Appendix B.) The second column contains a very brief description of the life-saving intervention. The

[8] Appendices describing the cost-effectiveness formulas used to operationalize these definitional goals, along with some examples of the calculations made by reviewers of the economic analyses, are available from Dr. Tengs.

[9] If savings exceed costs, the result could be negative, so that the cost-effectiveness ratio might be ≤\$0.

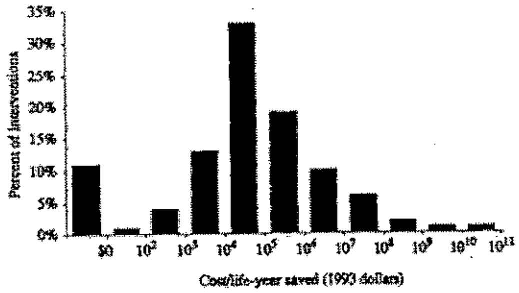

Fig. 1. Distribution of cost/life-year saved estimates (n = 587).

baseline intervention to which the life-saving intervention was compared appears parenthetically as "(vs. __)" when the author described it. The last column of Appendix A contains the cost per year of life saved in 1993 dollars.

As shown in Fig. 1, these interventions range from those that save more resources than they consume, to those costing more than 10 billion dollars per year of life saved. Furthermore, variation over 11 orders of magnitude exists in almost every category.

In addition to the large variation within categories, variation in cost-effectiveness also exists between categories. As summarized in Table I, while the median intervention described in the literature costs $42,000 per life-year saved (n = 587), the median medical intervention costs $19,000/life-year ($n$ = 310); the median injury reduction intervention costs $48,000/life-year ($n$ = 133); and the median toxin control intervention costs $2,800,000/life-year ($n$ = 144).

Cost-effectiveness also varies as a function of the sector of society in which the intervention is found. For example, as shown in Table I, the median intervention in the transportation sector costs $56,000/life-year saved ($n$ = 87), while the median intervention in the occupational sector costs $350,000/life-year ($n$ = 36). Further dividing occupational interventions into those that avert fatal injuries and those that involve the control of toxins, reveals medians of $68,000/life-year ($n$ = 16) and $1,400,000/life-year ($n$ = 20), respectively.

As noted in Table II, the median cost-effectiveness estimate among those interventions classified as primary prevention is $79,000/life-year saved ($n$ = 373), exceeding secondary prevention at $23,000/life-year ($n$ = 111) and tertiary prevention at $22,000/life-year ($n$ = 103). However, if medicine is considered in isolation, we find that primary prevention is more cost-effective that secondary or tertiary prevention at $5,000/life-year ($n$ = 96).

Table I. Median of Cost/Life-Year Saved Estimates as a Function of Sector of Society and Type of Intervention

	Type of intervention			
Sector of society	Medicine	Fatal injury reduction	Toxin control	All
Health care	$19,000 ($n$=310)	N/A[a]	N/A	$19,000 ($n$=310)
Residential	N/A	$36,000 ($n$=30)	N/A	$36,000 ($n$=30)
Transportation	N/A	$56,000 ($n$=87)	N/A	$56,000 ($n$=87)
Occupational	N/A	$68,000 ($n$=16)	$1,400,000 ($n$=20)	$350,000 ($n$=36)
Environmental	N/A	N/A	$4,200,000 ($n$=124)	$4,200,000 ($n$=124)
All	$19,000 ($n$=310)	$48,000 ($n$=133)	$2,800,000 ($n$=144)	$42,000 ($n$=587)

[a] Not applicable by definition.

Table II. Median of Cost/Life-Year Saved Estimates as a Function of Prevention Stage and Type of Intervention

	Type of intervetion			
Prevention stage	Medicine	Fatal injury reduction	Toxin control	All
Primary	$5,000 ($n$=96)	$48,000 ($n$=133)	$2,800,000 ($n$=144)	$79,000 ($n$=373)
Secondary	$23,000 ($n$=111)	N/A	N/A	$23,000 ($n$=111)
Tertiary	$22,000 ($n$=103)	N/A	N/A	$22,000 ($n$=103)
All	$19,000 ($n$=310)	$48,000 ($n$=133)	$2,800,000 ($n$=144)	$42,000 ($n$=587)

The median cost-effectiveness of proposed government regulations for which we have data also varies considerably. Medians for each agency are as follows: Federal Aviation Administration, $23,000/life-year ($n$ = 4); Consumer Product Safety Commission, $68,000/life-year ($n$ = 11); National Highway Traffic Safety Administration, $78,000/life-year ($n$ = 31); Occupational Safety and Health Administration, $88,000/life-year ($n$ = 16); and Environmental Protection Agency, $7,600,000/life-year ($n$ = 89).

4. LIMITATIONS

This compilation of existing data represents the most ambitious effort ever undertaken to amass cost-effectiveness information across all sectors of society. In addition, our work to bring diverse estimates into compliance with a set of definitional goals has improved the comparability of cost-effectiveness estimates that were originally derived by different authors using a variety of methods. Nevertheless, several caveats are warranted to aid the reader in interpreting these results.

First, the accuracy of the results presented herein is limited by the accuracy of the data and assumptions upon which the original analyses were based. There remains considerable uncertainty and controversy about the cost consequences and survival benefits of some interventions. This is particularly true for toxin control interventions where authors often extrapolate from animal data. In addition, due to insufficient information in some economic analyses, reviewers were not always successful in bringing estimates into conformity with definitional goals. For example, if the original author did not report the monetary savings due to the reduction in nonfatal injuries requiring treatment, we were unable to "net out" savings, and so the costs used to calculate cost-effectiveness ratios remain gross. While some of these omissions are important, others are largely inconsequential given the relative size of cost and effectiveness estimates.

Second, the life-saving interventions described in this report include those that are fully implemented, those that are only partially implemented, and those that are not implemented at all. These interventions are best thought of as opportunities for investment. While they may offer insight into actual investments in life-saving, the cost-effectiveness of possible and actual investments are not equivalent. Work on the economic efficiency of actual expenditures is in progress.[7]

Third, this dataset may not represent a random sample of all life-saving interventions, so the generalizability of any descriptive statistics may be limited. This is because interventions that have been subjected to economic analysis may not represent a random sample of all life-saving interventions due, for example, to publication bias. That is, those economic analyses that researchers have chosen to perform and journal editors have chosen to publish may be disproportionately expensive or inexpensive. However, the statistics presented herein are certainly applicable to the 587 life-saving interventions in our dataset which by themselves comprise a vast and varied set, worthy of interest even without generalization.

Finally, we recognize that many of these interventions have benefits other than survival, as well as adverse consequences other than costs. For example, interventions that reduce fatal injuries in some people may also reduce nonfatal injuries in others; interventions designed to control toxins in the environment may have short-term effects on survival, but also long-term cumulative effects on the ecosystem; medicine and surgery may increase quantity of life, while simultaneously increasing (or even decreasing) quality of life.

5. CONCLUSIONS

This compilation of available cost-effectiveness data reveals that there is enormous variation in the cost of saving one year of life and these differences exist both within and between categories. Such a result is important because efficiency in promoting survival requires that the marginal benefit per dollar spent be the same across programs. Where there are investment inequalities, more lives could be saved by shifting resources. It is our hope that this information will expand the perspective of risk analysts while aiding future resource allocation decisions.

APPENDIX A. Continued.

Ref no.[a]	Life-saving intervention[b]	Cost/life-year[c]
38	Coal-fired power plants emission control through coal beneficiation etc.	$37,000
745	Coke oven emission standard for iron- or steel-producing plants	$130,000
745	Acrylonitrile emission control via best available technology	$9,000,000
	Formaldehyde control	
716	Ban urea-formaldehyde foam insulation in homes	$11,000
311	Ban urea-formaldehyde foam insulation in homes	$220,000
1164	Formaldehyde exposure standard of 1 (vs. 3) ppm in wood industry	$6,700,000
	Lead control	
1217	Reduced lead content of gasoline from 1.1 to 0.1 grams per leaded gallon	≤ $0
	1,3 Butadiene control	
1138	1,3 Butadiene exposure standard of 10 (vs. 1000) ppm PEL in polymer plants	$340,000
1138	1,3 Butadiene exposure standard of 2 (vs. 1000) ppm PEL in polymer plants	$770,000
	Pesticide control	
713	Ban chlorobenzilate pesticide on noncitrus	≤ $0
403	Ban amitraz pesticide on apples	≤ $0
403	Ban amitraz pesticide on pears	$350,000
713	Ban chlorobenzilate pesticide on citrus	$1,200,000
	Pollution control at paper mills	
844	Chloroform emission standard at 17 low cost pulp mills	≤ $0
844	Chloroform private well emission standard at 7 papergrade sulfite mills	$25,000
844	Chloroform private well emission standard at 7 pulp mills	$620,000
844	Chloroform reduction by replacing hypochlorite with chlorine dioxide at 1 mill	$990,000
844	Dioxin emission standard of 5 lbs/air dried ton at pulp mills	$4,500,000
844	Dioxin emission standard of 3 (vs. 5) lbs/air dried ton at pulp mills	$7,500,000
844	Chloroform emission standard of 0.001 (vs. 0.01) risk level at pulp mills	$7,700,000
844	Chloroform reduction by replace hypochlorite with chlorine dioxide at 70 mills	$8,700,000
844	Chloroform reduction at 70 (vs. 33 worst) pulp and paper mills	$15,000,000
844	Chloroform reduction at 33 worst pulp and paper mills	$57,000,000
844	Chloroform private well emission standard at 48 pulp mills	$99,000,000,000
	Radiation control	
468	Automatic collimators on X-ray equipment to reduce radiation exposure	$23,000
881	Radionuclide emission control at underground uranium mines	$79,000
881	Radionuclide emission control at Department of Energy facilities	$730,000
1216	Radionuclide control via best available technology in uranium mines	$850,000
44	Radiation standard "as low as reasonably achievable" for nuclear power plants	$1,100,000
468	Radiation levels of 0.3 (vs. 1.0) WL at uranium mines	$1,600,000
1215	Radiation standard "as low as reasonably achievable" for nuclear power plants	$2,500,000
881	Radionuclide emission control at surface uranium mines	$3,900,000
881	Radionuclide emission control at elemental phosphorous plants	$9,200,000
881	Radionuclide emission control at operating uranium mill tailings	$11,000,000
1216	Radionuclide control via best available technology in phosphorous mines	$16,000,000
881	Radionuclide emission control at phosphogypsum stacks	$29,000,000
881	Radionuclide emission control during disposal of uranium mill tailings piles	$40,000,000
1216	Rdiation emission standard for nuclear power plants	$100,000,000
468	Radiation emission standard for nuclear power plants	$180,000,000
926	Thin, flexible, protective leaded gloves for radiologists	$190,000,000
881	Radionuclide emission control at coal-fired industrial boilers	$260,000,000
881	Radionuclide emission control at coal-fired utility boilers	$2,400,000,000
881	Radionuclide emission control at NRC-licensed and non-DOE facilities	$2,600,000,000
881	Radionuclide emission control at uranium fuel cycle facilities	$34,000,000,000

STATE OF CONNECTICUT

DEPARTMENT OF PUBLIC HEALTH

TESTIMONY PRESENTED BEFORE THE GENERAL LAW COMMITTEE
Feb 21, 2013

Ellen Blaschinski, Branch Chief, Regulatory Services Branch, (860) 509-817

House Bill 5908 – An Act Requiring Safety and Certification Standards For The Spray Foam Insulation Industry

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The Connecticut Department of Public Health opposes H.B. 5908.

The Connecticut Department of Public Health recognizes that there are potential health and safety hazards associated with spray polyurethane foam insulation (SPF). These hazards have been described by NIOSH, OSHA, CPSC, and EPA[i], and pertain to both installers and their helpers, as well as for household/building occupants that inhabit the building where SPF is installed. Many of these installations are performed without subsequent problems. However, a number of cases of faulty installations have resulted in improperly cured product that off-gas for many months. In these cases, building occupants report noxious odors and symptoms that include mucous membrane irritation, visual disturbances, respiratory problems, headache, and difficulty concentrating. Some of the problems identified during these faulty installations have included use of the wrong type of foam product for a given application, improper mixing of components, installing during environmental climate conditions outside of manufacturer recommendations, and improper installation technique.

Installers and the general public purchasing these services need to be better educated about SPF. Currently, there are national efforts to voluntarily educate and credential/certify professional installers. The largest trade organizations offer training and certification or credentialing for professional contractors and weatherization professionals, as well as information for the general public. The two most prominent organizations are the American Chemistry Council's Center for the Polyurethane Industry (CPI) and the Spray Polyurethane Foam Alliance (SPFA). Additionally, the US EPA has a great deal of guidance and informative publications for contractors and the general public, and is sponsoring research in this arena.

- CPI: http://spraypolyurethane.org/spf-chemical-health-and-safety-training
- SPFA: http://www.sprayfoam.org/
- US EPA: http://www.epa.gov/dfe/pubs/projects/spf/spray_polyurethane_foam.html

Rather than requiring Connecticut to develop standards for the SPF industry, a more practical approach would be to encourage persons installing SPF to obtain training, certification or credentialing from CPI, SPFA, or similar organization.

Phone: (860) 509-7269, Fax: (860) 509-7100
Telephone Device for the Deaf (860) 509-7191
410 Capitol Avenue - MS # 13GRE
P.O. Box 340308 Hartford, CT 06134
An Equal Opportunity Employer

Developing standards for installing SPF for the entire industry is beyond the resources and area of expertise of CT DPH. Our public health role is better suited to identifying and evaluating health risks and providing risk communication to help the public make informed choices about using these materials in CT homes/buildings.

Thank you for your consideration of the Department's views on this bill.

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[i] Governmental agency acronyms:
NIOSH- National Institute for Occupational Safety and Health. http://www.cdc.gov/niosh/
OSHA- Occupational Safety and Health Administration. http://www.osha.gov/
CPSC- Consumer Product Safety Commission. http://www.cpsc.gov/
EPA- Environmental Protection Agency. http://www.epa.gov/

Phone: (860) 509-7269, Fax: (860) 509-7100
Telephone Device for the Deaf (860) 509-7191
410 Capitol Avenue - MS # 13GRE
P.O. Box 340308 Hartford, CT 06134
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General Assembly

Proposed Bill No. 5908

January Session, 2013

LCO No. **994**

Referred to Committee on GENERAL LAW

Introduced by:

REP. JUTILA, 37th Dist.

AN ACT REQUIRING SAFETY AND CERTIFICATION STANDARDS FOR THE SPRAY FOAM INSULATION INDUSTRY.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

That the general statutes be amended to require the Commissioner of Consumer Protection, in consultation with the commissioners of Public Health and Energy and Environmental Protection, to develop safety and certification standards for the spray foam insulation industry.

Statement of Purpose:

To protect the health and safety of spray foam insulation installers and their customers.

General Assembly

Raised Bill No. 5100

February Session, 2014

LCO No. **868**

*00868_______GL_*

Referred to Committee on GENERAL LAW

Introduced by:

(GL)

AN ACT CONCERNING SAFETY AND CERTIFICATION STANDARDS FOR THE SPRAY FOAM INSULATION INDUSTRY.

Be it enacted by the Senate and House of Representatives in General Assembly convened:

Section 1. (NEW) (*Effective from passage*) The Commissioner of Consumer Protection, after consultation with the Commissioners of Public Health and Energy and Environmental Protection, shall adopt regulations, in accordance with the provisions of chapter 54 of the general statutes, to establish safety and certification standards for the spray foam insulation industry. Such regulations shall require all spray foam installers operating in this state to obtain training, credentialing or certification under programs established by the American Chemistry Council's Center for the Polyurethane Industry and the Spray Polyurethane Foam Alliance, in consultation with the United States Environmental Protection Agency, the National Institute for Occupational Safety and Health, and the Occupational Safety and Health Administration.

This act shall take effect as follows and shall amend the following sections:

Statement of Purpose:

To develop safety and certification standards for the spray foam insulation industry.

[Proposed deletions are enclosed in brackets. Proposed additions are indicated by underline, except that when the entire text of a bill or resolution or a section of a bill or resolution is new, it is not underlined.]

Raised H.B. No. 5100
Session Year 2014

Printer-Friendly With Notes | Printer-Friendly No Notes | Add to My Bills

AN ACT CONCERNING SAFETY AND CERTIFICATION STANDARDS FOR THE SPRAY FOAM INSULATION INDUSTRY.

To develop safety and certification standards for the spray foam insulation industry.

Introduced by: General Law Committee

New today	2-4 days old	5 days & older
Text of Bill Raised Bill [pdf]		

Add Notes to HB-5100

Bill History (in reverse chronological order)

Date	Action Taken
2/13/2014	Public Hearing 02/18
2/11/2014	Referred to Joint Committee on General Law

Click for Bills Similar to HB-5100

Click for Public Hearing Testimony

Please direct all inquiries regarding the status of bills to the House and Senate Clerks' Offices.

H.B. No. 5908
Session Year 2013

Printer-Friendly

AN ACT CONCERNING SAFETY AND CERTIFICATION STANDARDS FOR THE SPRAY FOAM INSULATION INDUSTRY.

To protect the health and safety of spray foam insulation installers and their customers.

Introduced by: General Law Committee

New today	2-4 days old	5 days & older

Text of Bill
- Public Act No. 13-100 [pdf]
- ENV Joint Favorable [pdf]
- File No. 169 [pdf]
- GL Joint Favorable [pdf]
- Committee Bill [pdf]
- Proposed Bill [pdf]

Committee Actions
- ENV Joint Fav. Rpt
- ENV Vote Tally Sheet [pdf]
- GL Joint Fav. Rpt
- GL Vote Tally Sheet [pdf]
- GL Vote Tally Sheet [pdf]
- GL Vote Tally Sheet [pdf]

Votes
- Senate Roll Call Vote 412 PASS
- House Roll Call Vote 57

Fiscal Notes
- Fiscal Note for File Copy 169

Bill Analyses
- Bill Analysis for File Copy 169
- Summary for Public Act No. 13-100

Bill History (in reverse chronological order)

Date		Action Taken
6/10/2013		Vetoed by the Governor
6/4/2013		Transmitted by Secretary of the State to Governor
6/4/2013		Transmitted to the Secretary of State
6/3/2013	(LCO)	Public Act 13-100
5/30/2013		On Consent Calendar / In Concurrence
5/30/2013		Senate Passed
4/26/2013		Senate Calendar Number 462
4/26/2013		Favorable Report, Tabled for the Calendar, Senate
4/24/2013		House Passed
4/10/2013		Tabled for the Calendar, House
4/10/2013		No New File by Committee on Environment
4/10/2013	(LCO)	Reported Out of Legislative Commissioners' Office
4/10/2013	(LCO)	Filed with Legislative Commissioners' Office
4/10/2013	(ENV)	Joint Favorable
4/5/2013		Referred by House to Committee on Environment
3/26/2013	(LCO)	File Number 169
3/26/2013		House Calendar Number 132
3/26/2013		Favorable Report, Tabled for the Calendar, House
3/26/2013	(LCO)	Reported Out of Legislative Commissioners' Office
3/19/2013	(LCO)	Referred to Office of Legislative Research and Office of Fiscal Analysis 03/25/13 5:00 PM
3/14/2013	(LCO)	Filed with Legislative Commissioners' Office
3/12/2013	(GL)	Joint Favorable
3/8/2013		Referred to Joint Committee on General Law
3/7/2013		Drafted by Committee
2/28/2013	(GL)	Vote to Draft
2/28/2013	(GL)	Vote to Draft
2/28/2013	(GL)	Vote to Draft
2/28/2013	(GL)	Vote to Draft
2/14/2013		Public Hearing 02/21

1/31/2013	(GL)	Reserved for Subject Matter Public Hearing
1/24/2013		Referred to Joint Committee on General Law

Co-sponsors of HB-5908

Rep. Ed Jutila, 37th Dist.
Rep. Louis P. Esposito, 116th Dist.
Rep. David A. Baram, 15th Dist.
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Click for Public Hearing Testimony

Please direct all inquiries regarding the status of bills to the House and Senate Clerks' Offices.

Subject: ASTM

From: PATAYA FLOORING&STONE,LLC (patayastonellc@prodigy.net)

To: patayastonellc@prodigy.net;

Date: Thursday, February 13, 2014 11:32 PM

Papers are Invited for ASTM Symposium on

Developing Consensus Standards for Measuring Chemical Emissions from Spray Polyurethane Foam (SPF)

Abstract Due: April 30, 2014

Symposium Objective: Standardized methods are needed to assess the potential impacts of SPF insulation products on indoor air quality and to establish re-entry or re-occupancy times after product installation in a building and post-occupancy ventilation needs. The objective of the symposium is to provide a forum for the exchange of ideas from SPF manufacturers, regulatory agencies, indoor air quality professionals, testing labs, air quality consultants, instrument vendors and other stakeholders. The symposium will be informative toward future development of standards for measuring emissions from SPF insulation. Papers are requested on the following topics:

- Research and method development for measuring potential SPF emissions of semi-volatile and volatile organic compounds used in the formulation (e.g., isocyanates, blowing agents, amine catalysts and flame retardants) and from potential reaction or byproducts
- Federal and other governmental agencies' regulatory approaches and supporting investigation, assessment and research needs
- Modeling, scaling up from lab to large scale chambers or buildings
- International perspective on regulation and testing of SPF insulation emissions
- Industry perspective/needs and product stewardship activities
- Field investigations or large-scale chamber/spray booth studies to evaluate emissions or ventilation rates
- Applying the knowledge from product emissions data/research to practice (e.g., stewardship commitment, green building practices, codes for residential ventilation and global leadership)

Submittal Date: April 30, 2014

Symposium Date: April 30-May 1, 2015

Location: Anaheim, CA

Sponsored by: Committee D22 on Air Quality

To participate, presenters/authors must submit an online Abstract Submittal Form, and attach a 250-300 word abstract by April 30, 2014. Presenters/authors will be notified of their paper's acceptance via postal mail by May 19, 2014. ASTM will then provide authors' instructions. The presentation and manuscript must not be of a commercial nature nor can it have been previously published.

Abstracts must:

- Clearly define the objective and approach of the work discussed
- Point out material that is new
- Present sufficient details regarding results

Qualified, peer-reviewed symposium papers will be published as an STP (Selected Technical Papers.)

For information on the symposium, use this link. For additional technical information, contact symposium co-chairmen John Sebroski (phone: 412-777-3420) or Mark Mason (phone: 919 541-4835).

Developing ASTM Standards for Measuring VOC and SVOC Emissions from Spray Polyurethane Foam Insulation Products

John Sebroski

Bayer MaterialScience LLC

American Chemistry Council | Center for the Polyurethanes Industry

From: nemc.us/docs/2013/presentations/Thu-Air-Methods & Monitoring: Indoor Air Quality & Vapor Intrusion-21.6-Sebroski.pdf

CPI Emissions Task Force Objective

Develop methods for SPF standardization that can be used by manufacturers to evaluate potential emissions released from SPF insulation samples.

Participate in research to support the development of SPF product emissions standards through ASTM Subcommittee D22.05 on Indoor Air Quality.

ASTM Subcommittee D22.05 on Indoor Air

SPF Emissions Task Group Members

- Industry (CPI, III)
- Regulatory (US EPA, CPSC, etc.)
- Instrument Vendors
- Consultants
- Air Quality Testing Labs
- Certification Programs
- Other Stakeholders

ASTM Work Items

- ✓ **ASTM WK30960 (Recently published as D7859-13e1)**

  Standard Practice for Spraying, Sampling, Packaging, and Test Specimen Preparation of Spray Polyurethane Foam (SPF) Insulation Samples for Environmental Chamber Emissions Testing

- **ASTM WK40293**

  New Practice for Estimating Chemical Emissions from Spray Polyurethane Foam (SPF) Insulation using Micro-Scale Environmental Test Chambers

- **ASTM WK40292**

  New Test Method for Measuring Chemical Emissions from Spray Polyurethane Foam (SPF) Insulation Samples in Environmental Test Chambers with Thermal Desorption and Gas Chromatography / Mass Spectroscopy (TD-GC-MS)

Generic SPF Formulations

Three generic SPF formulations were developed by CPI to evaluate the test methods for measuring emissions.

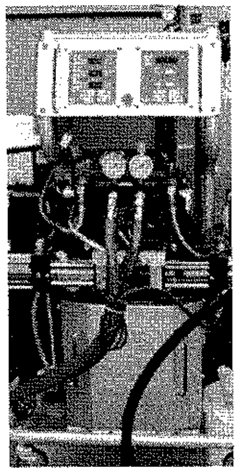
The formulations represent the following sample types:

Spray Polyurethane Foam
Open-cell 1/2 pound
High Pressure

Spray Polyurethane Foam
Closed-cell 2 pound
High Pressure

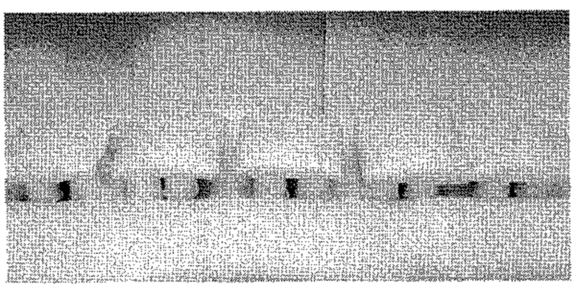
Spray Polyurethane Foam
Kit Formulation
2 Component, Low Pressure

ASTM Standard Practice D7859-13e1



Standardizes the procedures for spraying, sampling, packaging and test specimen preparation of SPF insulation for testing of emissions using environmental chambers.

Practice is applicable to both closed-cell and open-cell SPF insulation.



Spraying, Packaging and Transport

Spraying Parameters

- Specialized equipment with trained operators
- Samples are sprayed in spray booth under controlled conditions
- Samples sprayed onto sheets of HPDE as substrate
- Sample thickness specified for both open-cell and closed-cell SPF

Packaging and Transport

- Samples allowed to cure for 1-hour
- Samples are wrapped with aluminum foil then placed into layered polyethylene terephthalate (PET) bags with minimal headspace
- Samples shipped in insulated secondary container
- Electronic data loggers can be used to monitor temperature, pressure and relative humidity during transport
- Samples and data record shipped to laboratory via overnight delivery service

Laboratory Requirements

General Knowledge of SPF Formulations

- Define target compounds for emission monitoring
- Surface skin may need to be removed to simulate trimming of SPF insulation to wall studs or other structural elements

Sample Receipt and Storage

- Chain of custody
- Samples are stored in unopened bags at typical indoor office conditions (no refrigeration or freezing)

Holding Time

- Chamber testing must begin within 20 minutes of opening the PET bag and within 48-hours from spraying

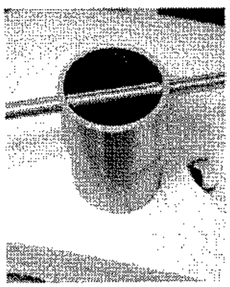
Preparation of Specimens

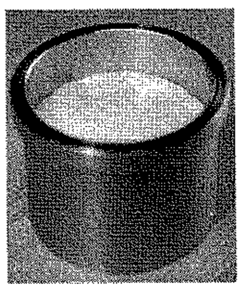
- Samples are cut to tightly fit into stainless steel sample holders or micro-scale chambers

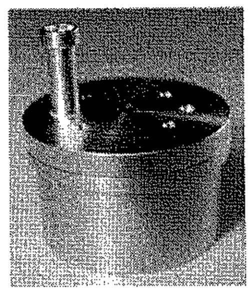
ASTM Work Item WK40293

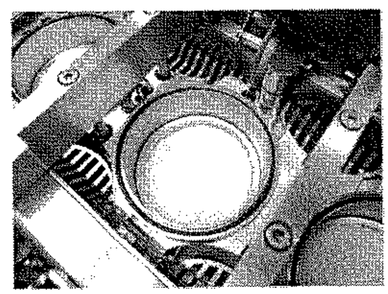
Describes the procedures to collect chemical emissions from SPF insulation samples using micro-scale environmental test chambers

Operating conditions minimize wall adhesion (sink effects) and maximize recovery of the SVOCs, which are captured onto sorbent tubes from the outlet of the micro-scale chamber





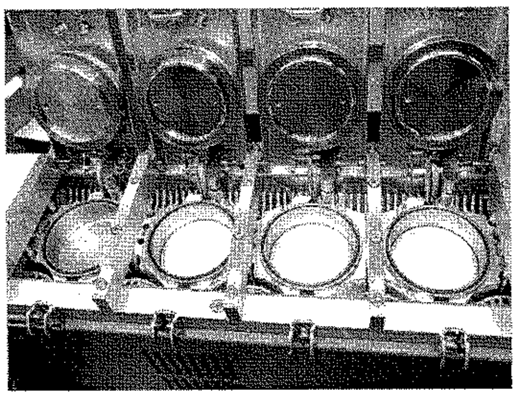


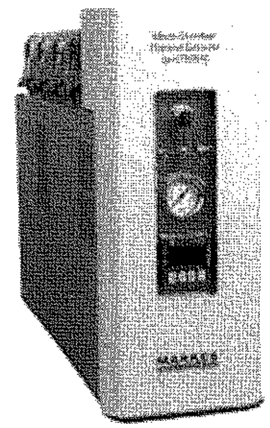


Micro-Scale Chamber Apparatus

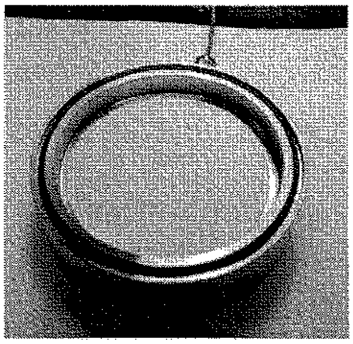
Apparatus shown below holds four micro-scale chambers, controls gas flow and temperature

After equilibration, samples are collected from exhaust ports at various times



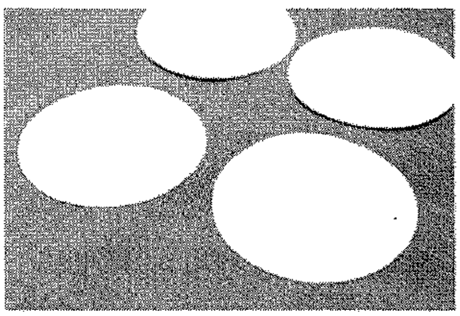


Sampling from Micro-Scale Chamber

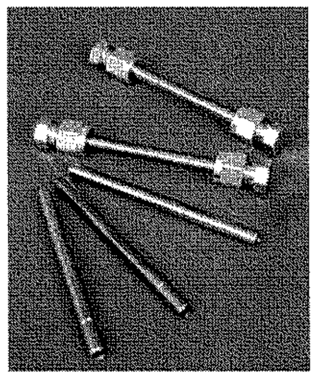


Internal 58mm internal glass-fiber filter with 1-(2-pyridyl)piperazine (PP)

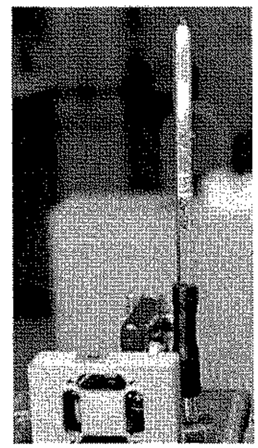
Flow calibrator



90mm glass-fiber filters with PP to wipe chamber walls



Thermal desorption tubes



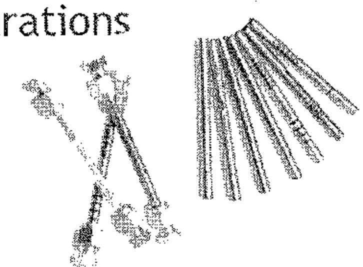
Silica gel with DNPH tube

ASTM Work Item WK40292

Analytical methodology utilizing thermal desorption GC/MS to measure the chemical emissions of semi-volatile and volatile organic compounds (SVOCs and VOCs) from SPF insulation samples

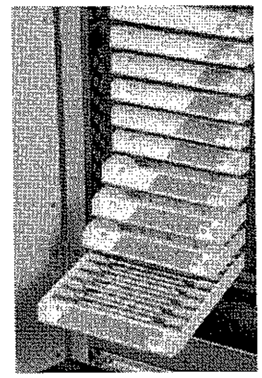
Thermal desorption tubes are used to collect air samples from:

- Micro-scale or conventional test chambers
- Buildings to monitor indoor air concentrations



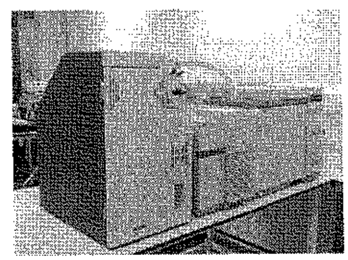
What is Thermal Desorption GC/MS?

VOCs and SVOCs are sampled onto thermal desorption tubes packed with a specific combination of sorbents containing glass wool, graphitized carbon and porous polymer adsorbent.



Samples can be stored in sealed containers prior to analysis.

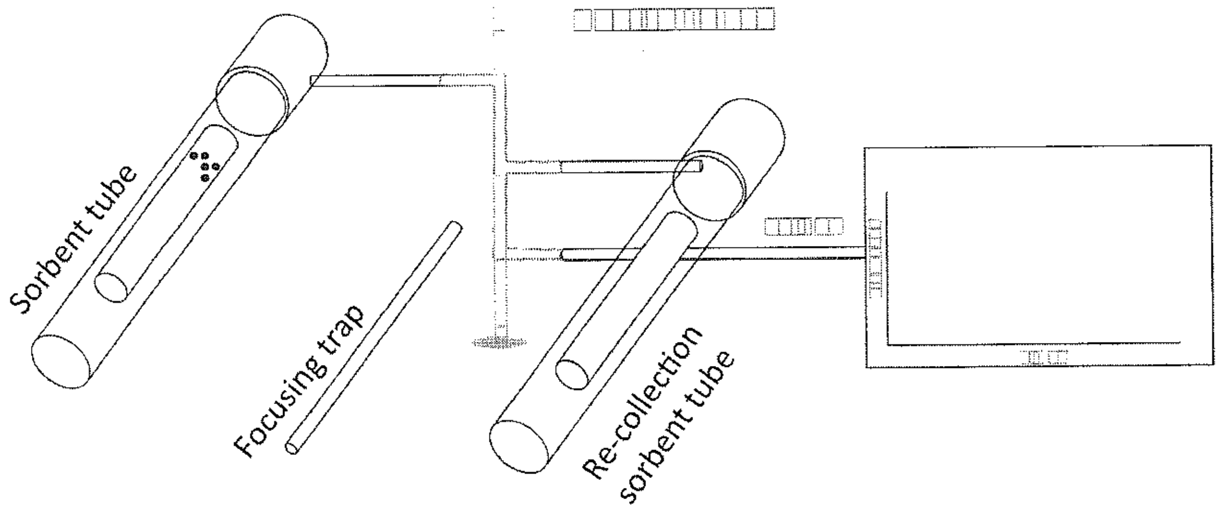
Captured organic compounds are released during a two-stage thermal desorption process and are identified and quantified by gas chromatography/ mass spectrometry.



Target compounds compared with reference standards; unknown compounds are tentatively identified with NIST Mass Spectral Library.

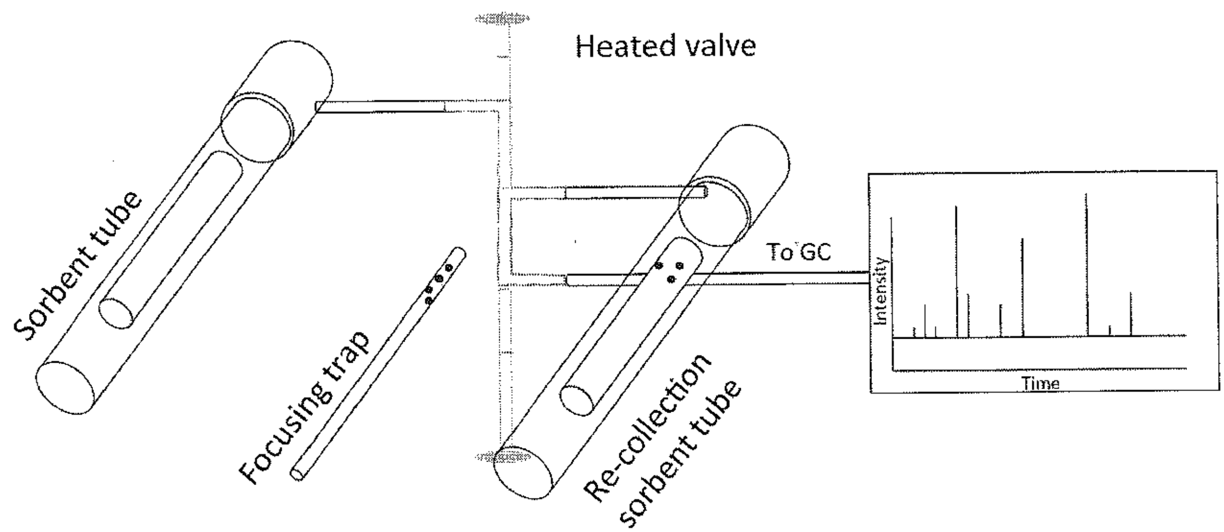
Two-Stage Thermal Desorption

Phase 1

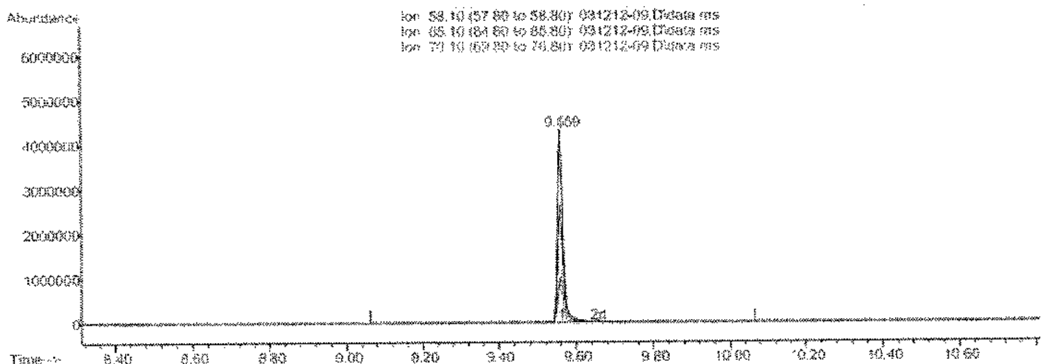


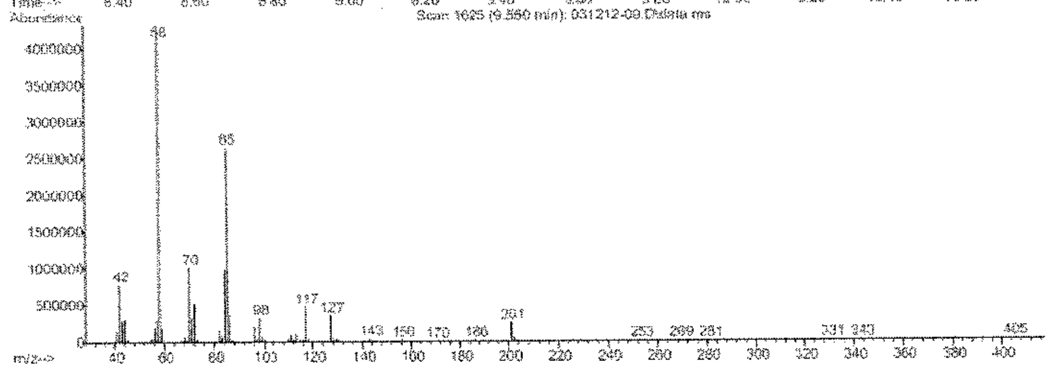
Two-Stage Thermal Desorption

Phase 2



Extracted Ion Chromatogram
Mass Spectrum





Generic SPF Target Compounds with Thermal Desorption GC/MS

Compound Name	Compound Type	Retention Time, minutes	Estimated Quantitation Limit, ng	Mean Recovery, %	Precision RSD, %
HFC-245fa	Blowing Agent	1.48	20	89.7	10.9
TMAEEA	Amine Catalyst	7.69	200	71.5	24.6
BDMAEE	Amine Catalyst	7.72	20	94.5	4.10
PMDTA	Amine Catalyst	8.26	50	92.9	3.52
DAPA	Amine Catalyst	9.56	100	96.2	3.38
TMIBPA	Amine Catalyst	9.65	200	68.1	13.3
TCPP	Flame Retardant	12.5	50	92.6	2.94

Evaluation of Data

Emissions factors

- Mass per surface area and time, µg / m^2 hour

Predicted building concentrations

- Loading factor in building, area /volume, m^2/m^3
- Air exchange rate (ventilation rate), fresh air exchanges / hour
- Predicted concentration values are typically calculated in $\mu g/m^3$

Evaluation of Data

Re-entry time

- Compare predicted concentrations at a given time with Occupational Exposure Limits (OELs)

Re-occupancy time

- Compare predicted concentration at a given time with Chronic Reference Exposure Limits (CRELs) or 1/100 OEL

Evaluate ventilation rates

- Evaluate ventilation rates to meet exposure limits or odor threshold limits

Research and Collaboration

Current Research Projects

- **Center for Polyurethane Industry (CPI)**
  - Further support development of analytical test methods
  - Optimize recovery of flame retardant and amine catalysts using micro-scale test chambers
- **International Isocyanate Institute (III)**
  - Evaluate prototype micro-scale test chambers optimized for MDI emissions

US EPA, Office of Research and Development

- Ongoing CPI and US EPA meetings to discuss current activities in each organization

ASTM D22.05 on Indoor Air

Subcommittee Ballot

- WK40292 Standard Test Method for Measuring SPF Chemical Emissions with Thermal Desorption Tubes and GC/MS
- WK40293 Standard Practice for using Micro Chamber to Measure SPF Emissions

Scheduled Meetings

- October 22, 2013, Jacksonville, Florida
- April 8, 2014, Toronto, Ontario, Canada

Acknowledgments

ASTM International Committee D22 on Air Quality

- Subcommittee D22.05 on Indoor Air

Bayer MaterialScience LLC

- Environmental Analytics Laboratory
- Product Safety and Regulatory Affairs

Center for Polyurethane Industry (CPI)

- SPF Emissions Task Force
- SPF Ventilation Task Force

Questions?

EFFECT OF VENTILATION RATES ON APPLICATOR EXPOSURE DURING SPF APPLICATION

CPI PROVIDES UPDATE ON RESEARCH PROJECT

American Chemistry Council | Center for the Polyurethanes Industry

BY **HEATHER PALFREY, MANAGER, ENVIRONMENTAL, HEALTH & SAFETY**
AMERICAN CHEMISTRY COUNCIL, CENTER FOR THE POLYURETHANES INDUSTRY

Industrial hygiene air monitoring was conducted in support of the Center for the Polyurethanes Industry (CPI) SPF Ventilation Research Project. The research plan for this project was detailed in SPFA's Fall 2012 *SPRAYFOAM Professional* magazine. The purpose of this research is to evaluate the impact of changes in ventilation rates on the concentration of chemical vapors and particulates emitted during SPF application.

This research consists of three phases: 1) Testing of spray equipment and generic formulations; 2) Monitoring chemical emissions during SPF application under controlled environmental conditions; and 3) Conducting field testing to verify Phase 2 results. Click here to read more about the project phases: www.nxtbook.com/nxtbooks/naylor/SPFQ0312/index.php#/16

Emissions from three SPF formulations were evaluated: a low density (1/2-pound) high pressure SPF, a medium-density (2-pound) high pressure SPF, and a low-pressure, two-component SPF kit. These three generic formulations were developed in Phase 1 of the project to be representative of formulations currently available in the SPF marketplace.

PHASE 2 UPDATE

The test chamber was approximately 8′ x 8′ x 8′ with a ventilation rate of 85 cubic feet per minute, or 10.4 air changes per hour (ACH) assuming perfect air mixing. Air flow was perpendicular to the worker and the spray application. The worker applying each SPF formulation wore portable sampling pumps with the sampling media placed in the vicinity of the worker's breathing zone. Area samples were located several feet behind the applicator, at a height of approximately 6.5 feet. After approximately 15 minutes of spray time, the applicator exited the test chamber and the personal and area samples were retrieved. The sprayed cardboard inserts were left inside the test chamber. A second set of "post-spray" area samples were collected for one hour beginning 30 minutes after spraying stopped. After the second set of area samples were completed, the sprayed cardboard inserts were removed and the test chamber was allowed to purge for two hours before starting another test run. A total of four runs were completed across two days for each of the three generic SPF formulations. The spray applicator's exposure and room concentrations of MDI, pMDI, amine catalyst, blowing agent, and fire retardant were measured during the experiment. Below is research finding on MDI and pMDI.

RESEARCH FINDINGS FOR MDI AT 10.4 ACH

As shown in Figure 1 the concentrations of 4,4′-methylene bisphenyl isocyanate (4,4′-MDI) were detected during spraying of both the low and medium density SPF formulations (0.011 to 0.037 parts per million or ppm), but not during spraying of the kit formulation (0.0012 to 0.004 ppm). The concentrations of 4,4′-MDI, 2,4′-MDI, and polymeric MDI (pMDI) were highest during spraying of the medium density formulation, next highest during spraying of the low density formulation, and lowest during spraying of the kit formulation.

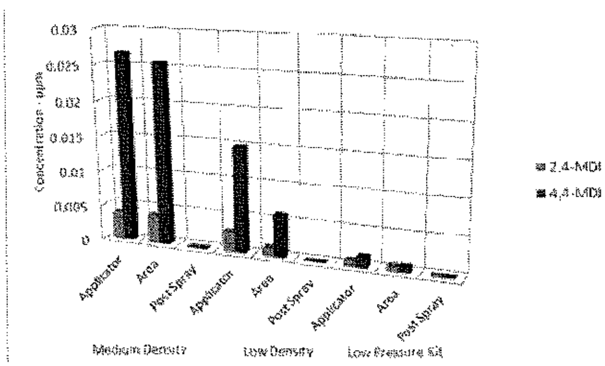


Figure 1: 2,4-MDI and 4,4–MDI (Average of 4 sessions - 15 min/session at 10.4 ACH)

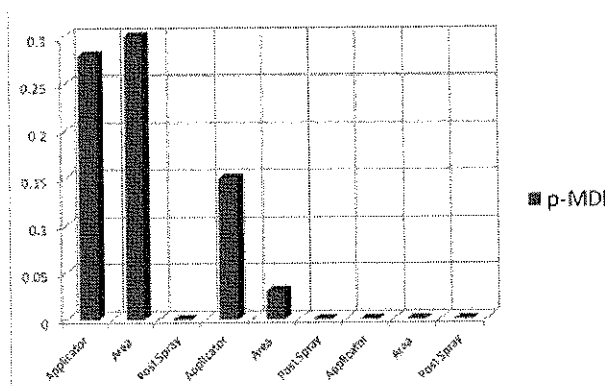


Figure 2: pMDI (Average of 4 sessions - 15 min/session at 10.4 ACH)

For all three formulations, MDI was not detected during the post-spray sampling period, 30 to 90 minutes after spraying stopped, with the SPF still inside the test chamber. The limits of detection for 4,4'-MDI and 2,4'-MDI were 0.00014 to 0.00021 ppm, while the limit of detection for pMDI was 0.0014 to 0.0021 milligrams per cubic meter (mg/m^3).

Following air sampling of the three generic formulations at 10.4 ACH, air sampling was conducted at approximately 600 air changes per hour exhaust ventilation using the medium-density (2-pound) high pressure SPF. The air sampling was conducted in a ventilated spray booth approximately 10' x 10'8" x 6'10" (729 cubic feet, ft^3), with a ventilation rate of 7,265 cubic feet per minute (cfm), or 598 air changes per hour (ach) assuming perfect air mixing. The temperature and humidity during spraying were approximately 71 degrees F and 30% relative humidity during all four runs.

The test procedures used for the 10.4ACH testing was also used for the 598ACH testing. The air flow was perpendicular to the worker and the spray application. The worker applying each SPF formulation wore portable sampling pumps with the sampling media placed in the vicinity of the worker's breathing zone. Area samples were located several feet behind the applicator, at a height of approximately 6.5 feet. After approximately 15 minutes of spray time, the applicator exited the test chamber and the personal and area samples were retrieved. The sprayed cardboard inserts were left inside the spray booth. A second set of "post-spray" area samples were collected for one hour beginning 30 minutes after spraying stopped. After the second set of area samples were completed, the sprayed cardboard inserts were removed and the test chamber was allowed to purge for two hours. A total of four runs were completed across two days for the generic medium density formulation.

RESEARCH FINDINGS FOR MDI AT 598 ACH

As shown in Figures 3 and 4, MDI was detected during spraying. The applicator and area results during spraying were similar during each run (+/- 36%) and varied by about a factor of 2 across the four runs. 2,4-MDI ranged from 0.0030 to 0.0058 ppm; 4,4-MDI ranged from 0.019 to 0.037 ppm; and pMDI ranged from 0.17 to 0.41 mg/m^3. All three were non-detect during the post-spray sampling period (limits of detection ranged from 0.0014 to 0.0021 mg/m^3 or 0.00014 to 0.00021 ppm).

Monitoring is still underway for Phase 2. One additional air sampling survey will be conducted as foam is sprayed in the spray booth at the reduced fan speed rate of 1/3 to 1/2 full speed rates to evaluate the effect of reduced ventilation on SPF emissions. ○

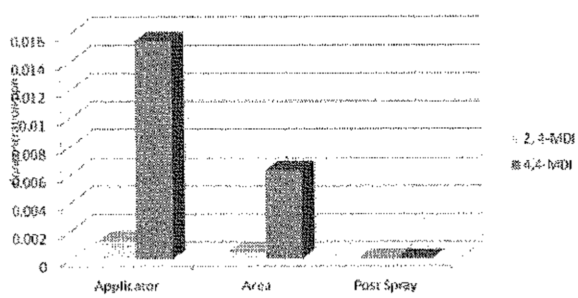


Figure 3: 2,4-MDI and 4,4-MDI (Average of 4 sessions - 15 min/session at 598 ACH)

Figure 4: pMDI (Average of 4 sessions -15 min/session at 598 ACH)

American Chemistry Council | Diisocyanates Panel

February 26, 2013

Submitted via Electronic Mail

Katherine Sleasman
Office of Pollution Prevention and Toxics
Chemical Control Division
Existing Chemicals Branch
1200 Pennsylvania Ave. NW
EPA East, Room 4410G
www.regulations.gov,
Sleasman.Katherine@epamail.epa.gov

Re: Methylene Diphenyl Diisocyanate (MDI) And Related Compounds Action Plan, RIN 2070-ZA15, April 2011

Dear Ms. Sleasman,

The American Chemistry Council Diisocyanates Panel ("Panel")[1] is pleased to have the opportunity to submit comments to the Environmental Protection Agency on the *Methylene Diphenyl Diisocyanate (MDI) And Related Compounds Action Plan* issued in April 2011. The following bullets summarize the Panel's general comments on the MDI Chemical Action Plan, while the attachment includes a line-by-line critique and provides additional details regarding our response.

- The statement that MDI is a "potent dermal and lung sensitizer" is not supported by the majority of literature, epidemiology studies, national surveillance programs, or manufacturers' experience with employees.

- Various national data collection programs on worker exposure and disease incidence present a fairly consistent picture, showing a reduction of diisocyanates-related asthma cases over the last decade.

- Regardless of the route of induction of "sensitization," inhalation exposures are necessary to exhibit a respiratory response. Thus, the role that dermal contact with diisocyanates plays in the development of occupational asthma remains unresolved for humans.

[1] The Panel includes U.S. manufacturers of TDI and/or MDI: BASF Corporation, Bayer Material Science, The Dow Chemical Company, and Huntsman Corporation.

- The reported symptoms (dizziness, nausea, sore throat, and breathing difficulties) in the Jan et al. 2009 study are consistent with an exposure to xylene, a known CNS depressant and upper respiratory tract irritant, that was used as a solvent for the applied MDI (0.1% MDI in xylene) and it is inaccurate to attribute the symptoms to MDI. In addition, no hydrolyzed MDI was found in the urine of the school children indicating a lack of exposure. The Panel recommends that EPA remove this reference.

- Due to the very low vapor pressure of MDI, the potential for airborne exposures to MDI while using products such as adhesives, glues, and sealants are likely to be below the limit of detection. Based on the physical and chemical properties of MDI, the potential for exposure to unreacted isocyanates in consumer products is low.

- There is no evidence to indicate that MDI hydrolyzes in the gas phase. The study by Dyson et al, 1971 is flawed with no attempt at measuring possible reaction of MDI with water to produce polyurea.

- Exposure of people and children to MDI in everyday life from fully cured products, such as by sitting on a carpet is not credible, as MDI would not be released from these consumer products in normal use, and the emphasis on a unique health concern of children potentially exposed to diisocyanates is not supported by scientific evidence.

- Some products (adhesives or sealants) may contain a small percentage of monomeric MDI (<5%) within the pre-polymer or polyisocyanate matrix. These adhesives and sealants would not be heated or sprayed upon application, but typically used at room temperature and trowel applied or applied with a caulking gun. The very low vapor pressures of both monomeric MDI and PMDI largely explain the very low to non-detectable airborne concentrations found in most applications involving a consumer product. Airborne concentrations of MDI are associated only with processes or applications that involve heating (well above 100 degrees F) and/or spraying (aerosolizing).

- Although some of the product types (rigid foam, adhesives) might be used by consumers, the exposure potential would be much lower than an industrial or construction work environment because of shorter durations of exposure, much lower volumes of MDI/pMDI used per application, and consumer products that contain uncured MDI are not usually heated or spray applied during use by the consumer.

- Installation of spray polyurethane foam (SPF) insulation in homes, schools and other public buildings is not a source of potential exposure to isocyanates if industry recommendations are followed. Most studies have shown that airborne concentrations of MDI are non-detectable within two hours after application.

- The potential for community exposure to isocyanates used in the industrial setting has been studied and a significant potential for exposure has not been demonstrated.

- There is a big difference between curing as it relates to completion of the physical characteristics of the product and emissions of airborne isocyanate (air emissions) from the product as it begins to cure immediately after application. It may take some PU products up to 24 hours to completely develop all of its physical properties or characteristics. However, MDI is generally non-detectable within the air and on the surface of the PU product within two hours after application without engineering controls (ventilation). Of course, with engineering controls, re-entry time can be significantly decreased depending on the PU product.

- There is currently no known substitute of the use of isocyanates to produce rigid foam-in-place insulation which can give the qualities required for this application. These qualities include low thermal conductivity, physical strength, adhesion to substrates, efficiency, and durability.

- Industry recommendations for engineering controls, personal protective equipment, and hazard communication are the same for all pre-polymers as for the MDI monomer.

- Current SPF industry recommendations by manufacturers are as follows:
    - the building should be vacated during SPF application;
    - where the building cannot be vacated, the spray application area should be contained/isolated and ventilated;
    - the spray area should be ventilated for a period of time following SPF installation;
    - building occupants should not return until after the manufacturer's recommended re-occupancy time (typically 24 hours) has elapsed.

  These measures can prevent potential MDI exposures to occupants and bystanders.

- The isocyanates used in the spray coatings applications referenced in the Action Plan are polyisocyanates based on hexamethylene diisocyanate (HDI), not MDI nor TDI.

The Panel urges the Agency to consider our comments and revise the MDI Chemical Action Plan accordingly. We look forward to continuing to work with EPA as it determines next steps with the Action Plans. If you have any questions or need additional information, please contact me at (202) 249-6721 or Sahar_Osman-Sypher@americanchemistry.com.

Sincerely,

Sahar Osman-Sypher

Sahar Osman-Sypher
Manager, Diisocyanates Panel

Attachment: Diisocyanates Panel Line-by-Line Critique of the MDI Chemical Action Plan

ATTACHMENT 1:
Line-by-Line Critique of the U.S. Environmental Protection Agency's
Methylene Diphenyl Diisocyanate (MDI)
And Related Compounds Action Plan
[RIN 2070-ZA15]

Page 2
Diisocyanates are potent dermal and lung sensitizers and a major cause of work-related asthma worldwide (NIOSH, 2006).

Comment: A comprehensive but not exhaustive literature review as of the end of 2009 found approximately 39 papers describing skin sensitization from isocyanates that are mainly case reports or small case studies. There are only two epidemiologic studies from two dermatology clinics (Liippo and Lammintausta, 2008; Kanerva et al., 1999a) that found MDI caused skin allergy in 0.4 - 0.8% of cases. A study in the occupational setting for orthopedic nurses working with MDI-based soft casts reported that diisocyanates are primarily irritants rather than sensitizers in this professional setting and that the skin symptoms of irritation were mild and temporary (Larsen et al., 2001). Over a period of almost 13 years, an occupational dermatology clinic investigating contact allergy found 12 patients who reacted to MDI (Aalto-Korte et al., 2012).

Various national data collection programs on worker exposure and disease incidence present a fairly consistent picture, showing a reduction of diisocyanates-related asthma cases over the last decade, in Finland, Ontario, Germany, Belgium, and France, against a background of increasing production and use around the world (Piipari and Keskinen, 2005; Buyantseva et al., 2011; DGUV, 2011; Vandenplas et al., 2011; Paris et al., 2012). To understand the prevalence of disease, a reasonable approach is to use the national statistics and estimates of workers in the industry. In the Canadian Province of Ontario, a reduced annual rate of successful isocyanate-related claims of occupational asthma for the period 1998-2002 (7.4 claims/year) compared to 1980-1993 (30.5 claims/year) was reported (Buyantseva et al., 2011). The reduction was thought to be due partly to the active occupational surveillance scheme. Using the CareEx data of 12,000 isocyanates workers in Ontario, one can derive a prevalence of 0.06 % (7.4/12000) (http://www.carexcanada.ca/en/toluene_diisocyanates/occupational_estimate/).

In conclusion the statement that MDI is a "potent dermal and lung sensitizer" is not supported by the majority of literature, epidemiology studies, national surveillance programs, or manufacturers' experience with employees.

Page 2
For example, installation of spray polyurethane foam insulation in homes, schools and other public buildings is a source of potential exposure to uncured isocyanates by building occupants, as well as in do-it-yourself (DIY) consumer projects.

Comment: The following information summarizes the findings of an air monitoring study (Lesage et al., 2007) in five residential structures.

- Airborne MDI concentrations decrease rapidly after foam application ceases.
- Area air samples were collected at fixed locations in the rooms to determine the change in airborne MDI concentrations with time following the end of SPF application. The air samples were taken at 15, 30, 45, 60, 75, and 90 minutes after foam application had ceased. Samples were also collected 24 hours after the end of the application to determine whether there was any MDI off-gassing from the cured foam. Quantifiable or detectable airborne concentrations of MDI were found at 15-minute and 45-minute sampling periods after spraying ceased and only one of seven data points at the 45-minute sample period resulted in a detectable airborne concentration of MDI (3 $\mu g/m^3$). Airborne MDI was not detected at the 30-minute sample period, nor at any of the sample time periods after 45-minutes.
- All of the post-spray data were well below the occupational exposure limit of 0.051 mg/m3 or 51 $\mu g/m^3$. Twenty-five (25) post-spray air samples were collected between 15 minutes and 90 minutes after SPF application. Twenty (20) of 25 post-spray samples for monomeric MDI were less than the LOQ (Limit of Quantitation) (non-detectable < 2.4 $\mu g/m^3$). PMDI was detected on 5 of the 10 area air samples collected at 15 minutes post-spray (ranging from 2 to 14 $\mu g/m^3$).
- Four of ten detectable 15-minute post spray airborne MDI monomer samples ranged from 8 $\mu g/m^3$ to 19 $\mu g/m^3$ (0.008 mg/m3 to 0.019 mg/m^3). Only one of seven 45-minute post spray samples was above the limit of quantitation for both MDI monomer and oligomer. The one reportable airborne MDI monomer concentration at 45 minutes after spray was 0.003 mg/m^3, mg/m^3 refers to milligrams per cubic meter.
- All samples collected 60-minutes or longer after spraying ceased were non-detectable (below the LOQ).
- Furthermore, surface wipe samples collected from the newly-installed SPF surfaces indicated that unreacted isocyanates were not detected 15 minutes following the end of SPF installation.

Another air monitoring (Roberge et al., 2009) evaluated airborne concentrations of MDI in 14 structures (includes both residential and commercial structures). Air sampling was conducted following SPF application. The average airborne MDI concentrations on the floor where spray foam was applied were 0.35, 0.078, and 0.03 $\mu g/m^3$ at 30, 60, and 120 minutes following the end of spraying, respectively. Migration of MDI from the floor being sprayed to lower/upper floors was found to be 0.3, 0.95, and 0.02 $\mu g/m^3$ at 30, 60, and 120 minutes following the end of spraying, respectively.

An air monitoring study conducted by Bayer (Karlovich, 2009) in five residential structures during and following SPF application indicated that, with two exceptions, airborne MDI could not be detected (<3.3 $\mu g/m^3$) in air samples collected at approximately 30, 60, 90, and 120 minutes following the end of SPF installation on the floor where spray foam was applied as well as to other (lower/upper) floors. MDI was detected in only two out of 64 post-spray samples, and these were both at 4.7 $\mu g/m^3$. In one residential structure, MDI was identified at 4.7 $\mu g/m^3$ at 30 minutes post-spray on the floor that had been sprayed. In a second residential structure, MDI was identified at

4.7$\mu g/m^3$ at 90 minutes post-spray on an adjacent floor. These levels are well below the MDI Occupational Exposure Limit (OEL) of 51 $\mu g/m^3$. In both cases, MDI was not detected in the subsequent samples at those particular locations.

The studies reviewed illustrate that at 120 minutes following the end of SPF application that airborne MDI concentrations were: Lesage (2007): ND < 2.4 ug/m3; Bayer (2009): ND < 3.3 ug/m3; Roberge (2009): 0.03 ug/m3. The Roberge (2009) study used an analytical method that was capable of reporting to a lower limit of quantification. The Roberge (2009) study indicated that within two hours following the end of spraying, airborne MDI levels were at extremely low levels that were well below the EPA MDI Reference Concentration (RfC) of 0.6 $\mu g/m^3$. Finally, the Lesage (2007) study results suggested that unreacted isocyanates were not present on the surface of newly installed SPF at 15 minutes following installation.

Please note that current SPF industry recommendations, as noted in various Center for the Polyurethanes Industry (CPI) documents and training materials, are as follows:
1) the building should be vacated during SPF application;
2) where the building cannot be vacated, the spray application area should be contained/isolated and ventilated;
3) the spray area should be ventilated for a period of time following SPF installation;
4) building occupants should not return until after the manufacturer's recommended re-occupancy time (typically 24 hours) has elapsed.

These measures should prevent potential MDI exposures to occupants and bystanders.

In conclusion, installation of SPF insulation in homes, schools and other public buildings is not a source of potential exposure to isocyanates if the measures noted above are followed. Most studies have shown that airborne concentrations of MDI are non-detectable within 2 hours after application.

Page 2
Readily available consumer products, such as adhesives (including glues) and sealants also contain diisocyanates that are not completely reacted when applied and can provide potential exposures (Krone, 2004; Bello et al., 2007).

<u>Comment:</u> It is important to note that the percentage of monomeric MDI in MDI pre-polymer products is low (generally <5% for consumer products). Consumer products that contain low levels of diisocyanates warn against dermal exposure and recommend use of protective gloves.

For additional information, please also see pages 7-9 of our comments that address EPA's statement "*To reduce vapor hazards....*"

Page 3

These researchers also noted that community exposures to isocyanates could potentially result from industrial exposures as well as the use of consumer products containing isocyanates (Redlich, et al, 2006).

Comment: A comprehensive review of MDI emission and modelling data across a wide range of facilities using MDI found extremely low emission levels of MDI and no application where the IRIS RfC level for MDI was exceeded (ACC, 2002).

In 2007, the North Carolina Department of Health and Human Services (NCDHHS) and the Agency for Toxic Substance and Disease Registry (ATSDR) conducted a joint study of environmental exposure to TDI and potential community health effects. Since the vapor pressure of MDI is much lower than TDI, the data from the study can be "read across" to potential MDI exposures as well. Data were collected from ten NC communities in four counties. Half were communities near facilities with reported TDI emissions (target areas) and half were communities where no TDI emissions were reported (comparison areas). The study results were released in May 2010 and did not find any significant health-related concerns associated with communities near plants using TDI. State and federal researchers concluded, "We did not find a scientific connection between respiratory problems and exposure to TDI…Overall, we did not find that people living near the plants that emit TDI have recent or current exposure to TDI at levels of health concern." The full TDI Community Health Report can be found online at: http://www.epi.state.nc.us/epi/oee/tdi/TDICommunityHealthReport.pdf

In March 2009, EPA initiated its School Air Monitoring Project that monitored the air in 22 states around 62 schools that were located near industrial facilities or in urban areas. Seven schools in six states were selected for diisocyanates air monitoring. EPA released analyses for 5 of the 7 schools, concluding that diisocyanates were non-detectable and well below levels of concern. Therefore, EPA is no longer monitoring at those schools. For 2 of the 7 schools, which are located a ½ mile apart in the same city, results are still pending. EPA has decided to continue air monitoring at these schools once the nearby facility is operating at a level closer to normal capacity. More information can be found on EPA website: www.epa.gov/schoolair.

In conclusion, the potential for community exposure to isocyanates used in the industrial setting has been studied and a significant potential for exposure has not been demonstrated.

Page 3

To reduce vapor hazards, polyisocyanates and pre-polymer forms of isocyanates were developed; however, many products contain a mixture of MDI monomer and a MDI-based polyisocyanate.

Comment: Prepolymer and polyisocyanates were developed to primarily provide additional properties for the end products, not to reduce vapor hazards. MDI, polymeric MDI, and MDI pre-polymers have an inherent characteristic of low volatility (e.g. at room temperature, MDI and polymeric MDI have a low evaporation rate and typically remain well below applicable occupational exposure limits). Unless heated or sprayed, these products do not have a high enough vapor pressure for airborne MDI exposures (Booth et al., 2009). Therefore, there is a very low potential for consumers to be exposed to MDI vapors while using products that contain MDI monomer, pMDI, or MDI pre-polymers. It is also important to note that the percentage of monomeric MDI in MDI pre-polymer products is low (generally <5% for consumer products).

The term 'pre-polymer' is typically used when discussing MDI-containing products, rather than the term MDI-based polyisocyanate. The term polyisocyanate is more commonly used for aliphatic isocyanates such as HDI.

Regarding other potential routes of exposure (i.e. skin contact), manufacturer product labels include warnings on preventing skin/eye contact.

More information on MDI monomer and pre-polymer forms of isocyanates in consumer products can be found in presentations made at the Federal Workshop hosted by ACC in February 2012 (http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPPT-2011-0182-0006).

For example, one floor adhesive manufacturer presented the following information about their product:

- Unreacted %NCO content of the pre-polymers are low (2-4%NCO by weight).
- Free monomeric MDI content ranges from 0.1% to 1.0% of the finished compound formulation.
- Full cure occurs from moisture reacting with all of the unreacted NCO functionality to form urea crosslinks creating a permanent, thermoset polymer network.

The flooring adhesive manufacturer provided the following example of the type of information provided on their product warning label:

- Warning: this product is irritating to the eyes and skin. Causes respiratory tract irritation and may cause skin reaction.
- Precaution: Wash hands after handling and before eating. Use with adequate ventilation. Wear appropriate protective equipment to avoid contact with skin and eyes.

A construction sealant manufacturer provided information on the chemical content of their "gun grade sealants." Typical sealant formulations consist of:

- Approximately 25-35% polyurethane pre-polymer.
- Typical residual MDI monomer content in their sealant is approximately 2.25%.

The sealant manufacturer provided the following example of the type of information provided on their product warning label:

- Avoid direct contact.

- Wear personal protective equipment (chemical resistant goggles/gloves/clothing) to prevent direct contact with skin and eyes.
- Use only in well ventilated areas. Open doors and windows during use.
- Wash thoroughly with soap and water after use.

In conclusion, some products (adhesives or sealants) may contain a small percentage of monomeric MDI (<5%) within the pre-polymer matrix. These adhesives and sealants would not be heated or sprayed upon application, but typically used at room temperature and trowel applied or applied with a caulking gun. The very low vapor pressures of both monomeric MDI and PMDI largely explain the very low to non-detectable airborne concentrations found in most consumer product applications. Studies show that airborne concentrations of MDI are associated only with processes or applications that involve heating (well above 100 degrees F) and/or spraying (aerosolizing) (Booth et al., 2009).

Page 4
Both inhalation and dermal exposures to diisocyanates are thought to contribute to the development of isocyanate asthma (Bello et al., 2007; Liljelind et al., 2010).

Comment: The ability of diisocyanates to induce respiratory sensitization in some individuals, and asthma in some cases, is a known potential adverse health effect in humans after inhalation exposure to concentrations above workplace exposure limits. Although there is still no validated experimental animal model accepted by regulatory agencies that adequately reflects the respiratory sensitization process and constellation of symptomology associated with occupational diisocyanate asthma, several researchers have shown respiratory changes (e.g. alterations in respiratory rate, non-specific hyperreactivity, influx of inflammatory cells) and/or antibody production in animals after induction exposure and subsequent challenge with MDI or TDI. (e.g., Pauluhn and Poole 2011; Rattray et al.; 1994, Pauluhn, 1994; Pauluhn and Mohr, 1994; Pauluhn, 1995; Blaikie et al 1995).

Of interest is a Brown Norway rat MDI respiratory sensitization study that demonstrated the existence of a threshold for the elicitation of respiratory hypersensitivity responses (Pauluhn and Poole, 2011). In addition, a high-dose MDI topical induction protocol using Brown Norway rats demonstrated a neutrophilic and eosinophilic inflammatory response in the lung following repeated inhalation challenge to MDI. These topically 'sensitized' rats did not exhibit marked respiratory changes after repeated inhalation challenges unless irritating concentrations of MDI aerosol were used (Pauluhn et al., 2005). It was demonstrated that at least three to four adequately spaced challenge exposures using moderately irritant concentrations of MDI are required, after topical application(s), to elicit a typical asthma phenotype (Pauluhn, 2005).

Data on this issue, including evidence from the workplace, have been considered (Graham et al., 2002) and it was concluded that while animal and human data suggest the immune system can be activated by topical exposures to MDI and TDI, experimental animal studies suggest that dermally-mediated activation of the immune system without a subsequent exposure of the respiratory tract is not sufficient to initiate a respiratory hypersensitivity response.

In conclusion, regardless of the route of induction of "sensitization," inhalation exposures are necessary to exhibit a respiratory response. Thus, the role that dermal contact with diisocyanates plays in the development of occupational asthma remains unresolved for humans.

Page 4
Replacement of diisocyanates in an environmentally and economically friendly manner presents a significant challenge. However, a new class of non-isocyanate polyurethanes that offers potentially safer alternatives to conventional polyurethanes has been reported by two research groups (Figovsky & Shapovalov, 2006: Javni et al., 2008 ...

Comment: There is currently no known substitute of the use of isocyanates to produce rigid foam-in-place insulation that can give the qualities required for this application. These qualities include low thermal conductivity, physical strength, adhesion to substrates, efficiency, and durability. Other properties required for certain applications include meeting flammability and high temperature performance requirements. The technology described by Figovsky may have some applicability in the coatings area as curing at elevated temperatures can be more easily achieved. Its use in the rigid foam area appears extremely limited due to the reported difficulties in obtaining a fast curing system and the cost impacts of the intermediates.

Page 5
It is well documented that isocyanate exposure is the leading cause of work-related asthma, and prevalence in the exposed workforce is estimated at 1- 20% (Ott et al., 2003; Bello et al., 2004.

Comment: Various national data collection programs on worker exposure and disease incidence present a fairly consistent picture, showing a reduction of diisocyanates-related asthma cases over the last decade in Finland, Ontario, Germany, Belgium, and France, against a background of increasing production and use around the world. (Piipari and Keskinen, 2005; Buyantseva et al., 2011; DGUV, 2011; Vandenplas et al., 2011; Paris et al., 2012). To understand the prevalence of disease, a reasonable approach is to use the national statistics and estimates of workers in the industry. In the Canadian Province of Ontario, Buyantseva *et al* (2011) reported a reduced annual rate of successful isocyanate-related claims of occupational asthma for the period 1998-2002 (7.4 claims/year) compared to 1980-1993 (30.5 claims/year). The reduction was documented to be due partly to the active occupational surveillance scheme. Using the CareEx data of 12,000 isocyanates workers in Ontario, one can derive a prevalence of 0.06 % (7.4/12000) (http://www.carexcanada.ca/en/toluene_diisocyanates/occupational_estimate/).

The underlying reason for the reduction in isocyanate-related asthma is multi-factorial, including better compliance with exposure standards, improved work practices, use of less volatile isocyanate forms (e.g. prepolymers) and better medical surveillance programs (*See*

Appendix 1). As several organizations have recognized some specific tasks, notably spray painting, are associated with higher asthma incidence, (McDonald et al. 2000; Karjalainen et al. 2002; Naylor and Curran, 2004; Cowie et al. 2005; Pronk et al. 2007; Buyantseva et al. 2011) improving work practices in these applications could offer the opportunity to reduce cases of asthma even further.

The reduction in asthma cases in the last decade may be attributed to heightened awareness from medical surveillance programs and improvements in occupational hygiene (Buyantseva et al., 2011). The German Committee on Hazardous Substances (AGS, 2006) concluded that if TDI exposure concentrations are kept below 10 to 20 ppb (0.07 - 0.14mg/m^3) few new cases of asthma are observed. Also, they found that healthy workers were unaffected by occasional TDI exposures at or near a ceiling of 20 ppb. It appears control of exposures and compliance with current occupational exposure limits have shown that isocyanate asthma can be minimized. This is evidenced by the production site data where there is training, surveillance, and exposure controls. (*See* Appendix 1 for more information).

There have been no large epidemiology studies of incidence and prevalence for MDI asthma. Review of individual studies reveal that the higher prevalence of 7-27% in two earlier studies (Liss, 1988; Zammit-Tabona, 1983) was not evident in a third cross-sectional study in a urethane mold plant designed to minimize MDI exposure. In that plant, a low prevalence of occupational asthma of 1.2%. was found. The authors concluded that aggressive environmental control of diisocyanate exposure decreased the expected prevalence of occupational asthma in this setting. This was supported by a large retrospective study involving 6,308 workers from the Ontario Ministry of Labour computerized database that included diisocyanate air sampling determinations conducted by the Ministry (Tarlo et al., 1997) that estimated an incidence of 0.9% per 4 years.

According to the NIOSH work-related asthma statistics, isocyanates are number 8 in frequency of reported cases with total numbers 2 to 3.5 times lower than the top 3 categories.
http://www2a.cdc.gov/drds/WorldReportData/FigureTableDetails.asp?FigureTableID=2607&GroupRefNumber=F09-01

Page 5
Once a worker is sensitized to diisocyanates, subsequent exposures can trigger severe asthma attacks. Higher incidences of asthma are typically associated with processes that generate higher exposures, such as spray application or heated processes that generate airborne vapors and mists that can expose workers via respiratory and dermal routes. For example, the UK Health and Safety Executive reported that vehicle refinishers who spray coatings containing isocyanates have an 80 times higher risk of getting asthma compared with the UK working population. (HSE 2009) [http://www.hse.gov.uk/mvr/priorities/isocyanates.htm/].

Comment: The isocyanates used in the spray coatings applications referenced above are polyisocyanates based on hexamethylene diisocyanate (HDI), not MDI nor TDI.

In addition, the HSE report expressed caution in interpreting the report since there may be other occupations and industries with higher rates of occupational asthma but with a low number of cases due to the size of the industry and these were not included in the report.

http://www.hse.gov.uk/statistics/causdis/asthma/asthma.pdf

Page 5
There are very few reports of non-occupational exposures to diisocyanates available; however, some incidents have been reported where diisocyanates in products are suspected of causing asthma reactions in humans (Dietemann-Molard et al., 1991; NIOSH, 1996; Jan et al., 2008).

Comment: EPA assumes that purported asthma-like symptoms observed in school children were due to a MDI exposure (Jan et al., 2008). However, the reported symptoms (dizziness, nausea, sore throat, and breathing difficulties) are more likely due to xylene, a known CNS depressant and upper respiratory tract irritant that was used as a solvent for the applied MDI. This theory is based on the following: (a) air monitoring was not conducted for either volatile organic compounds or MDI, and (b) despite the claim by Jan and coworkers, an earlier work referenced by the authors did not detect MDI near polyurethane tracks up to a week after application. Examination of another reference (Chang et al., 1999) reveals no mention of MDI measurements. Further support for the absence of an exposure to MDI comes from the observation that no MDA was detected in the hydrolyzed urine of school children purportedly exposed to MDI.
The extreme difference in volatility between xylene and MDI, the high xylene content compared to MDI in the applied product (0.1% MDI in xylene), as well as the symptoms consistent with xylene or other solvent exposure, indicate that the symptoms observed were most likely due to the inhalation of xylene.

Therefore, the Panel asks that EPA remove this reference because the Reactive Airways Dysfunction Syndrome (RADS)-like effects (*e.g.*, dyspnea, cough, headache) seen can be attributed to the irritating and highly volatile solvent, xylene. A more detailed critique of the Jan et al. (2008) paper concludes that due to significant lapses of proper scientific consideration, this paper should be regarded as unreliable, and should not be used as evidence of health effects attributable to MDI exposure. This review is attached to these comments as Appendix 2.

In conclusion, the reported symptoms (dizziness, nausea, sore throat, and breathing difficulties) are consistent with an exposure to xylene, a known CNS depressant and upper respiratory tract irritant, that was used as a solvent for the applied MDI (0.1% MDI in xylene) and it is inaccurate to attribute the symptoms to MDI asthma. In addition, no hydrolyzed MDI was found in the urine of the school children indicating a lack of exposure. The Panel recommends that EPA remove this reference for these reasons.

Page 5
Data shows that water from humidity in air can hydrolyze MDI thus forming the amine, methylene diphenyl diamine/toluene diamine (MDA), which also has hazards associated with

Page 7

EPA is aware that there is uncertainty about curing time of various products under different situations and that additional data are needed to address certain concerns, such as re-entry time, which are important for improving communication to prevent exposure.

Comment: Curing refers to the reaction that occurs between the two primary chemicals used to form a polyurethane product. These primary chemicals are commonly referred to as a diisocyanate (A-side material) and a polyol (B-side material). The A-side material, or diisocyanate, is highly reactive and curing begins immediately upon mixing with the B-side material. The cure time varies depending on the type of polyurethane product being produced, the ingredient formulations and other factors in the manufacturing process.

Many polyurethane products are completely cured and therefore considered "inert" before they are sold, such as mattresses, pillows, furniture cushions, car seating, refrigerator insulation, footwear, ski bindings or inline skates. This means that the original reactive ingredients, the diisocyanates and polyols, are no longer present in their original form in the cured polyurethane product.

Spray polyurethane foam (SPF) insulation is unique because the reaction between the A-side material (MDI in most cases for rigid foam insulation) and the B-side material (polyol) occur at the customer site. The diisocyanate (MDI) reacts quickly with the polyol to begin forming the foam insulation. Research studies by Lesage et. al., 2007 report that by the time 60 minutes has passed (post application time), airborne concentrations of MDI are below the analytical detection limit. Lesage *et. al.* also monitored the foam surface with isocyanate-indicating colorimetric wipes at various times after application. Their results showed the presence of removable isocyanate on the foam immediately after spraying, but in all cases (20 samples) no removable isocyanate was detectable on the foam surface 15 minutes after application.

There are various ways to define when SPF insulation is fully cured. Some look at certain physical properties of the installed SPF and believe when these have been achieved the insulation is cured (the SPF is tack-free within several minutes of application, and may achieve its desired physical properties within 24 hours of application). Others may look at the amount of unreacted isocyanate (which appears to be below the limit of detection on the surface of the foam within 15 minutes and below the limit of detection in the air within 2 hours after application). Additional discussion may be needed in this area to agree on an exact definition of cured SPF. However, each SPF manufacturer is knowledgeable about the curing characteristics of its particular SPF product(s). This information is used by the manufacturer in recommending re-occupancy times after SPF installation. Also, while curing time and re-occupancy time may be related, they are not necessarily one in the same.

In conclusion, there is a big difference between curing as it relates to completion of the physical characteristics of the product and emissions of airborne isocyanate (air emissions) from the product as it begins to cure immediately after application. It may take some PU products up to 24 hours to completely mature or develop all of its physical characteristics. However, MDI is generally non-detectable within the air and on the surface of the PU product within two hours after application without engineering controls (ventilation). Of course, with engineering controls, re-entry time can be significantly decreased.

Page 7

Consumer/General Population Exposure. The higher exposure operations identified in occupational settings (Booth et al., 2009) use polyurethane products which are most commonly used by consumers (e.g., spray foam, adhesives). Thus, consumers, bystanders, building occupants (including children), hobbyists and DIY applicators may be exposed to uncured MDI when using similar products.

<u>Comment:</u> The Booth et al. 2009 paper summarizes a large body of industry air sampling data (8,134 samples) in which airborne MDI concentrations were measured in a wide variety of manufacturing processes. A total of 606 industrial hygiene surveys were conducted for 251 companies at 317 facilities during the period 1984 through 1999. The product types evaluated during these industrial hygiene surveys included: binders (mostly to make composite boards such as OSB, engineered lumber, medium density fibreboard, and particleboard), coatings, adhesives, sealants, and elastomers (for applications such as manufacture of electronics, furniture, footwear, appliances, tires, etc...), and rigid foam applications (spray applied roofing insulation on commercial buildings and as wall insulation for residential homes).

Most of the data summarized in the Booth et al. paper are in exposure situations involving high volume usage of MDI/pMDI and full shift durations (e.g. 8-hour exposures). Although some of the product types (rigid foam, adhesives) might be used by consumers, the exposure potential would be much lower than an industrial or construction work environment.

Personal and area samples that were reviewed in the Booth et al. paper indicate that for most industrial operations/processes using MDI or pMDI, worker exposure to airborne MDI is below the occupational exposure limits. The paper emphasizes that the preponderance of personal sampling data show airborne MDI concentrations ranging below the limit of quantification (LOQ) to the TLV of 0.051 milligrams per cubic meter (mg/m^3). Only in operations where MDI is spray applied or used at elevated temperatures did airborne MDI concentrations exceed the TLV of 0.051 mg/m^3.

The paper further documents that workplace airborne MDI concentrations are extremely low in a majority of manufacturing operations. Most (74.6%) of the airborne MDI concentrations measured in the personal samples were non-detectable, i.e., below the limits of quantification (LOQ). The very low vapor pressure of both monomeric MDI and polymeric MDI largely explain the low airborne concentrations found in most industrial/construction settings evaluated. One would expect consumer exposures to be much lower than industrial/construction applications because of shorter durations of exposure and less volume of MDI/pMDI used per application. In addition, most of the consumer products that contain uncured MDI are not heated or spray applied during use by the consumer.

Only operations that include heating and/or spraying MDI/pMDI result in airborne concentrations above the TLV of 0.051 mg/m^3. Such operations include spray applying adhesives/coatings and installation of high pressure spray polyurethane foam insulation typically applied by professional trades. These operations are not likely to be performed by consumers, hobbyists, and DIY applicators.

Fomo Products cited one case study at the Federal Workshop meeting on February 15, 2012 at the ACC pertaining to testing for airborne MDI in a laboratory setting while using a cylinder foam product (low pressure, open cell foam product; product contains 10-15% free MDI). Only 2 of 15 samples taken directly at the source of spraying showed detectable levels. The Table below summarizes the data found:

Sample Type	**MDI (ug/m^3) [range]**	**# of Samples**	**# Non-detected**
Personal - Applicator	ND <1 to ND <8	11	11
Area Samples: Near (1-3 ft) Far (10-20 ft)	 ND < 1 ND < 0.9	 1 1	 1 1
Area: Source (< 18 inches)	ND < 6 to 51 (mean = 9.2)	15	13

A second study presented by Fomo Products pertained to the use of Low Pressure SPF Kit on an actual weatherization job in 2011 (Weatherization MDI Case Study, Environmental Investigation for Association for Energy Affordability, Project No. NJ11-0140). The work was performed by a BPI-certified building analyst and involved air sealing an attic and applying SPF in the basement of a residential structure. MDI monitoring was completed using OSHA Method 42/47. The contractor performing the work did use mechanical ventilation during the project. No airborne levels of MDI were found in the work areas during or after foam application. Sampling conducted one (1) hour after completion of work did not result in detectable airborne MDI concentrations in the attic, 2nd floor, or the 1st floor of the structure.

The Fomo weatherization study noted above is posted on EPA's Docket: EPA-HQ-OPPT-2011-0182 (http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPPT-2011-0182-0006).

In conclusion, although some of the product types (rigid foam, adhesives) might be used by consumers, the exposure potential would be much lower than an industrial or construction work environment because of shorter durations of exposure, much lower volumes of MDI/pMDI used per application, and consumer products that contain uncured MDI are not usually heated or spray applied during use by the consumer.

Page 7

In the U.S., only isocyanate monomers (e.g., TDI and MDI) are regulated, although similar polyisocyanates that are widely used in commercial and consumer products contain the same reactive isocyanates. EPA is concerned that there does not appear to be sufficient recognition that potential exposures of consumers and non-OSHA regulated workers to MDI, TDI and their related polyisocyanates may need to be addressed with similar recommendations for use of engineering controls, PPE, and hazard communication as those required for OSHA-regulated occupational settings.

<u>**Comment:**</u> Recognizing that there are potential exposures from pre-polymers used in commercial and consumer products, industry provides warning labels on the hazards of the monomers and pre-polymers (MDI and PMDI). For most operations/processes involving the use of MDI or PMDI, the airborne concentrations of these chemicals are typically non-detectable or very low in relation to the occupational exposure limit. See Lesage et al., 2007 and Booth et al., 2009 for more information. The very low vapor pressure of both monomeric MDI and PMDI (larger molecular weight structures) largely explain the low airborne concentrations. Airborne concentrations of MDI above the occupational exposure limit are unlikely except for those applications/processes where MDI or PMDI containing mixtures are spray applied (i.e. SPF or truck bed liner work), where MDI is adsorbed to cellulosic materials (such as wood fibers where heat/pressure is associated with this process); and where MDI/PMDI is heated well above 100 degrees F. In these applications, industry typically measures the 2 and 3 ring structures of MDI. If the 3 ring structure is collected on the sample media (impinger solution and backed up with a 13 mm filter) and detected during subsequent lab analysis, it indicates aerosolization is occurring.

In conclusion, industry recommendations for engineering controls, personal protective equipment, and hazard communication are the same for all pre-polymers as for the MDI monomer.

Page 8

Children exposed to the same airborne concentrations of MDI as adults may receive a larger dose because they breathe more per pound body weight and per unit respiratory surface area. Additionally, children may be more highly exposed to environmental toxicants through dermal routes than adults. For instance, children may crawl, roll or sit on surfaces treated with chemicals (i.e., carpets and floors) and play with objects such as toys where residues may settle. Similarly, children have a higher surface area relative to body weight, which would result in a greater dose relative to body weight for a child than for an adult with equivalent skin exposure (EPA, 2008a), and children are more likely to crawl, lay, or spend time on the floor. Children may have a greater potential for exposure if they use or are bystanders to the use of uncured MDI products, because they may not have fully developed judgment for following labeling instructions and safety precautions and may not cease activity even when they are experiencing symptoms of exposure. An accidental acute exposure of children to high levels of MDI in a polyurethane sealant used on a school athletic track was associated with asthma-like symptoms, including among children with no prior history of respiratory dysfunction (Jan et al., 2008). This observation is consistent with MDI being a well known source of occupational asthma. Children with asthma are an especially vulnerable population

for exposure; they are more susceptible to inflammatory narrowing of the airways, which results in a proportionally greater obstruction of their smaller respiratory system (NIH, 2011; Trasande & Thurston, 2005).

Comment: As commented previously, the reported symptoms (dizziness, nausea, sore throat, and breathing difficulties) are consistent with an exposure to xylene, a known CNS depressant and upper respiratory tract irritant, that was used as a solvent for the applied MDI (0.1% MDI in xylene) and it is inaccurate to attribute the symptoms to MDI asthma. In addition, no hydrolyzed MDI was found in the urine of the school children indicating a lack of exposure to MDI. For these reasons, the Panel recommends that EPA remove the reference, *Jan et al., 2008.*

There are recent publications looking at emission and migration of TDI from TDI-based flexible foam. (Arnold et al., 2012; Vangronsveld et al., 2013 in press).While all foams tested had detectable levels of solvent-extractable TDI, no TDI was detected in any of the emission or migration tests. Similar studies are currently underway for MDI-based products and based on the chemistry and physical chemical properties, similar results are expected.

The special needs and safety of children are integral considerations in the establishment of community exposure limits. Children live safer, healthier lives thanks in part to the development of many products and technologies made with diisocyanates chemistry that improve public health and safety.

The case is often made that children are more susceptible to asthma, and the exacerbation of pre-existing asthma, than adults. On a generic level, the physiological differences between children and adults (*e.g.*, breathing rates, lung size) can result in the lungs of children receiving a higher dose of any asthmogen at any given air concentration (Schwartz, 2004). Thus, an increase in the incidence of asthma in children could be more reflective of higher asthmogenic doses rather than an inherently higher susceptibility to asthma in general. This does not mean that the underlying cellular and biochemical processes that mediate an asthmatic response are more active or efficient in children.

Specifically with regard to diisocyanates, it is becoming increasingly clear that the macromolecular and cellular pathways that are associated with childhood asthma and predominate in early childhood (Th2) are different from those associated with the full manifestation of diisocyanate asthma in adults (Th1). This dichotomy in pathophysiology indicates that children are likely to be less susceptible to any given dose of diisocyanate-induced asthma than adults.

For example, while childhood asthma is characterized by the actions of Th2-type interleukins as well as the presence of IgE antibodies and eosinophilia (Levine and Wenzel, 2010; Liu and Wisnewski, 2003), IgE antibodies are found in only a small fraction (5-30%) of workers diagnosed with diisocyanate (TDI and MDI) asthma (Tee et al., 1998; Ott et al., 2007). Furthermore, Th1 pathway cytokines (e.g., interferon γ) participate in the full manifestation of the asthmatic response (e.g., bronchial hyperreactivity) of children to environmental allergens (Heaton et al., 2005) as well as the human (Liu and Wisnewski, 2003) and animal responses (Matheson et al., 2005) to TDI. Since the Th2 pathway generally predominates in early life while the Th1 pathway is less well developed, children can be less sensitive – not more sensitive – to the expression of atopy if exposed to diisocyanates because the Th1 pathway is required for full manifestation of an asthmatic response. Therefore, based on the above, the Panel contends that the emphasis on a unique health concern of children potentially exposed to diisocyanates is not supported by scientific evidence.

In conclusion, exposure of people and children to MDI in everyday life from fully cured products, such as by sitting on a carpet is not credible, as MDI would not be released from these consumer products in normal use, and the emphasis on a unique health concern of children potentially exposed to diisocyanates is not supported by scientific evidence.

Page 8

Rigid foam products containing MDI are predominantly used to make spray foam insulation by a variety of systems. Exposures to consumers are not well characterized. The exposure potential varies with the method and quantity used, particle size distribution, and end-product curing time. With two-component high pressure spray polyurethane foam systems, chemical migration between floors was noted with certain conditions. Area samples show that occupants and bystanders, including sensitive populations, may be exposed at levels above the workplace exposure limits (Crespo & Galan, 1999; Lesage et al., 2007; Bayer, 2009; IRSST, 2009).

Comment: Some of the referenced studies did identify that airborne MDI levels can exceed the OEL at distances of up to approximately 20 feet from the sprayer. In addition, Bayer (Karlovich, 2009) found that migration of airborne MDI to other floors of a building can occur during spraying; in two of five surveys conducted in residential structures, a slight migration of MDI from the floor being sprayed to lower floors was identified. In one survey, the airborne MDI levels identified on lower floors were 2.3 μg/m3 and 1 μg/m3. In the second survey, the levels identified were 5.9 μg/m3 and 2.2 μg/m3. Each of these concentrations is well below the MDI OEL of 51 $\mu g/m^3$.

As previously stated, current SPF industry recommendations by manufacturers are as follows:
1) the building should be vacated during SPF application;
2) where the building cannot be vacated, the spray application area should be contained/isolated and ventilated;
3) the spray area should be ventilated for a period of time following SPF installation;
4) building occupants should not return until after the manufacturer's recommended re-occupancy time (typically 24 hours) has elapsed.

These measures can prevent potential MDI exposures to occupants and bystanders.

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Appendix 1

Trends in the incidence/prevalence of diisocyanate related asthma in the workplace.

Executive Summary

Recent data from several sources on isocyanate-related asthma indicates a reduction in cases in the last decade. The data indicate that where controls and current exposure standards are met, new asthma cases can be eliminated.

Introduction

Tracking the frequency of diisocyanate related asthma is subject to different study designs and different metrics. The frequency of any disease in a population is reported through registries, surveillance schemes or compensation statistics. In a workforce, it is reported through epidemiologic studies. In such studies, incidence is a measure of the risk of developing some new condition within a specified period of time. Although sometimes loosely expressed simply as the number of new cases during some time period, it is better expressed as a proportion or a rate. Prevalence is the proportion of individuals in a population having a disease or condition at a given time. Another frequently used metric is attributable risk, which is the fraction of cases attributed to a specific risk factor (e.g. diisocyanate exposure).

The incidence, prevalence and relative frequency of diisocyanate asthma cases that arise due to exposure to diisocyanates, has been reported in many publications. In 1993 a review of occupational asthma and diisocyanates, Vandenplas et al (1993) noted that information on prevalence in exposed workers was scarce and restricted to some cross sectional studies that might underestimate actual prevalence. Nevertheless they concluded from the literature that some 25% of occupational asthma was related to diisocyanate exposure and that about 10% was a reasonable approximation for prevalence.

For the last decade and more, occupational exposure limits for diisocyanates have been set at low levels, generally at 5ppb (8 hour twa) and 20ppb for a short term exposure. These equate for MDI to 0.052mg/m^3 and 0.21mg/m^3 and for TDI to 0.036mg/m^3 and 0.14mg/m^3. Some limits are set for total isocyanate group concentrations (at 0.02 and 0.07 mgNCO/m^3 for short and long term exposures respectively in UK and Eire, which is equivalent to about 0.03 and 0.21 mg/m^3 for MDI, for example). The recent studies of diisocyanate related asthma should be of use in reassessing asthma prevalence, in context of compliance with the current exposure standards and improvements in worker training and industrial hygiene compliance

Recent Reviews

In a review of studies describing occupational diisocyanate asthma, Ott (2002) noted the annual incidence of TDI-related occupational asthma declined from 5.6% in a study covering the period 1961-1970, to 1.8% in a study of the period 1967-1979, and in a study covering 1980-1996 the annual incidence was 0.7%. The review also showed an improving reduction of exposures over time. Based on the epidemiologic literature, Ott et al (2003) drew the following conclusions:

1. The incidence of TDI induced asthma may have been as high as 5 % in the early years of the industry. Incidence rates have declined, paralleling the decline of exposure levels.

2. When 8-hour time-weighted-average exposure levels are maintained below 5 ppb, the annual incidence of TDI induced asthma is likely to be below 1 %.

3. There is limited evidence indicating that short-term exposure concentrations exceeding 20 ppb and occasionally exceeding 40 ppb have caused the initiation of TDI induced asthma.

A similar trend was noted by Diller (2002) who reviewed the literature and concluded that prevalence of diisocyanate induced asthma had repeatedly been above 10 % before 1985, but had been mostly between zero and 10% in years contemporary to the publication.

MDI and TDI Production Sites

It is certainly the experience that asthma cases occurring in production plants for the diisocyanates MDI and TDI can be avoided. In such plants exposures are avoided by applying good engineering controls and a trained workforce complying with current hygiene standards and good work practices. Table 1 shows no asthma cases were reported and only one case of other respiratory disease occurred in all TDI production sites in Europe, in 2000-2005 (III, Unpublished data).

Table 1: Reported respiratory disease in European TDI production sites.

Period	Site Activity	Reported Health Problems		
		Asthma	Other Respiratory	Skin disorders
2001-2003	TDI production	0	0	0
2001 - 2003	TDI production	0	0	0
2002 - 2005	TDI production	0	0	0
2003-2005	TDI production	0	0	0
2002 - 2004	TDI production	0	0	0
	Formulations	0	0	0
2005	TDI production	0	0	0
	Formulations	0	1	0
TOTAL		**0**	**1**	**0**

Total exposed population: 185 at <4 hrs/ day and 438 at >4 hrs/day, While the time basis and number of potentially exposed workers varies for each site, it can be concluded that with application of industrial hygiene practices meeting current regulations, the incidence of respiratory disease and asthma are well controlled.

One of the worksites detailed in Table 1 reported from earlier years that over a period of 27 years (1973 to 2000) there were 16 cases of asthma and 3 other respiratory disease cases with the last case being diagnosed in 2000. Personal sampling data for this site in years 2002 through 2004 were between <0.0015 mg/m^3 and 0.03 mg/m^3 (total isomers). Two samples in 2005 were 0.01 and 0.046 mg/m^3. This indicates that the recent exposure data which is compliant with current occupational exposure standards is not associated with occupational asthma cases.

It is notable that no skin disease has been reported for any TDI production plant.

EU National Data

Data on worker exposure and disease incidence collected for national review schemes and worker injury compensation claims, made available via government sources and publications, provide the majority of data on isocyanate asthma. The utility of these data depends on the basis of data collection for each. For example the UK SWORD system, (initiated in 1988), was based on the voluntary submission of monthly reports of all newly diagnosed cases of occupational respiratory illness which, in the opinion of specialist occupational and chest physicians, were work-related. In contrast to the SWORD system, the systems in Germany and other countries use specific and rigorous diagnosis, typically including a positive inhalation challenge.

In Germany, the cases of confirmed (recognised) isocyanate related disease for worker compensation steadily declined in the period 1990-2010 (DGUV, 2011) (Table 2).

Table 2 – Isocyanate related asthma - Germany

Year	1995	2000	2005	2010
Reported suspected cases	121	91	99	119
Recognised cases	59	45	35	30

In France, work related asthma assigned to isocyanates declined over the period 2001-2009 (Paris et al 2012), from 12.7% to 6.2% of all cases. During this time the decline in isocyanate-related cases was significant (P=0.007) even while the total numbers of cases due to all agents also declined.

In Switzerland, diagnoses of occupational respiratory disease due to diisocyanates has remained similar in the period 2005-2009, accounting for about 5% of all respiratory cases (SUVA 2011).

A study specifically to assess time trends in incidence of occupational asthma, used data from a workers' compensation scheme (Vandenplas *et al* 2011). Again, a general downward trend in isocyanate-related asthma was seen in Belgium in the period 1993-2002, with just 12 compensated cases in 2002.

In the UK, during the period 1992 – 2001, the annual rate ascribed to isocyanate exposure as causal in the SWORD system was consistent at about 14% of all occupational asthma, or an annual average of 84 cases (McDonald et al 2005). However, data from SWORD in the period 1989-1991 showed a higher proportion of occupational asthma ascribed to isocyanates of 22% (McDonald et al, 2000) and data for 2008-2010 gives an annual average of 44 cases (UK HSE 2011). Also in the UK, a regionally based system reporting occupational asthma in the West Midlands, an industrialized area, has made its occupational asthma and causative agents data available for 1999-2010 online (SHIELD 2012). While there is no information on the exposed population, the new cases ascribed to isocyanates from 2007-2010 are generally below earlier numbers (Table 3).

Table 3. New cases of asthma reported to SHIELD

	New cases ascribed to isocyanates
1999	13
2000	14
2001	24
2002	19
2003	21
2004	20
2005	11
2006	19
2007	12
2008	10
2009	3
2010	11

In Finland, the national register of occupational diseases reporting isocyanate related asthma cases from 1986 to 2002 (Piipari and Keskinen 2005) showed a decline from 22 cases in 1986 to 6 cases in 2002. These numbers representing 10% to 2% respectively all cases of occupational disease.

In the Netherlands, for the years 2000 through 2004, cases of occupational asthma per year reported to the Dutch Centre for Occupational Disease ascribed to isocyanates and anhydrides (grouped together) were few, with between none and 5 cases reported (Dekkers et al 2006). In the years 2009-2011 isocyanate-related cases were reported as none to 4 (Nederlands Centrum voor Beroepsziekten, 2012).

Other Data

In the Canadian Province of Ontario Buyantseva *et al* (2011) reported a reduced annual rate of successful isocyanate-related claims of occupational asthma for the period 1998-2002 (7.4 claims/year) compared to 1980-1993 (30.5 claims/year). The reduction was thought to be due partly to the active occupational surveillance scheme.

Discussion

The data from various national schemes present a broadly consistent picture, showing a reduction of diisocyanate related asthma cases over the last decade, against a background of increasing production and use. The absence of the actual numbers of potentially exposed individuals makes it impossible to calculate the prevalence of disease. While some reports derive a prevalence, these are usually based on small group of workers often with ongoing health problems and subsequently exaggerate the overall prevalence for the whole industry. To understand the true prevalence of disease a reasonable approach is to use the national statistics and estimates of workers in the industry.

The underlying reason for the reduction in isocyanate related asthma must be multi-factorial, including better compliance with exposure standards, improved work practices, use of less volatile isocyanate forms (e.g. prepolymers) and better surveillance programs. As several organisations have recognised some specific tasks, notably spray painting, are associated with higher asthma incidence, (McDonald et al 2000, Karjalainen et al 2002, Naylor and Curran, 2004, Cowie et al 2005, Pronk et al 2007, Byuntseva et al 2011) improving work practices in these applications offers the opportunity to reduce cases on asthma even further.

Conclusion

Various recent data on isocyanate related asthma incidence indicates a reduction in cases in the last decade. Where controls and current exposure standards are met, new asthma cases can be eliminated.

The German Committee on Hazardous Substances (AGS, 2006) concluded that if TDI exposure concentrations are kept below 10 to 20 ppb (0.07 - 0.14mg/m^3), generally no new cases of asthma are observed. Also that healthy workers were unaffected by occasional TDI exposures at or near a ceiling of 20 ppb. It is possible to conclude that where there is good control of exposures and compliance with current occupational exposure limits, then isocyanate asthma can be minimised. This is evidenced by the production site data where there is good training and surveillance and exposure control is rigorous.

MA Collins, PhD   3 May 2012, International Isocyanate Institute Inc., Manchester, UK

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Appendix 2

III Scientific Office
Critique of Jan et al. (2008)

Summary and Conclusion

A paper published by Jan et al. has been cited in several regulatory reviews as an example of public health effects from use of a reactive polyurethane product. The paper reports health effects experienced by school children in Taiwan following the application of an MDI-containing outdoor track surfacing product. Upon even casual reading of the paper, numerous problems with the paper are evident. For example, simple items such as spelling errors (e.g. the use of "tract" when "track" is intended) call into question the quality of both peer review and editing that was applied to the paper. On the more scientific level, there is a fundamental question about attribution of health effects to MDI without considering the possible or probable role of other chemicals known to be present. Also, there is an apparent misunderstanding of air concentration data and exposure guidelines, as well as frankly erroneous attribution of MDI exposure data to a reference which, upon inspection, contains no such data. Because of these significant lapses of proper scientific consideration, this paper should be regarded as unreliable, and should not be used as evidence of health effects attributable to MDI exposure.

Critique Details

The details of the major criticisms of the paper outlined above are given below;

- **False statement** - One of the most egregious errors in this paper appears to be a false statement concerning earlier work done by one of the authors: in the last page of the paper, the authors say, "We previously showed that polyurethane athletic tracks continue to release certain isocyanates and volatile solvents during the paving process and beyond. Adjacent to such tracks, air levels of MDI were easily detectable even after the first week of tract (sic) installation [11]" There is no mention of isocyanates in the 1999 paper referenced [Chan et al., 1999]; which measures and discusses individual and total VOCs.

- **Attribution of noted effects (CNS) to MDI** - Jan et al. reports on acute respiratory symptoms following exposure to MDI and xylene. They distinguish between immunologic and irritant-induced asthma or reactive airway dysfunction syndrome (RADS) and provide two references of previously reported MDI – induced RADS. Only one of the two actually involved MDI (Leroyer et al. 1998) and interestingly enough this case also involved MDI mixed with a solvent. The MDI exposure in the Jan paper was not described; a "mixture of MDI and xylene" was the material spilled during the incident. The acute symptoms consisted of dizziness, nausea, sore throat, and breathing irregularities, symptoms associated with solvent exposure and specifically xylene, which is well known to cause acute to chronic CNS encephalopathy. MDI on the other hand, has not been associated with CNS symptoms, except in the presence of other confounders such as when mixed with solvents and other chemicals (Herbert et al.

1995, Longley 1964) and in litigation cases (Reidy 1994). However, a detailed review found no evidence of CNS effects of MDI exposure (Carson et al. 2011). In conclusion, we do not believe that the health effects reported by Jan et al., can be linked to MDI exposure. In addition, local newspaper reports of the incident attributed the children's symptoms to xylene (per communication of Alex Xu, BASF via William Robert, BASF)

- **Misstatements concerning MDI concentrations** – in the abstract, the authors state, "In a simulation, we found the raw material used for tract (sic) surfacing, primarily MDI dissolved in xylene, to be present at a concentration (870 ppm w/w) more than 8000-fold the level defined as safe for a working environment". In the results section, the authors explain, "The raw material used for track surfacing was found to be primarily MDI dissolved in xylene at a concentration of 870 ppm w/w, by use of the reference Occupational Safety and Health Administration analytical method 42 [6], more than 8000-fold the recommended safe minimum inhalation concentration for a working environment [7]". It appears that the authors have a poor understanding of the application of OSHA occupational exposure limits (OELs). The OEL referenced is the NIOSH REL – 0.005 ppm (8-h TWA), 0.02 ppm (Ceiling) in air on a molar volume (i.e., v/v) basis. The authors' statement implies that they somehow applied the OSHA Method 42 (1,2-pyridyl piperazine derivatization air monitoring filter method) to assay the composition of the bulk liquid solution (as further indicated by the weight basis designation (i.e., w/w), as would be typical for reporting liquid solution compositions). The authors then apparently proceeded in a conceptually flawed approach to compare the liquid concentration with the air concentration somehow, although it is unclear how they arrived at the factor of 8000. For example, 870 ppm / 8000 = 0.109 ppm; 870 ppm / 0.02 ppm = 43,500; 870 ppm / 0.005 ppm = 174,000.

Poor logic in statement of attribution of effects to MDI – In the results section of the paper, the authors make the statement, "The direct cause-effect relationship for MDI exposure and health effects on the students was confirmed by an inverse linear relationship between the incidence of students in various classrooms and the distance from the site of MDI spillage ($r = -0.48$, $p<0.05$) [Fig. 2]" *(Note: the text reports a value of -0.48 for r yet the figure indicates 0.51).* Figure 2 is included below for reference. The poor correlation indicated might demonstrate some association of effects in the children with the site of the spill, but says nothing about what component of the spilled material caused the effects – if xylene were the causative agent, the data would look the same.

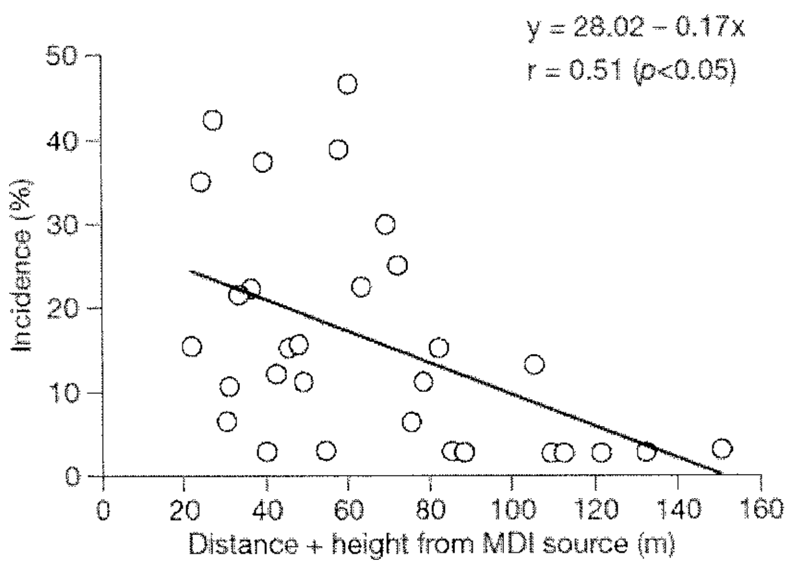

Fig. 2. Linear relationship between the incidence of affected students in various school classrooms and distance/height combinations from the suspected methylene diphenyl diisocyanate (MDI) emission source.

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MDI and the National Toxics Inventory

10th Annual Emission Inventory Conference

Bill Robert
BASF, Diisocyanates Panel

Scott Schang
Latham & Watkins

Adams Mark Hotel
Denver, Colorado
May 3, 2001

Diisocyanates Panel

- The Diisocyanates Panel is a self-funded panel of the American Chemistry Council that represents the major manufacturers of diisocyanates, including MDI.
- Members of the Panel are BASF Corporation, Bayer Corporation, The Dow Chemical Company, Huntsman Polyurethanes, and Lyondell Chemical Company.