

# Health Consultation

---

Exposure Investigation Report

AIRBORNE EXPOSURES TO MOISTURE CURE URETHANE (MCU)  
IN MULTI-FAMILY RESIDENTIAL BUILDINGS

NEW YORK, NEW YORK

MAY 27, 2005

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  
1-888-42ATSDR

or

Visit our Home Page at: <http://www.atsdr.cdc.gov>

HEALTH CONSULTATION

Exposure Investigation Report

AIRBORNE EXPOSURES TO MOISTURE CURE URETHANE (MCU)  
IN MULTI-FAMILY RESIDENTIAL BUILDINGS

NEW YORK, NEW YORK

Prepared by:

Agency for Toxic Substances and Disease Registry  
Division of Health Assessment and Consultation  
Exposure Investigations and Consultation Branch

---

## Table of Contents

Executive Summary .....	1
Objectives and Rationale .....	3
Background .....	4
Adverse Health Effects of Ethyl Benzene, Xylenes, and TDI.....	4
Ethyl Benzene .....	4
Xylenes .....	5
TDI.....	5
Children’s Susceptibility.....	6
Exposure Limits for Ethyl Benzene, Xylenes, and TDI .....	7
New York State Regulation of VOC Content in Varnishes.....	8
Methods.....	8
Exposure Investigation Design .....	8
Target Population.....	9
Informed Consent .....	9
Questionnaire .....	10
Indoor Air Testing.....	10
Data Collection .....	10
Air Monitoring and Sampling Procedures .....	12
TDI.....	12
VOCs.....	14
Results.....	16
TDI.....	16
VOCs .....	16
Charcoal Tubes .....	16
SUMMA® Canisters .....	18
PID Readings .....	20
Questionnaire Results .....	26
Discussion.....	27
Limitations .....	27
TDI.....	28

Ethyl Benzene and Xylenes .....29

Regulatory Issues .....30

Occupational Health Issues.....31

Conclusions.....31

Recommendations.....31

Authors, Technical Reviewers .....34

References.....35

Appendix A: Criteria and Rationale for ATSDR Levels of Concern for Ethyl Benzene,  
Xylenes, and TDI..... A-1

Appendix B: EI Protocol.....B-1

Appendix C: Map of the Hasidic community in Williamsburg, Brooklyn, New York .....C-1

Appendix D: Labels from MCU containers in use during the EI ..... D-2

## **Executive Summary**

In March 2003, the New York City Department of Health and Mental Hygiene (DOHMH) conducted an exposure investigation (EI) in the Williamsburg Hasidic community in Brooklyn, New York. The investigation was conducted in response to odor complaints and health concerns related to the use of moisture cure urethane (MCU) in multi-family apartment buildings.

Many residents use MCU as a finish on their wood floors because of its durability, humidity tolerance, and high gloss finish. During its application and curing, MCU releases several chemical vapors into the air. The main chemical vapors released are toluene diisocyanate (TDI) and the volatile organic compounds (VOCs), ethyl benzene and xylenes. When MCU is fully cured, it is completely dry and no vapors are released. MCU cures in about 48 hours.

DOHMH found TDI, ethyl benzene and xylene vapors in a hallway outside an apartment treated with MCU. They also found low levels of ethyl benzene and xylenes in a nearby apartment. Because of these findings, DOHMH recommended that residents not use MCU inside the apartment buildings unless vapors were vented to the outside of the building during application and curing.

However, widespread use of MCU continued, as did complaints about odors and illnesses from residents near apartments in which MCU was used. In September 2003, DOHMH asked the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct an EI to help determine if MCU use in the buildings could pose a health threat to residents.

ATSDR conducted the EI with the following three objectives in mind:

1. To find out if TDI and VOC vapors were entering neighboring apartments or shared hallways during or after MCU was applied.
2. To find out whether exposures to the vapors were occurring at levels that could be harmful to health (especially the health of children).
3. To find out how long the vapors persisted in the treated apartment after the final coat of MCU was applied.

In March 2004 ATSDR, DOHMH, and the New York State Department of Health (NYSDOH) conducted indoor air testing in the Williamsburg community. The testing was done in neighboring apartments and hallways near two apartments being treated with MCU. The purpose of this testing was to find out whether significant levels of TDI and VOCs entered these areas during and after MCU use. One treated apartment was monitored after the final coat of MCU to determine the duration of vapor emissions.

The results show that VOCs, specifically ethyl benzene and xylenes, likely exceeded exposure limit guidelines in a neighboring apartment and a shared hallway following MCU use in nearby apartments. The potential for involuntary exposure is a concern, especially for infants and young children.

Within 24 hours after the third coat of MCU, ethyl benzene and xylene levels inside the treated apartment were below the ATSDR minimal risk level (MRL). However, VOCs were elevated for at least 43 hours.

TDI was not detected during this EI. However, the EI was limited in scope, and these negative findings must be interpreted with caution. In addition, equipment failure prevented us from capturing any TDI emissions that might have been present in the treated apartment after MCU use.

The EI findings show that ethyl benzene or xylenes, or both were likely to be present at potentially hazardous levels in neighboring apartments and hallways during and after MCU use. Therefore, ATSDR recommends that MCU not be used in occupied, residential multi-family buildings.

Potential exposures from MCU use in other occupied buildings, such as office buildings and schools, should also be considered. Community health education efforts should target potential health effects from MCU and other VOC exposures, along with the safe use and handling of these products. Health care provider education should target patient assessment for environmental exposures to MCU and other sources of VOCs.

---

## Objectives and Rationale

In March 2003, the New York City Department of Health and Mental Hygiene (DOHMH) conducted an investigation into a possible link between the use of a type of wood floor finish — generically known as moisture cure urethane (MCU) — and adverse health effects [1]. A local organization by the name of Healthy Environment and Safety Solutions (HESS) requested the investigation. The request was based on health complaints that residents in the Hasidic section of Williamsburg in Brooklyn attributed to MCU use in neighboring apartments. Of particular concern were asthma-like reactions in children.

MCU contains diisocyanates, typically toluene diisocyanate (TDI), as well as volatile organic compounds (VOCs), predominantly xylenes and ethyl benzene. These volatile chemicals are released into the air during MCU application and curing [1,2,3]. The DOHMH investigation demonstrated that VOCs — particularly ethyl benzene and xylenes — and TDI were found outside of apartments in which the MCU was applied [1]. The maximum TDI level in a 2-hour hallway sample collected outside the treated apartment was 0.87 parts per billion (ppb). No TDI was detected inside a neighboring apartment. The maximum ethyl benzene and xylene levels found in 1-hour hallway samples were 35 parts per million (ppm) and 53 ppm, respectively. These VOCs were also detected inside a neighboring apartment, but at much lower levels.

Peak and time-weighted average concentrations, and the duration of exposure help determine whether a health hazard exists. The samples collected by DOHMH might not have captured the peak (or maximum) concentrations of TDI and VOCs. In addition, the DOHMH investigation did not determine the amount of time that vapors remained in the treated apartment and nearby areas after the final coat of MCU.

In September 2003, the DOHMH asked the Agency for Toxic Substances and Disease Registry (ATSDR) to conduct an exposure investigation (EI) to further characterize exposures from residential MCU use. ATSDR agreed to conduct the EI to determine whether these exposures pose a health threat to residents.

The EI had three objectives. The first was to measure peak and time-weighted average levels of TDI and VOCs in a residential apartment building. More specifically, ATSDR planned to measure these levels in targeted areas within the building during MCU use in one of the apartments. The second objective was to evaluate whether exposures to these substances could occur at levels that pose a health threat to building residents, especially children. The third objective was to determine the amount of time required for TDI levels to subside to non-detect and for VOCs to return to background levels within the treated apartment.



## **Background**

MCU is a highly durable sealant typically used in commercial and industrial settings where resistance to abrasion and corrosion is essential. These include bowling alleys, indoor basketball courts, marine environments (e.g., piers, bridges, and ships), concrete surfaces, structural steel, and other industrial uses [1,2]. The product's durability and high gloss finish, along with word-of-mouth advertising, have also made it the wood floor treatment of choice among many Hasidic Jewish families living in Williamsburg, Brooklyn, New York. However, some families are concerned about potential adverse health effects resulting from exposure to MCU emissions when it is used in adjacent or nearby apartments.

Housing in the Williamsburg community consists primarily of multi-family apartment buildings. Occupants of apartments in which floors will be treated usually move out before the MCU is applied and return after the final coat is dry. Occupants of other apartments within the same building — including those immediately adjacent to the apartment being treated — often do not move out. In fact, they often do not even know about the MCU treatment until application begins, at which point making temporary living arrangements elsewhere could be impossible.

HESS received numerous resident complaints of strong odors, respiratory distress, and other symptoms during and after MCU use in other apartments. As a result, HESS launched an extensive campaign against using MCU in the Hasidic community. The campaign included providing educational information about MCU to the community and to medical clinics, as well as alerting the DOHMH to the issues and requesting their involvement. DOHMH subsequently conducted the 2003 investigation.

In February 2004, after interviewing several residents and local physicians, the Rabbinical Court of Brooklyn, consisting of nine rabbinical leaders, issued a ban against residential MCU use in the community. Twenty-three additional rabbis endorsed the ban [4]. The efforts of HESS along with the rabbinical ban convinced many community members to switch to floor treatments more appropriate for residential use. Nevertheless, many residents continue to use MCU.

## **Adverse Health Effects of Ethyl Benzene, Xylenes, and TDI**

### *Ethyl Benzene*

Short exposures to high levels of ethyl benzene primarily cause respiratory tract irritation, eye irritation, burning and tearing, fatigue, and neurologic symptoms (such as dizziness and headache). These symptoms have been documented in human studies and case reports from exposure levels exceeding 1000 ppm [5]. The usefulness of these studies is limited by inadequate information about exposure levels, duration, and measurement methods [5]. For adults, once the exposure has ended, most acute symptoms (i.e., intense symptoms that occur quickly) dissipate without lasting effects.

Available information regarding the effects of ethyl benzene exposure in children is also limited [5,6]. However, a growing body of evidence recognizes the role of indoor air pollutants in the development of asthma and in the exacerbation of asthma symptoms in young children [7,8,9,10]. The most consistently implicated VOCs are toluene and benzene, but ethyl benzene exposure has also been suggested as a potential cause of increased asthma risk [7,9,10].

### *Xylenes*

Central nervous system (CNS) effects and eye and respiratory tract irritation are the primary effects of exposure to xylenes. Xylenes refer collectively to the isomers o-xylene, m-xylene, and p-xylene, all of which possess similar properties [11]. Mild CNS effects, including decreased reaction time, decreased short-term memory, lightheadedness, and unsteadiness are documented from exposures of 100 ppm for 4–6 hours [11]. One study in healthy male volunteers documented prolonged reaction time after 4 hours of exposure at 100 ppm [12]. The differences in reactions could be sex-based. Women volunteers reported headache and dizziness after 1–7.5 hours of daily exposure for 5 days to 100 ppm, but men exposed at 150 ppm did not [13]. Eye, nose and throat irritation has been documented in healthy volunteers from 3–5 minute exposures at 200 ppm [13,14].

Little or no information is available regarding the health effects of xylene exposures in children [6,11]. However, some data suggest that pregnant women, fetuses, and very young children could be unusually susceptible to the toxic effects of xylenes [11]. For pregnant women exposed to xylenes, ingestion of aspirin could increase the effects of xylenes in both the mother and offspring. The ability of fetuses and very young children to metabolize certain xenobiotics (i.e., chemicals not naturally found in the body) is reduced because of their immature enzyme detoxification systems [11].

### *TDI*

TDI is a powerful irritant to the mucous membranes of the respiratory tract, the eyes, and the skin. TDI is also a respiratory tract and skin sensitizer. Exposures to TDI (and diisocyanates in general) might not only exacerbate existing asthma and other chronic respiratory conditions, but might actually cause asthma [15,16,17,18]. In fact, diisocyanates are a leading cause of occupational asthma worldwide [16,17]. The mechanisms by which TDI causes asthma are not completely understood. However, increasing evidence supports both immunological and non-immunological mechanisms, including interactions between the human immune response and airway epithelium, and genetic susceptibility [17,18,19].

Exposure to TDI can cause some people to become sensitized in a way that is, at least in part, similar to becoming sensitized, or “allergic” to ragweed or animal dander. Once sensitization has developed, subsequent re-exposure to very small amounts of TDI can induce asthmatic reactions. In workers who were previously sensitized, subsequent

exposures to as little as 1.0 ppb of TDI caused asthmatic reactions ranging from mild to severe, including fatal reactions [16,19].

Exactly what level and duration of exposure induces TDI sensitization is not clear. Most of what is known about TDI-induced asthma is based on animal studies and occupational exposures. Opinions differ as to which type of exposure is most often responsible for inducing sensitization in humans. Existing evidence suggests that sensitization results from acute exposures to relatively high levels of TDI (perhaps >20 ppb), or from chronic exposures to lower levels. No documented evidence suggests that sensitization in humans develops after short-term, low-dose exposures [16,19,20].

Recent reports link non- or para-occupational TDI exposures in adults with TDI sensitization and asthma. However, data on the associated exposure levels are not available [21,22]. There is little guidance on non-occupational exposures to TDI, and little or no data on the health effects of TDI exposure in children.

### **Children's Susceptibility**

There are differences between children and adults in chemical exposure rates, absorption, metabolism, and organ development, making children uniquely vulnerable to environmental hazards [5,6,7,11,23,24,25,26]. For example, children tend to have a faster metabolic rate. While in some instances this can be protective, in others it can increase susceptibility [26]. Children also have a faster breathing rate, more lung alveolar surface area, and more skin surface area compared to their body mass. All of these characteristics could increase their internal dose compared to an adult when both are exposed to the same concentration of a given chemical [25,26].

Because children are still growing and developing, they have “windows of vulnerability” when their target organs could be more susceptible to environmental toxins [5,6,7,11,25,26]. Metabolic processes develop over time. A particular metabolic process could be inactive, or active to a lesser degree, compared to the same process in an adult. For example, fetuses and very young children have immature enzyme detoxification systems, resulting in a reduced ability to metabolize certain xenobiotics [11]. Another example of this “window of vulnerability” involves the myelin sheath. The myelin sheath is generally incompletely formed until age 2–3 years, increasing the potential for neurotoxic effects from certain exposures [6,11,26]. In addition, growing and developing children are vulnerable to toxins, which have the potential to reduce or arrest some aspect of growth and development [6,26]. In fact, there is a growing body of evidence suggesting that during infancy and early childhood the respiratory system might be particularly susceptible to exposure to environmental toxins, including VOCs. Such exposures in early childhood could increase the risk for developing asthma [7,8,9,10,24].

The compounds of concern in this EI — ethyl benzene, xylenes, and TDI — are all heavier than air and tend to sink toward the floor, increasing the likelihood that they would be at higher concentrations within a small child's breathing zone [5,6,11,23,24,25]. Consequently, a small child could be exposed to higher levels of these compounds than an adult in the same room.

Scientific understanding about the specific effects of ethyl benzene, xylene, and TDI exposure in children is limited. Nevertheless, some toxicological and physiological evidence suggests that children could be more vulnerable than adults to the toxic effects of these chemicals. A key message from the 10-year Children's Health Study is that the first year of life is an extremely important time for respiratory health. Young children might be uniquely susceptible to factors responsible for the development of asthma [23]. This message emphasizes the importance of minimizing children's exposures to air contaminants, especially those with known adverse respiratory effects.

### **Exposure Limits for Ethyl Benzene, Xylenes, and TDI**

The relative toxicity of a chemical is an important factor in assessing the potential health risk from exposure. However, the response of the human body to a chemical exposure is determined by many factors. Factors related to the exposure itself include the magnitude of the exposure (how much), the duration of the exposure (how long), and the route of the exposure (breathing, eating, drinking, or skin contact). After exposure has occurred, individual characteristics such as age, sex, nutritional status, overall health, and genetic make-up influence how the chemical is absorbed, distributed, metabolized, and eliminated from the body. Lifestyle factors (e.g., occupation and personal habits) could also have a major impact. Combinations of all these factors determine an individual's physiological response to chemical exposures and to the subsequent adverse health effects that might ensue.

Exposure limit guidelines (i.e., recommended maximum concentration for a specified duration of exposure) for many chemicals have been developed by governmental and professional agencies. Although most of these guidelines pertain to occupational exposures, a limited number apply to non-occupational exposures. However, even less information is available regarding the effects of exposures in children.

In particular, exposure limit guidelines for residential exposures to ethyl benzene, xylenes, and TDI in indoor air are limited. The available guidelines address acute (short-term) health threats such as workplace exposures or catastrophic exposures considered immediately dangerous to life or health (IDLH).

Based on the exposure scenarios and available exposure guidelines, ATSDR identified levels of concern for potential health threat. These levels of concern are for a) initial screening, b) exposures lasting up to 1 hour, and c) exposures lasting up to 15 minutes. In addition, levels were compared to the ATSDR minimal risk levels (MRLs). The MRL is an estimate of daily human exposure that is unlikely to be associated with any appreciable non-cancerous health risk over a specified duration of exposure [28]. Appendix A provides a detailed explanation for how and why we developed these exposure limit guidelines.

The exposure limit guidelines used to evaluate exposures to ethyl benzene, xylenes, and TDI are summarized in Table 1. These guidelines address potential non-cancer health threats since these chemicals are not classified as carcinogens by the International

Agency for Research on Cancer (IARC) or the EPA or both [5,11,27]. Exceeding these exposure guidelines does not necessarily indicate the presence of a health threat.

**Table 1. ATSDR exposure limit guidelines for ethyl benzene, xylenes, and TDI**

Chemical	MRL	Screening Level	Exposures <1 hour	Exposures <15 minutes
Ethyl Benzene	1.0 ppm*	2.4 ppm	5.0 ppm	12.5 ppm
Xylenes	1.0 ppm <sup>†</sup>	2.4 ppm	5.0 ppm	12.5 ppm
TDI	NA	0.15 ppb	1.0 ppb	1.0 ppb

\* Intermediate exposure duration (14–365 days)

<sup>†</sup> Acute exposure duration (0–14 days)

NA – not available

### New York State Regulation of VOC Content in Varnishes

The New York State Department of Environmental Conservation (NYSDEC) Regulation 6 NYCRR Part 205 (Architectural and Industrial Maintenance [AIM] Coatings) restricts the VOC content in architectural surface coatings. It allows a maximum VOC content of 450 grams per liter (g/L) in varnishes [29]. The regulation was amended as of January 1, 2005, lowering the maximum allowable VOC content in varnishes to 350 g/L [30].

Since MCU is considered a varnish, this regulation is relevant to the EI and will be addressed later in the report [29]. VOCs are a major contributor to the production of ozone, and this regulation is part of an effort to achieve compliance with the U.S. EPA's National Ambient Air Quality Standard (NAAQS) for ozone.

## Methods

### Exposure Investigation Design

This EI was designed to collect short-term, residential, indoor air monitoring and sampling data associated with MCU emissions (TDI and VOCs). The EI protocol is provided in Appendix B.

Air monitoring refers to the continuous, real-time measurement of chemical vapors over a period of several hours or days. Air sampling refers to discrete air samples drawn over a finite period, such as 1 minute, 15 minutes, or 2 hours. Typically, these samples are submitted to a laboratory for analysis. Air monitoring helps determine when to take

samples (e.g., to capture peak concentrations). Air sampling results can validate the readings from real-time monitors and show the actual concentrations of individual chemicals present at the time of sampling.

ATSDR selected air monitoring and sampling methods to determine

- a. Background levels in the treated apartment, in nearby hallways, and neighboring apartments prior to MCU use,
- b. Peak and time-weighted average air concentrations in hallways and neighboring apartments after MCU use in another apartment, and
- c. The approximate duration of MCU emissions in a treated apartment after the final coat was applied.

These specific methods are described in the “Air Monitoring and Sampling Procedures” section.

### **Target Population**

The specific population for this EI included five Hasidic Jewish families living in Williamsburg, Brooklyn, New York. The population potentially affected by the results of the EI includes all Hasidic Jewish families living in multi-family apartment buildings in Williamsburg whose neighbors might treat their floors with MCU. This community covers an area of approximately 20-square blocks. The population of the entire Williamsburg Hasidic community, based on census tract data, is approximately 34,000 [31]. The majority (~ 90%) of these families live in multi-family apartment buildings of three or more units. Less than 1% live in single, detached homes, and less than 2% live in attached 2-unit homes [31]. Appendix C shows a map of the community.

### **Informed Consent**

Four families initially participated in the EI. One of these families had arranged to have their floors treated with MCU; the other three families live in nearby apartments. The purpose of the EI and any benefit or risk was explained to at least one adult member in each household. Investigators encouraged and answered questions from participants. Each participant read and signed the consent form, which was available in English and in Yiddish [Appendix B]. Two participants requested the Yiddish version. HESS provided verbal Yiddish translation when needed.

Another apartment building and participant family were added to the investigation on March 10<sup>th</sup> (the third day of the EI). The rationale for adding this sampling site is explained in the “Indoor Air Testing” section. The fifth participating family lives in an apartment above one being treated with MCU. This family had temporarily re-located by the time EI sampling began on March 10<sup>th</sup>. However, the head of the household provided verbal consent via a HESS representative for ATSDR and the New York State Department of Health (NYSDOH) to conduct air testing in the apartment. Access to the apartment for testing was provided by the HESS representative.

## Questionnaire

For three of the five testing locations, ATSDR investigators administered a short, two-part household questionnaire to an adult member of the household. The questionnaire was designed to gather demographics of household members and identify the presence of substances in the home that could affect testing results [Appendix B].

For residents of the treated apartment, investigators administered only Part-1 of the questionnaire. The questions in Part-2 pertained to those days during and after MCU use, when these residents were not at home. For the apartment added to the EI on March 10<sup>th</sup>, residents were unavailable to respond to the questionnaire.

## Indoor Air Testing

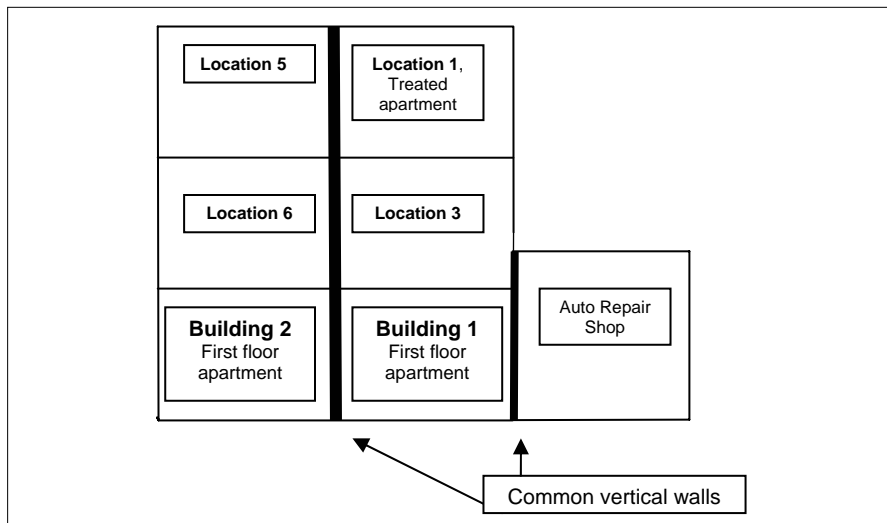
### Data Collection

Through an interagency agreement with the U.S. Environmental Protection Agency Environmental Response Team, ATSDR obtained assistance from the Response, Engineering, and Analytical Contract (REAC). REAC conducted the indoor air testing for TDI and VOCs.

Air monitoring and sampling were conducted in the homes of five families. HESS identified two families who planned to treat their floors with MCU. One of these families was willing to participate in the EI. The other four families live near the apartments that were to be treated with MCU.

Four of the five families live in Buildings 1 and 2, which are side-by-side, 3-story, older buildings that share a common wall and have one apartment per story [Figure 1]. The family living in the 3<sup>rd</sup> floor apartment of Building 1 was having their floors treated. The other three families live in the 2<sup>nd</sup> floor apartment of Building 1 (directly below the treated apartment), and in the 2<sup>nd</sup> and 3<sup>rd</sup> floor apartments in Building 2.

**Figure 1. Diagram of Buildings 1 and 2**



The fifth family lives in a 2<sup>nd</sup> floor apartment of Building 3 (not shown), directly above a 1<sup>st</sup> floor apartment that was being treated with MCU. Building 3 is a six-story, newly constructed building, with two apartments per story.

Building 3 had been considered, but not initially selected, as an EI testing location. Because work inside the building was not completed, only a few occupants had moved in at the time of the EI. Investigators were especially concerned that VOC emissions from ongoing interior finishing work in some of the apartments could interfere with testing results. Nevertheless, Building 3 was included as a testing site on March 10<sup>th</sup>.

Investigators discovered that Buildings 1 and 2 represent some of the older apartment buildings in the area, but not the majority of apartment buildings in the Hasidic community. In recent years, widespread remodeling and new construction have created significant differences between older and newer buildings. These differences include size, architectural design, and heating/ventilating/cooling systems. Since Building 3 is more representative of these new or remodeled apartment buildings, investigators ultimately decided that sampling there might provide useful data.

In addition, upon arriving to conduct the EI, investigators discovered that Building 1 (already selected for the EI) shared a common wall with a small automotive repair shop [Figure 1]. Investigators realized that air emissions from the auto repair shop could also interfere with air testing results.

Because testing in Building 3 was not initially planned, only limited equipment was available for use in Location 7. REAC conducted the TDI testing, while NYSDOH monitored VOC levels. Table 2 describes the EI sampling locations. Table 3 shows the locations, dates, and times of MCU applications.

**Table 2. Description and identification of EI sampling locations**

Location ID	Location Description
1	Building 1 – 3 <sup>rd</sup> Floor Apartment (B-1/3 <sup>rd</sup> floor apt.) (floors treated with MCU on March 9, 10, 11, 2004)
2	Building 1 – 3 <sup>rd</sup> Floor Hallway (B-1/3 <sup>rd</sup> floor hall)
3	Building 1 – 2 <sup>nd</sup> Floor Apartment (B-1/2 <sup>nd</sup> floor apt.)
4	Building 1 – 2 <sup>nd</sup> Floor Hallway (B-1/2 <sup>nd</sup> floor hall)
5	Building 2 – 3 <sup>rd</sup> Floor Apartment (B-2/3 <sup>rd</sup> floor apt.)
5A	Building 2 – 3 <sup>rd</sup> Floor Apartment (Child's Bedroom) (B-2/3 <sup>rd</sup> floor apt. - Child's BR)
6	Building 2 – 2 <sup>nd</sup> Floor Apartment (B-2/2 <sup>nd</sup> floor apt.)
7	Building 3 – 2 <sup>nd</sup> Floor Apartment (Child's Bedroom) (B-3/2 <sup>nd</sup> floor apt. - Child's BR)



**Table 3. Dates, times, and locations for MCU applications**

Location ID	Location	Date	Time
1	Building 1, 3 <sup>rd</sup> Floor Apt.	3/9/04	16:15
1	Building 1, 3 <sup>rd</sup> Floor Apt.	3/10/04	11:25
1	Building 1, 3 <sup>rd</sup> Floor Apt.	3/11/04	15:40
8	Building 3, 1 <sup>st</sup> Floor Apt.	3/10/04	16:00
8	Building 3, 1 <sup>st</sup> Floor Apt.	3/11/04	16:30 (estimated)

The brand of MCU applied on the floors in Location 1 was TC Dunham. HARCO brand MCU was used at Location 8. At the time they were used, both brands exceeded the state regulation for VOC content [29]. The labels of these products are shown in Appendix D.

### **Air Monitoring and Sampling Procedures**

MCU applications in Location 1 occurred on March 9<sup>th</sup>, 10<sup>th</sup>, and 11<sup>th</sup>, 2004. On March 8<sup>th</sup>, prior to the first MCU application, REAC conducted indoor air monitoring and sampling for baseline VOC levels and background TDI levels [32]. Due to emissions from both the auto repair shop and the interior finishing work in Building 3, initial VOC levels were not expected to reflect typical background VOC levels for indoor air. Therefore, the term “baseline” is used to indicate the starting point for VOC levels.

From March 9<sup>th</sup>–12<sup>th</sup>, REAC used air testing devices in Locations 2–6 [32]. On March 12<sup>th</sup>, monitors were returned to Location 1 to measure vapor emissions following the 3<sup>rd</sup> MCU coat.

MCU use in Location 8 occurred on March 10<sup>th</sup> and 11<sup>th</sup>. REAC and NYSDOH conducted air monitoring and sampling in Location 7 (one story above Location 8) on March 10<sup>th</sup>–11<sup>th</sup> [32, New York State Department of Health, unpublished data, 2004]. No air monitoring or sampling was conducted in Location 8.

### ***TDI***

#### *Air Monitoring*

Four Zellweger Analytics Single Point Monitors (SPMs) equipped with the ChemKey® and Chemcassette® detection systems were used to monitor the air for TDI [33]. These devices are commonly referred to as tape meters. The Chemcassettes® are chemically treated tapes used to detect specific compounds of interest. The ChemKey® is an electronic chip that provides the SPM with compound-specific information for detection range, sample time, and alarm levels. In this investigation, each tape meter was configured to monitor for TDI within the ranges of 2 ppb to 60 ppb. An attached data logger, Logic Beach Modulogger™, polled each meter for data every 20 seconds. REAC

personnel downloaded the information stored on the Modulogger™ after all data were collected [32].

From March 9<sup>th</sup>–12<sup>th</sup> continuous TDI monitoring with tape meters occurred in Locations 2, 3, and 5/5A. On the afternoon of March 10<sup>th</sup>, the tape meter used in Location 5 was moved from the main living area to a child's bedroom (Location 5A). This occurred because the handheld instruments used by the NYSDOH to monitor VOC levels showed significantly higher readings in the child's bedroom than in the main living area. The assumption was that the airflow dynamics affecting VOC emissions would likely affect TDI emissions in the same way.

In addition, the tape meter used on March 9<sup>th</sup>–10<sup>th</sup> at Location 6 was relocated to Location 7 on March 10<sup>th</sup>–11<sup>th</sup> because no other TDI tape meters were available. Location 6 was furthest away from the treated apartment and least likely to have detectable emissions. In addition, no VOCs had been detected in Location 6, and it was presumed that no TDI would be detected there either. The investigators felt that the other three TDI tape meters located in Buildings 1 and 2 would likely capture any TDI emissions from Location 1.

### *Air Sampling*

Indoor air sampling for TDI was conducted using the American Society for Testing and Materials (ASTM) method D5932-96 [34]. This method involves the use of an ISO-CHEK® — a sampling device with a coated filter placed within a two-stage cassette [35]. The ISO-CHEK® is attached to an SKC® personal sampling pump to collect any isocyanate vapor and particulate phases present. REAC personnel calibrated the sampling pump to collect 1 liter per minute (L/min) of air through the filter for a duration of 15 minutes.

The EI protocol established a procedure for ISO-CHEK® sample collection when tape meter readings exceeded 2 ppb [Appendix B]. However, no elevated readings were observed during the investigation. As a result, samples were collected one or more hours following MCU use in an attempt to capture peak TDI levels. Once a sample was collected, the coated filter was removed from the cassette holder and placed into a solvent for shipment to the laboratory. Table 4 summarizes the locations, dates, and descriptions for ISO-CHEK® sample collection, including the collection times relative to MCU applications.

**Table 4. Summary of TDI ISO-CHEK® sample collection times and locations**

Location ID	Location	Date	Start Time	Purpose/Event
1	B-1/3 <sup>rd</sup> floor apt.	3/8/04	1530	Background Sample
3	B-1/2 <sup>nd</sup> floor apt.	3/9/04	1951	Approx. 3.5 hours after the 1 <sup>st</sup> MCU application in Building 1 at 1615
5	B-2/3 <sup>rd</sup> floor apt.	3/9/04	1942	"
6	B-2/2 <sup>nd</sup> floor apt.	3/9/04	1948	"
2	B-1/3 <sup>rd</sup> floor hall	3/10/04	1330	Approx. 2 hours after the 2 <sup>nd</sup> MCU application in Building 1 at 1125
5A	B-2/3 <sup>rd</sup> floor apt., Child's BR	3/10/04	1453	"
7	B-3/2 <sup>nd</sup> floor apt., Child's BR	3/10/04	1735	Approx. 1.5 hours after the 1 <sup>st</sup> MCU application in Building 3 at 1600
2	B-1/3 <sup>rd</sup> floor hall	3/11/04	1650	Approx. 1–1.5 hours after the 3 <sup>rd</sup> MCU application in Building 1 at 1540
3	B-1/2 <sup>nd</sup> floor apt.	3/11/04	1652	"
5A	B-2/3 <sup>rd</sup> floor apt., Child's BR	3/11/04	1702	"
7	B-3/2 <sup>nd</sup> floor apt., Child's BR	3/11/04	1755	Approx. 3.5 hours after the 2 <sup>nd</sup> MCU application in Building 3 at about 1630
1	B-1/3 <sup>rd</sup> floor apt.	3/12/04	1445	Approx. 24 hours after the 3 <sup>rd</sup> coat of MCU was applied in Building 1
2	B-1/3 <sup>rd</sup> floor hall	3/12/04	1500	"
3	B-1/2 <sup>nd</sup> floor apt.	3/12/04	1319	"
5A	B-2/3 <sup>rd</sup> floor apt., Child's BR	3/12/04	1420	"

## VOCs

### Air Monitoring

REAC used a RAE Systems PGM-50 MultiRAE Plus photo-ionization detector (PID) with a 10.6 electron volt lamp to conduct VOC monitoring [36]. This instrument's response time for VOCs is 10 seconds, with a range of 0.1–200 ppm. The PID was calibrated using 25 parts per million (ppm) isobutylene, and readings were logged at 2-minute intervals. Measurements were stored in the PID and downloaded in 24-hour segments.

On March 8<sup>th</sup>, REAC conducted VOC baseline air monitoring in Location 1 and on March 9<sup>th</sup>–12<sup>th</sup> conducted continuous air monitoring in Locations 2, 3, 5, and 6. On

March 10<sup>th</sup>, however, the NYSDOH handheld PIDs showed significantly higher readings in a child's bedroom than were being recorded by the stationary PID in the main living area [New York State Department of Health, unpublished data, 2004]. As a result, later that day, in an attempt to capture worst-case exposures in that apartment, the Location 5 PID was moved from the main living area to a child's bedroom (identified as Location 5A). On March 12<sup>th</sup>, REAC placed a PID in Location 1 to measure vapor emissions after the 3<sup>rd</sup> MCU application [32].

From March 10<sup>th</sup> (at 2:52 PM) through March 12<sup>th</sup> (at 10:22 AM), NYSDOH monitored VOC levels in Location 7, using a Perkin-Elmer, Photovac 2020 PID with a 10.6 electron volt lamp. This PID monitors VOCs in the range of 0.5 to 2000 ppm with a response time of less than 3 seconds to reach 90% of the final measured value. The PID was calibrated using 10 ppm isobutylene, and readings were logged at 15-minute intervals. The minimum, maximum and average readings for the 15-minute period were stored in the PID and later downloaded. Results were reported as total photoionizable compounds in ppm, isobutylene equivalents [New York State Department of Health, unpublished data, 2004].

Using the NYSDOH PID, NYSDOH and DOHMH staff also conducted periodic walk-through monitoring in Location 1. Location 1 monitoring occurred prior to the first application of MCU, and on several days following the final MCU application. The walk-through readings for a specific location within the apartment were recorded as a range of values for a <5-minute period [New York State Department of Health, unpublished data, 2004].

On March 11<sup>th</sup>, NYSDOH and DOHMH staff conducted walk-through PID monitoring in the auto repair shop adjoining Building 1. The shop owner was present and voluntarily consented to the walk-through. PID readings ranged from 1–5 ppm. Shop workers were using a degreaser (listing xylenes and ethyl benzene as ingredients) during the walk-through. The previous day investigators and residents had noted solvent-like odors in the hallway of Building 1. However, monitoring was not conducted in the shop at that time because the repair shop owner was not available to provide consent. When investigators contacted the New York City Department of Environmental Protection (NYCDEP), they learned that NYCDEP had previously visited the building after receiving complaints from residents.

### *Air Sampling*

Time-weighted indoor air sampling was conducted using the modified NIOSH Method 1501 for Aromatic Hydrocarbons [37,38]. REAC collected indoor air samples using a 600-milligram (mg) charcoal sorbent tube connected to an SKC® personal sampling pump [32]. Baseline samples in four apartments (Locations 1, 3, 5, and 6) within Buildings 1 and 2 were collected on March 8<sup>th</sup> and 9<sup>th</sup>. Each baseline sample was collected for a period of 4 hours using a flow rate of 2 liters per minute (L/min). Sampling durations varied from 2.5 to 24 hours for the samples collected on March 9<sup>th</sup>–12<sup>th</sup> following MCU applications. As a result, those flow rates were calibrated at 2 or 0.2 L/min, depending on the sampling duration.

On March 9<sup>th</sup>–12<sup>th</sup>, REAC also collected indoor air grab samples for VOCs using certified SUMMA® canisters [32,35]. REAC noted the concurrent PID reading prior to collecting each grab sample to ensure that VOCs were present. After the grab samples were collected, the canisters were shipped to the analytical laboratory for TO-15 analysis.

During and after the ATSDR investigation, NYSDOH and DOHMH collected a total of 17 separate 2-hour SUMMA® air samples from Building 1. NYSDOH collected three samples prior to the application of MCU on March 8<sup>th</sup> and five samples during the MCU application process. The sampling locations included various areas in the 2<sup>nd</sup> and 3<sup>rd</sup> floor apartments, in the 2<sup>nd</sup> and 3<sup>rd</sup> floor hallways, and the outdoor stoop. DOHMH also collected nine samples from these locations during a 3-week period following completion of the MCU applications [New York State Department of Health, unpublished data, 2004]. These SUMMA® samples were sent to the NYSDOH laboratory in Albany, NY for analysis.

## Results

### *TDI*

The background tape meter for Location 1 did not detect any TDI (with a 2 ppb lower detection limit). Subsequent monitoring results from the tape meters in Locations 3, 6, and 7 were also non-detect. Results from the tape meters in Locations 2 and 5/5A were considered unreliable as a result of SPM and Moduloggers™ system errors. REAC determined that these errors resulted from an intermittently faulty ground connection within each of the two data loggers [32].

Although the data for the Location 2 monitor were considered unreliable, the presence of six peaks warranted further evaluation. These peaks occurred at times ranging from 0.5–4.5 hours following the three MCU applications. One of the ISO-CHEK® samples collected by REAC corresponded to the time a peak reading occurred on the tape meter. The concurrent ISO-CHEK® sample showed no detectable levels of TDI, indicating that the tape meter data for Location 2 are not reliable. No detectable TDI levels were found in any of the other 14 ISO-CHEK® samples.

### *VOCs*

#### *Charcoal Tubes*

Charcoal tube samples were analyzed for both ethyl benzene and xylenes. Baseline results showed non-detect or very low levels of these VOCs. The sample collected on March 8<sup>th</sup> in Location 1 showed levels of ethyl benzene and xylenes of 11 ppb and 28 ppb, respectively. The three baseline samples collected for 4-hour durations on March 9<sup>th</sup> in Locations 3, 5, and 6, indicated no detectable levels of ethyl benzene in any location. The only detectable level of xylenes was 19 ppb found in Location 3. This level was consistent with the results from the SUMMA® samples collected by NYSDOH.

Samples collected during and after MCU use showed elevated levels of ethyl benzene and xylenes. REAC collected a sample in each of Locations 3, 5, and 6 during and after the 1<sup>st</sup> MCU application. In Location 3, the 4-hour time-weighted average level for ethyl benzene rose to 150 ppb (from a baseline of non-detect). The 4-hour time-weighted average level for xylenes rose to 530 ppb (from a baseline level of 19 ppb). In Location 6, ethyl benzene levels did not change, but xylene levels rose to 14 ppb, time weighted over 2½ hours. In Location 5, ethyl benzene levels rose from non-detect to 36 ppb, and xylene levels rose from non-detect to 120 ppb (in 2½-hour time-weighted samples).

On March 10<sup>th</sup>, sampling in Locations 3, 5, and 6 began approximately one hour before the 2<sup>nd</sup> MCU application. In Location 3, the 18-hour time-weighted average for ethyl benzene was 12 ppb, and for xylenes was 47 ppb. In Locations 5 and 6, the 24-hour time-weighted averages for ethyl benzene were 200 ppb and 64 ppb, respectively, while the 24-hour averages for xylenes were 750 ppb and 240 ppb, respectively.

The March 11<sup>th</sup> sampling started about 5½ hours before the 3<sup>rd</sup> MCU application. In Locations 3 and 6, the 24-hour time-weighted averages for ethyl benzene were 10 ppb and 230 ppb, respectively, while average xylene levels were 38 ppb and 750 ppb, respectively. In Location 5, the 10-hour time-weighted average for ethyl benzene was 150 ppb, and the average xylene levels were 540 ppb.

**Table 5. Charcoal tube results\* for ethyl benzene and xylenes by location**

Location ID	Location	Date	Ethyl Benzene Level (ppb)	Xylene Level (ppb)	Sampling Duration (hours)	Event
1	B-1/3 <sup>rd</sup> floor apt.	3/8/04	11.0	28.0	4.0	Baseline
3	B-1/2 <sup>nd</sup> floor apt.	3/9/04	<4.8	19.0	4.0	Baseline
		3/9/04	150.0	530.0	4.0	After 1 <sup>st</sup> application
		3/10/04	12.0	47.0	17.8	After 2 <sup>nd</sup> application
		3/11/04	10.0	38.0	24.0	Before, during, and after 3 <sup>rd</sup> application
5	B-2/3 <sup>rd</sup> floor apt.	3/9/04	<4.8	<4.8	4.0	Baseline
		3/9/04	36.0	120.0	2.6	After 1 <sup>st</sup> application
		3/10/04	200.0	750.0	23.6	After 2 <sup>nd</sup> application
		3/11/04	150.0	540.0	10.25	Before, during, and after 3 <sup>rd</sup> application
6	B-2/2 <sup>nd</sup> floor apt.	3/9/04	<4.8	<4.8	4.0	Baseline
		3/9/04	<7.7	14.0	2.5	After 1 <sup>st</sup> application
		3/10/04	64.0	240.0	24.0	After 2 <sup>nd</sup> application
		3/11/04	230.0	750.0	24.0	Before, during, and after 3 <sup>rd</sup> application

\* Values less than the detection limit are included as one-half the detection limit.

*SUMMA® Canisters*

Results from the REAC SUMMA® canister samples are shown in Table 6. In samples collected after MCU use, ethyl benzene and xylenes comprised 81%–94% of the total VOCs. Other VOCs, including acetone, 2-Butanone, and toluene, were detected in small amounts with combined levels ranging from 4%–13%. These results indicate that ethyl benzene and xylenes are the most predominant VOCs that residents could be exposed to during MCU use.

Levels for both ethyl benzene and xylenes at Location 2 exceeded 12.5 ppm, indicating a potential health threat. These results (from grab samples collected for <1 minute) are consistent with concurrent PID readings in terms of the relative increase over baseline VOC levels.

**Table 6. REAC SUMMA® canister sampling results for total VOCs, ethyl benzene and xylenes by location**

Location ID	Location	Collection Date	Collection Time	Event	Total VOCs* † (ppm)	Ethyl Benzene (ppm)	Xylenes (ppm)
3	B-1/2 <sup>nd</sup> floor apt.	3/9/04	12:58	Before 1 <sup>st</sup> application	0.343	0.005	0.018
4	B-1/2 <sup>nd</sup> floor hall	3/9/04	16:20 (18:50?)	After 1 <sup>st</sup> application	5.158	0.940	3.36
5A	B-2/3 <sup>rd</sup> floor apt., Child's BR	3/10/04	15:00	After 2 <sup>nd</sup> application	0.945	0.190	0.620
2	B-1/3 <sup>rd</sup> floor hall	3/11/04	16:54	After 3 <sup>rd</sup> application	56.09	13.0	39.8
1	B-1/3 <sup>rd</sup> floor apt.	3/12/04	14:47	Post application	2.853	0.45	1.850

\* Includes estimated values

† Includes tentatively identified compounds

On March 9<sup>th</sup>, prior to the 1<sup>st</sup> MCU application, REAC collected a baseline grab SUMMA® sample from Location 3. The results show low levels of ethyl benzene (5.3 ppb) and xylenes (18 ppb). Investigators also found elevated levels of other VOCs, including acetone, toluene, and styrene.

In addition, two SUMMA® samples collected by NYSDOH on March 8<sup>th</sup> in each of Locations 1 and 4 showed elevated levels of these and other VOCs. Table 7 summarizes the results of baseline samples collected by REAC on March 9<sup>th</sup>, and baseline samples collected in Locations 1 and 4 by NYSDOH on March 8<sup>th</sup> [32, New York State

Department of Health, unpublished data, 2004]. For the NYSDOH results, only the higher level from either Location 1 or 4 is shown.

Table 7 includes the most conservative, relevant MRLs [28]. The baseline VOC levels found by NYSDOH exceed the ATSDR MRLs for toluene and benzene. The VOC levels in all three Building 1 samples were above the NYSDOH typical background indoor air concentrations [New York State Department of Health, unpublished data, 2004]. These VOCs appear to reflect periodic vapor emissions from the auto repair shop located in the building adjoining Building 1. We do not have sufficient data to characterize the indoor air quality resulting from the auto repair shop emissions. After receiving these results, DOHMH requested an inspection by NYCDEP to determine whether the shop was in violation of the New York City's Air Pollution Control Code (Title 24 of the NYC Administrative Code) [40]. This Code specifically prohibits the emission of any odorous air contaminant, which could cause detriment to health, safety, welfare or comfort of a person, and requires a permit for the type of work done in this shop.



**Table 7. REAC and NYSDOH baseline SUMMA® canister results for Locations 3, and 1 or 4 with NYSDOH typical background indoor air levels for comparison**

VOC	Location 3 Results* (ppb)	Location 1 or 4 Results** (ppb)	ATSDR MRL (ppb)	NYSDOH Background Indoor Air Level (ppb)
Ethyl benzene	5.3	65.0	1000	0.1PL–0.6
m,p,o-xylenes	18.0	42.1	100	0.2–1.8
Acetone	140	1348	13,000	1.8–5.9
Styrene	36	31	60	<0.1–0.1
Toluene	40	<b>398</b>	80	1.1–6.6
2-Butanone (MEK)	15	305	1695	0.4–1.8
Vinyl Acetate	4.7	-	10	-
Benzene	1.0	<b>17</b>	4	<0.4–0.8
4-Methyl-2-Pentanone	4.3	68	732 <sup>†</sup>	<0.1–0.2
Ethyl alcohol	3.7	2496	-	21–323
Freon	0.39	4.7	-	<0.5–1.1
Isoprene	-	23	-	<0.3–1.5
n-Hexane	-	85	600	-
n-Octane	-	77	-	<0.1–0.5
Ethyl-cyclohexane	-	81	-	<0.1–0.3
Methylene chloride	0.45	6.0	300	0.1 PL–1.8
MTBE	ND	18	700	<0.1–1.5
Cyclohexane	-	4.7	1744	<0.1–0.8
Iso-Octane	-	4.5	-	<0.1–0.6
n-Heptane	-	61	-	0.3–1.9
Methylcyclohexane	-	23	-	<0.1–0.5
n-Nonane	-	34	-	0.1 PL–0.7
n-Decane	-	21	-	0.2 – 1.2
1,2,4-Trimethylbenzene	0.67	3.9	-	0.1 PL – 0.9
d-Limonene	-	6.3	-	0.1 PL – 1.7
n-Undecane	-	9.2	-	0.1 PL – 0.9

\* Results from sample collected by REAC on March 9, 2004

\*\* Higher of two results from samples collected in Locations 1 and 4 by NYSDOH on March 8, 2004

PL – present, but less than the limit of detection indicated

- Value not available

<sup>†</sup> Value is an RfC

---

### *PID Readings*

PIDs are general survey instruments used to screen for the presence of VOCs. These instruments do not distinguish individual VOCs, but they are often used to provide qualitative information about VOCs in air.

Quantitative analyses using PIDs are based on the fact that most organic compounds and some inorganic compounds can be ionized when they are bombarded by high-energy ultraviolet (UV) light [36]. Some compounds are ionized easily, while others are not. As a result, these instruments respond differently, depending on which VOCs are present. It is possible to use PIDs quantitatively if only one chemical is present in air, or if a mixture of chemicals is present and each chemical has the same ionization potential (IP) [42]. In this case, the concentration can be estimated by using a standard correction factor (CF) [42].

All PID readings are relative to the gas used to calibrate the instrument. For this investigation, the PIDs were calibrated with isobutylene —so instrument readings showed isobutylene equivalent levels [36]. To obtain estimated concentrations for specified VOCs, published correction factors (CFs) are available for adjusting PID readings to isobutylene equivalents.

For the PID used in this EI, the CF for ethyl benzene is 0.5 [43]. Each xylene isomer (m-, o-, and p-) has a slightly different CF (0.4, 0.6, and 0.5 respectively). ATSDR used an average CF of 0.5 for total xylenes, based on the assumption that each xylene isomer is present in approximately equal amounts. Because the individual CFs for ethyl benzene and xylenes are 0.5, the CF for the mixture is also 0.5. ATSDR used this CF, when appropriate, to estimate the combined levels for ethyl benzene and xylenes (EBX). For example, a PID reading of 10 ppm (applying the overall CF of 0.5) yields an estimated EBX of 5.0 ppm.

It is important to emphasize that adjusting the PID readings using this CF only estimates EBX levels. Differences between the readings and actual levels can result from the nonlinear nature of the CF, differences in vapor pressures for the VOCs present, fluctuations in humidity, slight variations in sampling location, and the presence of other VOC sources. An assumption used when applying the CF to the PID readings is that ethyl benzene and xylenes were the only VOCs present.

Results from the SUMMA® canister samples collected by REAC indicate that other VOCs were present. EBX comprised only 7% of VOCs in the baseline sample, but comprised 81%–94% of VOCs in the four samples collected following MCU use in Building 1. Three of these four samples were collected in different locations (2, 4, and 5A) within 3½ hours after each of the first three applications. REAC collected the fourth sample in Location 1, approximately 23 hours after the 3<sup>rd</sup> MCU application.

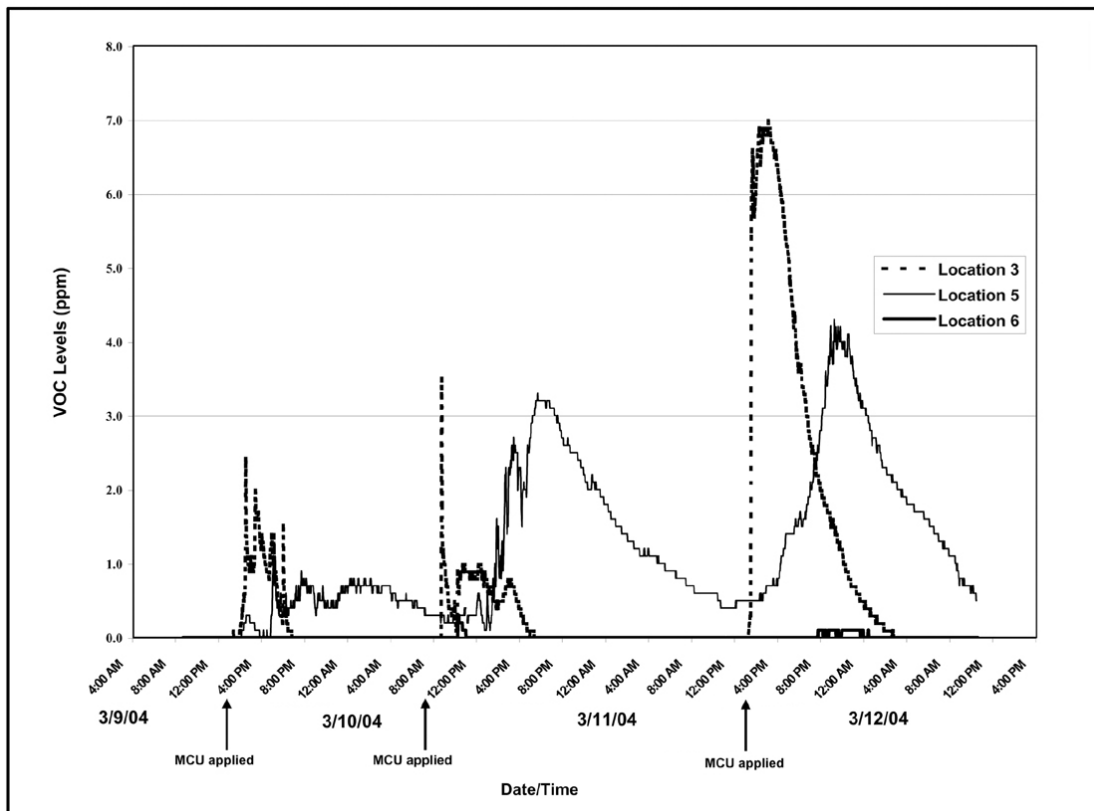
Adjusted PID readings noted at the time of sample collection match the SUMMA® results reasonably well for Locations 1, 2 and 5A, and less well for Location 4. However, these adjusted PID readings tend to overestimate actual EBX levels as those levels

decline. Nevertheless, the adjusted PID readings are useful for showing relative changes in VOC levels for the living spaces and hallway near the treated apartment.

Figures 2–5 show the continuous PID readings for Locations 1, 2, 3, 5/5A, 6, and 7. The MCU application times in Location 1 (3<sup>rd</sup> floor apartment in Building 1) are noted with arrows. The readings for Locations 3, 5/5A, and 6 (Figure 2) are shown separately from the Location 2 readings (Figure 3) because the levels in Location 2 were much higher and not easily shown on the same scale.

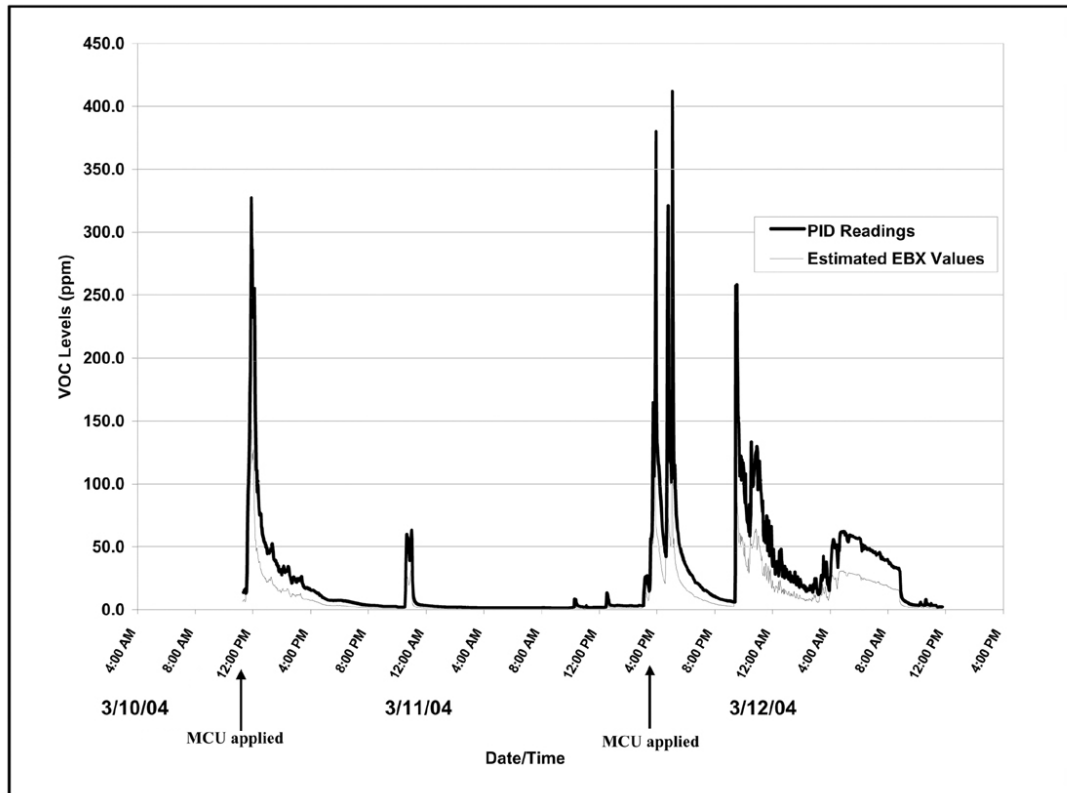
The readings in Locations 2 and 5/5A (nearest Location 1), show a similar pattern: VOC levels rose to a peak within 1–4 hours after MCU use, and then declined over the next several hours. The readings in Location 6 (farthest from Location 1) increased only slightly after each MCU application. Following the 3<sup>rd</sup> MCU coat, the VOC readings in Location 2 show a pattern of three peaks over a period of several hours (Figure 3). The reason for this pattern is unclear, but could be related to opening and closing the door to the treated apartment (Location 1).

**Figure 2. Measurements\* of total volatile organic compounds in 3 untreated apartments (Locations 3, 5, and 6) — Williamsburg community, March 2004**



↑ Arrows indicate MCU application times in Location 1: 3/9 (4:15 PM); 3/10 (11:25 AM); 3/11 (3:40 PM)  
 \* Measurements taken with a photo-ionization detector (PID). The PID was moved from living room (Location 5) to child's bedroom (Location 5A) on 3/10 at 11:00 AM

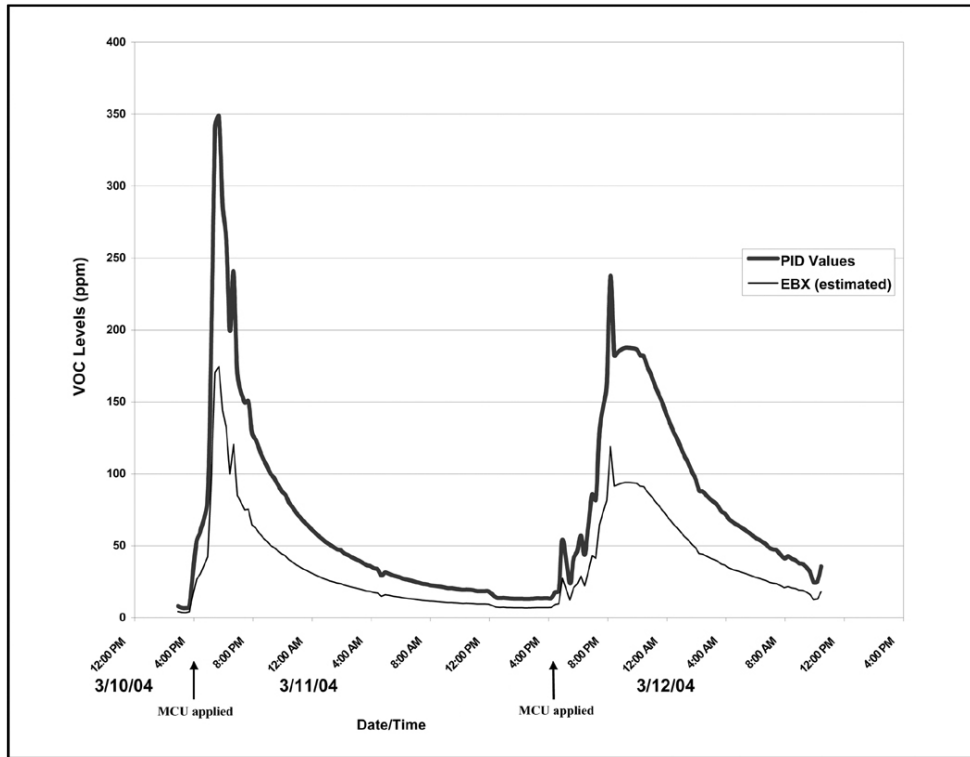
**Figure 3. Measurements\* of total volatile organic compounds in a hallway (Location 2) outside the treated apartment, and estimated levels of ethyl benzene and xylenes combined (EBX) — Williamsburg community, March 2004**



↑ Arrows indicate 2<sup>nd</sup> (3/10 at 11:25 AM) and 3<sup>rd</sup> (3/11 at 3:40 PM) MCU application times in Location 1.  
 \* Measurements taken with a photo-ionization detector (PID)

Figure 4 (on the next page) shows the continuous PID readings in Location 7 following the two MCU applications in Location 8 (1<sup>st</sup> floor apartment of Building 3). Similar to PID readings in Location 2, the readings in Location 7 rose to a peak within one to three hours after each application in the neighboring apartment, and then declined over the next several hours.

**Figure 4. Measurements\* of total volatile organic compounds in the untreated apartment (Location 7) in Building 3, and estimated levels of ethyl benzene and xylenes combined (EBX) — Williamsburg community, March 2004**

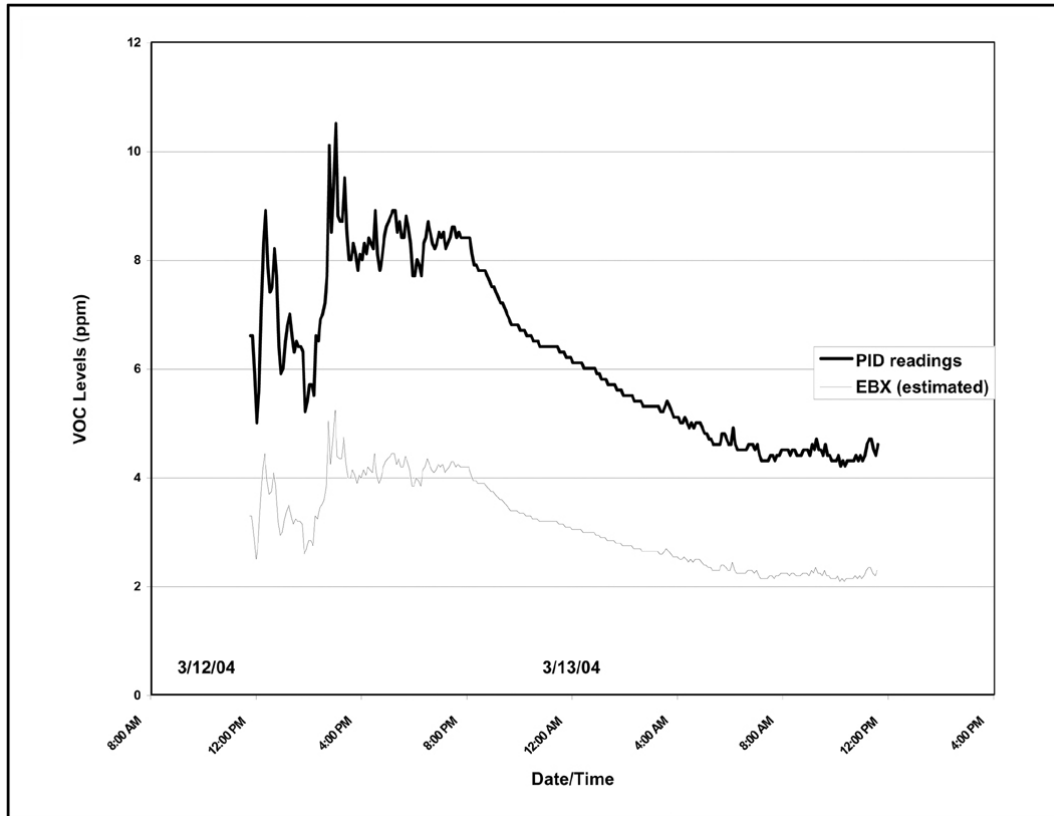


↑ Arrows indicate MCU application times in Location 8 on 3/10 (4:00 pm) and 3/11 (4:30 pm).  
 \* Measurements taken with a photo-ionization detector (PID)

Eighteen hours after the 2<sup>nd</sup> MCU coat, the Location 7 residents requested that the testing equipment be removed. At that time, PID readings were still well above baseline levels. Because the PID monitoring was stopped, investigators could not determine the duration of elevated VOC levels for Location 7.

REAC set up a PID in Location 1 to monitor VOC levels after the 3<sup>rd</sup> MCU coat. The monitor was in place for approximately 24 hours (11:45 AM on March 12<sup>th</sup> until 11:05 AM on March 13<sup>th</sup>). Figure 5 shows the PID readings for Location 1.

**Figure 5. Measurements\* of total volatile organic compounds in the treated apartment (Location 1) in Building 1, and estimated levels of ethyl benzene and xylenes combined (EBX) — Williamsburg community, March 2004**



\* Measurements taken with a photo-ionization detector (PID)

### *DOHMH and NYSDOH Results*

From March 12<sup>th</sup> until April 1<sup>st</sup> DOHMH staff made several site visits to Location 1 to record PID levels and to collect SUMMA® samples. The results from two 2-hour SUMMA® samples collected on March 12<sup>th</sup> and 13<sup>th</sup> are shown in Table 8. The March 12<sup>th</sup> sample was collected about 24 hours after the 3<sup>rd</sup> MCU application. The results showed 147 ppb and 231 ppb of ethyl benzene and xylenes, respectively. The March 13<sup>th</sup> sample, collected about 43 hours after the 3<sup>rd</sup> application, showed levels of ethyl benzene and xylenes at 164 ppb and 244 ppb, respectively [44]. These levels exceed March 8<sup>th</sup> baseline levels (ethyl benzene at 18 ppb; xylenes at 42 ppb) by an order of magnitude. However, these levels do not exceed either the screening level of 2.4 ppm or the MRL.

**Table 8. NYSDOH/DOHMH SUMMA® Location 1 Indoor Air Sampling Results**

Collection Date	Event	Ethyl Benzene (ppm)	Xylenes (ppm)
3/8/04	Baseline	0.018	0.042
3/12/04	24 hours after 3 <sup>rd</sup> MCU application	0.147	0.231
3/13/04	43 hours after 3 <sup>rd</sup> MCU application	0.164	0.244

When DOHMH staff arrived at Location 1 on March 16<sup>th</sup> to collect samples, they discovered that a 4<sup>th</sup> coat of MCU had been applied on March 15<sup>th</sup> in the baby's room. Therefore, Location 1 samples collected after March 15<sup>th</sup> do not reflect VOC emissions associated with the 1<sup>st</sup>–3<sup>rd</sup> MCU applications and are not addressed in this report.

### *Overall Results*

Following each MCU application in Location 1, the VOC levels increased dramatically in Location 2. A similarly dramatic increase in VOC levels occurred in Location 7 after each MCU coat in Location 8. Peak elevations lasted for an hour or more, and were followed by decreasing levels over the next several hours. Despite the limitations of PID screening data, it is likely that during peak readings the levels of ethyl benzene and xylenes exceeded the ATSDR exposure guidelines of either 5 ppm for 1 hour or 12.5 ppm for 15 minutes. The Location 5A levels of ethyl benzene or xylenes, or both may have exceeded the MRL (1.0 ppm) for a period of up to 12 hours.

The data suggest that VOC levels remained elevated above baseline for up to 43 hours after the 3<sup>rd</sup> MCU coat. However, SUMMA® samples collected by DOHMH 24 and 43 hours after the 3<sup>rd</sup> coat show that ethyl benzene and xylene levels were above baseline but below the MRL (1.0 ppm).

### **Questionnaire Results**

One adult from each of the four families in Buildings 1 and 2 completed a questionnaire [Appendix B] on March 11, 2004. The residents in Building 3 had temporarily moved elsewhere and were unavailable to respond to the questionnaire.

All four families in Buildings 1 and 2 had rented their respective apartments for 3–7 years. The previous instance of MCU use in either building occurred seven years earlier in the same apartment being treated during this EI (Location 1). The interior walls in Location 1 had also been painted with an oil-based paint during the previous six months. The three other apartments had not recently been painted. Neither household members nor any visitors smoke tobacco. No obvious sources of VOCs or other substances were identified that might affect the air testing results. The family in Location 5 reported symptoms after the March 9<sup>th</sup> application in Location 1. Both adults noticed an odor and sensation of sharpness in the throat. One of the adults reported mildly itchy eyes. The 2-year old child awoke with cold-like symptoms (runny nose, cough) on the morning of

March 11<sup>th</sup>. Responses to questions 11–29 of the questionnaire are summarized in Table 9.

**Table 9. Summary of responses to questions 11–29 on household questionnaire**

Location ID	Stored chemicals	Smoker/Visitors who smoke	Hobbies	Number of adults	Number of children	Age of youngest child	Age of oldest child	Odors/Fumes reported after MCU use in Location 1
1 (B-1/3 <sup>rd</sup> floor apt.)	No	No / No	No	2	1	NA	2 yrs	NA*
3 (B-1/2 <sup>nd</sup> floor apt.)	No	No / No	No	2	3	2 wks	4 yrs	NA <sup>†</sup>
5 (B-2/3 <sup>rd</sup> floor apt.)	Paint thinner (stored in plastic container)	No / No	No	2	1	NA	2 yrs	Yes
6 (B-2/2 <sup>nd</sup> floor apt.)	Paint (maybe)	No / No	Paint thinner (maybe)	2	3	9 mos	4.5 yrs	No

\* Location 1 is the treated apartment.

<sup>†</sup> The family relocated prior to application and returned approximately 24 hours after the 3<sup>rd</sup> MCU coat.

## Discussion

### Limitations

This EI has several limitations. Because of cultural practices and religious constraints, all contacts with residents were arranged and facilitated by HESS. This limited the residents with whom we interacted, the number of residents with whom we interacted, and the conditions under which those interactions occurred.

Secondly, there were only a limited number of apartment buildings suitable for conducting the EI. A major constraint was that families had to be willing to divulge their MCU plans to HESS, and be able to do so enough in advance for the EI team to make arrangements for travel and testing equipment. Although the three apartment buildings used for this EI were the best available at the time, they were not ideal choices. Buildings 1 and 2 do not represent the majority of apartment buildings in the community in terms of age, size, design, or the heating/ventilating/cooling systems. In addition, the neighboring auto repair shop was a potential source of additional VOCs. ATSDR included Building 3 in the investigation after discovering the limitations of Buildings 1 and 2. Although Building 3 was more representative of apartment buildings in the area, it had been



recently constructed and the ongoing interior finishing work also generated VOCs. In addition, at the time the EI was conducted, only 2–3 families lived in Building 3.

To identify peak exposures to TDI and VOCs, ATSDR selected testing locations where peak levels were most likely to occur. The grounding problems with the TDI tape meter in Location 2 (the hallway outside the treated apartment in Building 1) might have prevented capturing peak TDI levels using the ISO-CHEK® devices. The complete malfunction of the tape meter in Location 1 (the treated apartment in Building 1) during the post-application period resulted in a failure to collect any data on levels and duration of TDI (if any) after applications were completed.

As compared to the qualitative VOC screening data from PIDs, SUMMA® canister samples provide quantitative VOC data. The EI sampling plan specified the collection of 12 SUMMA® samples, but only 6 SUMMA® canisters were delivered to the site. Because of the limited number of available SUMMA® canisters, samples were collected in Buildings 1 and 2 but not in Building 3. As a result, only PID monitoring data are available for Location 7.

Finally, the data collected for this EI show the short-term, indoor air concentrations of TDI and VOCs measured during the investigation. These measurements reflect two specific brands of MCU, both of which, according to the labels, contain 550 g/L of VOCs. Because not all brands or types of MCU have the same VOC or TDI content, emissions could vary depending on the specific product used, as well as on the building's architectural design and other variables. Therefore, these data cannot be generalized to address exposures associated with future MCU applications. However, they could still indicate the types and extent of exposures that might occur under similar circumstances.

Despite these limitations, and despite the cultural and logistical challenges and equipment failures encountered during this investigation, ATSDR obtained valuable data and achieved most of the EI objectives. The remainder of this discussion addresses the air monitoring and sampling results.

## **TDI**

During this investigation, continuous, real-time air monitoring with tape meters did not indicate the presence of TDI in any testing location. In addition, the results from all ISO-CHEK® samples were non-detect (with a 0.15 ppb lower detection limit).

The tape meters used in Locations 2 and 5A malfunctioned. If it had functioned properly, the tape meter in Location 2 (3<sup>rd</sup> floor hallway of Building 1) might have captured elevated TDI levels. Based on PID readings indicating significant vapor intrusion, Location 2 was one of two areas in which elevated TDI levels were most likely to occur.

Elevated TDI levels were also expected in Location 7 (Building 3) based on significantly elevated PID readings. Yet here also, no TDI levels were detected (above the tape meter detection limit of 2 ppb) throughout the nearly 48-hour monitoring period. It is possible that TDI levels above 1.0 ppb (the level of concern) but below the 2 ppb tape meter detection limit occurred but were missed during ISO-CHEK® sampling.

Overall, 14 ISO-CHEK® air samples were collected after MCU use. To ensure that sampling did not miss TDI levels that were  $\geq 1.0$  but  $< 2$  ppb, air sampling would have been required every 15–30 minutes for up to 4 hours after each MCU application. When ATSDR developed the EI sampling plan, the need for such extensive sampling was not anticipated.

The 2003 DOHMH investigation found TDI levels of 0.87 ppb and 0.26 ppb in hallways outside treated apartments, indicating that TDI off-gassed during MCU use. However, TDI was not detected inside adjacent apartments. In addition, both of these measured values were below 1.0 ppb. Because hallway exposures would be expected to be short-term (less than 15 minutes), the levels found by DOHMH were below ATSDR's exposure limit guidelines for TDI.

No TDI was detected during this EI, and the only levels detected during the DOHMH investigation were in non-living spaces at levels below 1.0 ppb. As a result, it appears unlikely that TDI at levels high enough to induce sensitization occurred outside a MCU-treated apartment.

The TDI tape meter stationed in Location 1 (the treated apartment in Building 1) malfunctioned throughout the entire post-application monitoring period. As a result, we were not able to determine how high the TDI levels might have been, or how long they might have persisted after the all MCU applications were completed.

### **Ethyl Benzene and Xylenes**

The assessment of exposures to ethyl benzene and xylenes from MCU use was limited to PID monitoring and a small number of SUMMA® canister and charcoal tube samples. The VOC patterns relative to MCU application times show the impact of MCU on indoor VOC levels. The SUMMA® results indicate that ethyl benzene and xylenes most likely comprised a significant portion of the total VOCs at times near peak readings. This determination is based on the following three findings:

1. SUMMA® samples, collected shortly after MCU use, showed that ethyl benzene and xylenes comprised more than 80% of the VOCs present.
2. Location 2 SUMMA® results indicate high concentrations of ethyl benzene and xylenes, which correlate well with the levels estimated from the concurrent PID reading (adjusted using a CF of 0.5).
3. Following MCU use, the charcoal tube results show relative increases in ethyl benzene and xylene levels consistent with increases in corresponding PID readings.

ATSDR's exposure guidelines for ethyl benzene and xylenes include a screening level of 2.4 ppm, a level of 5.0 ppm for exposures of 1 hour, and a level of 12.5 ppm for 15-minute exposures. The available data for evaluating whether VOC levels posed a potential health hazard include qualitative PID data and the corresponding estimated EBX levels. While all PID data were carefully evaluated, ATSDR focused on PID readings

where VOC (EBX) levels were likely to have exceeded the higher exposure limit guidelines (greater than 5 ppm or 12.5 ppm, or both). When determining how long ethyl benzene and xylenes might have persisted in the treated apartment after the last application of MCU, ATSDR focused on the minimum level of 2.4 ppm because the duration of possible exposure was greater than 24 hours. These PID data were evaluated in conjunction with SUMMA® data collected after the 3<sup>rd</sup> MCU application.

The SUMMA® results from samples collected in the hallway (Location 2) showed that after MCU use in the adjacent apartment, ethyl benzene levels rose as high as 13 ppm, and xylene levels rose as high as 39.8 ppm. The SUMMA® data also indicated that these two VOCs together comprised 81%–94% of the total VOCs in the post-MCU samples. Nevertheless, because SUMMA® data are from grab samples, they do not provide information on the duration of elevated levels.

The PID readings suggest that the estimated combined levels of ethyl benzene and xylenes (EBX) were as high as 100–150 ppm. In Locations 2 and 7, levels above 12.5 ppm appeared to be sustained for several hours after each MCU application. These PID data, supported by limited SUMMA® data, suggest that after MCU use in nearby apartments, ethyl benzene and xylenes likely exceeded ATSDR's 15-minute exposure limit guideline in a living space (Location 7) and in a shared hallway (Location 2). Elevated levels of these VOCs in a living space are a greater concern than their presence in a hallway. Exposures in a living space are usually more frequent and of longer duration.

The PID readings in both Locations 2 and 7 suggest that significantly elevated levels of VOCs, including ethyl benzene and xylenes, could migrate from a treated apartment and cause involuntary exposure to other residents who live nearby. This potential for exposure is of particular concern for infants and young children, because they are likely to spend a great deal of time at home.

Following the 3<sup>rd</sup> coat of MCU, PID readings in Location 1 remained above baseline levels for a period of at least 43 hours. The 2-hour SUMMA® samples collected by DOHMH confirm this finding. However, ethyl benzene and xylene levels were less than 1 ppm after 24 hours. These data indicate that 24 hours after the last application of MCU, VOC levels were below levels of health concern. Nevertheless, waiting 24–48 hours before returning to a treated apartment minimizes the potential for exposure to elevated VOC levels.

### **Regulatory Issues**

During the writing of this report NYSDEC Regulation 6 Part 205, restricting the VOC content of varnishes to 450 g/L, was brought to the attention of ATSDR and New York public health officials. A review of the product labels revealed that both brands of MCU used during this EI contained 550 g/L of VOCs, and were therefore in violation of that regulation. The NYSDEC issued Notices of Violation against the manufacturers of the brands of MCU used in the EI and also issued Notices of Violation to other manufacturers of MCU products that exceed regulatory limits.

## Occupational Health Issues

Investigators observed workers applying MCU without using any respiratory protection. Workers applying MCU to floors can have potentially significant chemical exposures. Although occupational issues are beyond the scope of this EI, investigators discussed these issues, including the relevant NIOSH guidelines, with the workers who applied MCU in Location 1. Investigators also provided these workers with a NIOSH point of contact and telephone number to call for anonymously requesting a health hazard evaluation.

## Conclusions

1. Indoor air sampling results show that ethyl benzene or xylenes, or both likely reached and stayed at levels posing a potential public health hazard. Neighboring residents could be exposed to harmful levels both during and after application of MCU with a content of 550 g/L.
2. The VOC content of the MCU brands used during this EI (550 g/L) exceeded the VOC content allowed by New York State Regulation Part 205. Manufacturing, selling, and using these products violated the NY regulation. The new regulation effective January 1, 2005, changed the limit from 450 g/L to 350 g/L.
3. Air sampling results showed that levels of ethyl benzene and xylenes were below the ATSDR MRL about 24 hours after the 3<sup>rd</sup> MCU coat. However VOC levels in the treated apartment did not return to baseline levels for at least 43 hours after application of the 3<sup>rd</sup> coat.
4. Limited air monitoring and sampling for TDI outside of apartments treated with MCU did not detect TDI.

The TDI monitoring equipment placed in the treated apartment after the 3<sup>rd</sup> MCU coat did not work properly. As a result, there are no data showing the length of time that TDI, if any, remained in the air after the applications.

5. EI testing was done only in residential buildings. However, the results suggest that occupants in other types of buildings (for example, office buildings, schools, and bowling alleys) might be exposed to VOCs at levels of health concern when MCU (550 g/L of VOCs) is applied to floors.
6. The VOC content of any product, if high enough, might pose a health threat when used indoors. It is important to follow the manufacturer's instructions for safe use; including making sure the area has adequate ventilation.
7. Vapor emissions and possible health effects from the indoor use of MCU products that comply with the current New York State Regulation 205 (maximum VOCs: 350 g/L) are not known.

## Recommendations

1. MCU containing VOCs at 550 g/L should not be used in occupied multi-family dwellings. There is a potential for exposure to levels of VOCs (specifically ethyl benzene and xylenes) that may be harmful to health. Furthermore, a VOC content of 550 g/L violates New York State Regulation Part 205 Architectural and Industrial Maintenance (AIM) Coatings.
2. Floor treatments should comply with the January 1, 2005 New York State Regulation Part 205, Architectural and Industrial Maintenance (AIM) Coatings. This regulation limits the amount of VOCs in wood floor and other finishes to 350 g/L. ATSDR supports continued efforts to limit the VOC content of products that are used indoors.
3. Residents (of a treated apartment or an apartment near one being treated with MCU) should vacate their homes during an application of MCU that contains 550 g/L of VOCs. Furthermore, they should wait at least 24–48 hours after a final application of MCU before returning home.
4. Community health education efforts should target the following areas:
  - Potential health risks to occupants of apartments in which MCU is used and to occupants of neighboring apartments.
  - Safe use of residential floor treatments, including proper handling and use (for example, using adequate ventilation), potential health risks, and symptoms of exposure.
  - Proper handling and use of products containing VOCs in the home, common sources of VOCs, potential health risks, and symptoms of exposure.
  - Importance of seeking medical attention if symptoms develop that may be associated with environmental exposures to VOCs, MCU, and other chemicals.
  - Importance of informing health care providers about suspected environmental exposures causing an illness or other symptoms.
5. Health Care Provider education should include the following:
  - Useful environmental health references.
  - Importance and components of an exposure history.
  - Health risks and symptoms associated with MCU and VOCs.
  - Common household sources of VOCs and other possible respiratory irritants or toxicants.
6. Education should be provided for the general public, schools, and businesses to promote awareness of the potential health risks associated with indoor MCU use in occupied buildings.

- 
7. An investigation into the extent of VOC emissions and migration into neighboring residences in multi-family structures should be considered for products with a VOC content of 350 g/L.

## **Authors, Technical Reviewers**

### **Authors**

Gail E. Scogin, MS

Environmental Health Scientist  
Exposure Investigations Team  
Exposure Investigations and Consultation Branch  
Division of Health Assessment and Consultation

Karen J. Marienau, MD, MPH

Medical Officer  
Exposure Investigations Team  
Exposure Investigations and Consultation Branch  
Division of Health Assessment and Consultation

### **Report Reviewed by:**

Susan Metcalf, MD

Medical Officer  
Exposure Investigations Team Leader  
Exposure Investigations and Consultation Branch  
Division of Health Assessment and Consultation

Susan Moore, MS

Environmental Health Scientist  
Chief, Exposure Investigations and Consultation Branch  
Division of Health Assessment and Consultation

Ken Orloff, PhD

Toxicologist  
Assistant Director of Science  
Division of Health Assessment and Consultation

---

## References

1. The City of New York Department of Health and Mental Hygiene. Environmental investigation of chemical ingredients of Moisture Cure Urethanes used as wood floor coatings. New York, NY: Environmental & Occupational Disease Epidemiology Program; 2003 May 20.
2. Environmental Protective Coatings, Inc. Available at: <http://www.enviroprotectcoatings.com/epcprintimages.php>. Last accessed 2003 October 17.
3. Harco Chemical Coatings, Inc. Moisture Cure Urethane VOC-Material Safety Data Sheet (MSDS); manufacturer's code 3100, 3101, 3102, 3110. Brooklyn, NY; 2002 March.
4. Severe warning of prohibition. Rabbinical Court Decision., Brooklyn, NY: Rabbinical Court, Mishpot Sholem; 2004 February 20.
5. Agency for Toxic Substances and Disease Registry. Toxicological profile for ethyl benzene (update). Atlanta: US Department of Health and Human Services; 1999 July. p. 11–113.
6. Geller R, MD, FAAP, ACMT. E-mail communication re: Xylenes and ethyl benzene exposure levels of concern in young children. Atlanta: Emory University School of Medicine; 2004 April 5.
7. Rumchev K, Spickett J et al. Association of domestic exposure to volatile organic compounds with asthma in young children, *Thorax* 2004;59:746–51.
8. Thurston GD and Bates DV. Air Pollution as an underappreciated cause of asthma symptoms. *JAMA* 2003;290(14):1915–17.
9. Jones AP. Asthma and domestic air quality. *Soc Sci Med* 1998;47(6):755–64.
10. Johnson CC, Ownby DR et al. Environmental epidemiology of pediatric asthma and allergy. *Epidemol Rev* 2002;24:154–75.
11. Agency for Toxic Substances and Disease Registry. Toxicological profile for xylenes (update). Atlanta: US Department of Health and Human Services; 1995 Aug. p. 13–142.
12. Dudek B, Gralewicz K, Jakubowski M et al. Neurobehavioral effects of experimental exposure to toluene, xylene, and their mixture. *Pol J Occup Med* 1990;3:109–16.
13. Hake CLR, Stewart RD, Wu A et al. p-Xylene: Development of a biological standard for the industrial worker. Report to the National Institute for Occupational Safety and Health, Cincinnati, OH, by the Medical College of Wisconsin, Inc. Milwaukee, WI: PB82-152844; 1981.



14. Carpenter CP, Kinkead ER, Greary DJ et al. Petroleum hydrocarbon toxicity studies: V. Animal and human response to vapors of mixed xylenes. *Toxicol Appl Pharmacol* 1975;33:543–58.
15. BASF Corporation. Polyurethane TDI Handbook 2000. Available at: <http://www.basf.com/businesses/polymers/urethanes/pdfs/chemicals/Other/2000tdihandbook.pdf>. Last accessed 2004 February 4.
16. Lemiere C, Romeo P, Chaboillez S, Tremblay C, Malo JL. Airway inflammation and functional changes after exposure to different concentrations of isocyanates. *J Allergy Clin Immunol* 2002;110(4):641–6.
17. Liu Q and Wisnewski AV. Recent developments in diisocyanate asthma. *Ann Allergy Asthma Immunol* 2003;90:35–41.
18. Redlich CA and Karol MH. Diisocyanate asthma: clinical aspects and immunopathology. *Int Immunopharmacol* 2002;2:213–224.
19. Bernstein JA. Overview of diisocyanate occupational asthma. *Toxicol* 1996;111:181–9.
20. Ott GA. Occupational asthma, lung function decrement, and toluene diisocyanate (TDI) exposure: a critical review of exposure-response relationships. *App Occup Environ Hygiene* 2002;17(12):891–901.
21. DeZotti Z, Muran A, and Zamborn F. Two cases of paraoccupational asthma due to toluene diisocyanate (TDI). *Occup Environ Med* 2000;57:837–39.
22. Orloff K, Batts-Osborn D, Kilgus T, Metcalf S, and Cooper M. Antibodies to toluene diisocyanate in an environmentally exposed population. *Environ Health Perspect* 1998;106(10):665–66.
23. Salam MT, Li YF, Lanholz B, and Gilliland FD. Early life environmental risk factors for asthma: findings from the Children’s Health Study. *Environ Health Persp* 2004 (in press). Online 2003 Dec 9. Available at: <http://dx.doi.org>.
24. Belanger K, et al. Symptoms of wheeze and persistent cough in the first year of life: associations with indoor allergens, air contaminants, and maternal history of asthma. *Am J Epidem* 2003;158:195–202.
25. American Academy of Pediatrics Committee on Environmental Health. Developmental toxicity: special considerations based on age and developmental stage. In: Etzel RA and Balk SJ, eds. *Pediatric environmental health*. 2nd ed. Elk Grove Village, IL: American Academy of Pediatrics; 2003. p. 9–23.
26. Etzel RA. Environmental risks in childhood. *Pediatr Ann* 2004;33(7):431–6.
27. International Agency for Research on Cancer (IARC). Available at: <http://www.iarc.fr/>. Last accessed 2005 March.
28. Agency for Toxic Substances and Disease Registry. Minimum risk levels (MRLs) 2003 January. Available at: <http://www.atsdr.cdc.gov/mrls.html#bookmark02>. Last accessed 2004 February.

29. State of New York. Environmental Conservation Regulation 6 NYCRR Part 205, Architectural Surface Coatings, effective 1988 September 14. Available at: <http://www.dec.state.ny.us/website/regs/part205.html>. Last accessed 2004 August.
30. State of New York. Environmental Conservation Regulation 6 NYCRR Part 205 (New), Architectural and Industrial Maintenance (AIM) Coatings, effective 2005 January 1. Available at: [http://www.dec.state.ny.us/website/regs/part205\\_new.html](http://www.dec.state.ny.us/website/regs/part205_new.html) Last accessed 2004 August.
31. Bureau of the Census. United States Census 2000. Available at: <http://www.census.gov/main/www/cen2000.html/>. Last accessed 2004 August
32. Lockheed Martin Technology Services. Environmental Services REAC, Edison, NJ. Trip Report: Moisture Cure Urethane, Brooklyn, NY: WA# R1A11040. 2004 16 April.
33. Zellweger Analytics, Inc.; Response Verification Procedures for Chemcassette-Based Toxic Gas Monitoring Systems, 1997.
34. American Society for Testing and Materials. D5932-96(2002) Standard test method for determination of 2,4-toluene diisocyanate (2,4-tdi) and 2,6-toluene diisocyanate (2,6-tdi) in air (with 9-(n-methylaminomethyl) anthracene method) (mama) in the workplace. Available at: [http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE\\_PAGES/D5932.htm?E+mystore](http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/D5932.htm?E+mystore) Last accessed 2003 October 17.
35. Omega Specialty Instrument Co. Iso-Check® Isocyanate sampling cassette for 2,4 TDI, 2,6 TDI, 1,6 HDI, and MDI. Houston, TX; 1996.
36. RAE Systems, Inc. MultiRAE-Plus® products. Available at: [http://www.raesystems.com/Products/MultiRAE\\_Plus](http://www.raesystems.com/Products/MultiRAE_Plus). Last accessed 2004 August.
37. US Environmental Protection Agency. Compendium of methods for the determination of toxic organic compounds in ambient air. Cincinnati, Ohio: Center for Environmental Research Information, National Risk Management Research Laboratory, Office of Research and Development, EPA/625/R-96/010b (NTIS PB99-172355); 1999 January.
38. National Institute for Occupational Safety and Health. Analytical Methods, compendium of methods, DHHS (NIOSH) Publication 94-113 (1994 August). Available at: <http://www.cdc.gov/niosh/nmam/nmammenu.html> / [now <http://www.cdc.gov/niosh/nmam/>] Last accessed 2003 October 17.
39. New York State Department of Health. Study of Volatile Organic Chemicals in Air of Fuel Oil Heated Homes 2003. Available at: [http://www.health.state.ny.us/nysdoh/indoor/fuel\\_oil.htm](http://www.health.state.ny.us/nysdoh/indoor/fuel_oil.htm). Last accessed 2005 April 22.
40. New York City's Air Pollution Control Code (Title 24 of the NYC Administrative Code). <http://public.leginfo.state.ny.us/menugetf.cgi>. Last accessed 2004 August.

41. DiNardi SR, ed. The occupational environment - its evaluation and control. Fairfax, VA: American Industrial Hygiene Association (AIHA) In press 1997.
42. RAE Systems, Inc. PID calibration actors, ionization potentials, and calibration characteristics. Available at:  
<http://www.woorisystems.co.kr/techapp/tn106.htmcalc/> Last accessed 2004 August.

---

## Appendix A: ATSDR Levels of Concern for Ethyl Benzene, Xylenes, and TDI

### Background

Exposure limit guidelines for many chemicals have been developed by government and professional agencies, with the majority of these guidelines relating to occupational exposures. Existing exposure guidelines usually focus on acute, high exposure levels (e.g., from industrial accidents), chronic, low-level, lifetime exposures, or exposures calculated to be below a health threat level. Few guidelines pertain to short-term exposures of low-to-moderate levels, even for predictable or routine exposures.

The chemicals of concern for this EI, ethyl benzene, xylenes, and TDI, are known to cause a variety of health effects, including effects on the respiratory tract. Young children may be particularly vulnerable to health effects from exposure to these chemicals. The levels and duration of exposures anticipated for this EI include relatively short peaks (several minutes to a few hours) of moderately high levels after each application of MCU, followed by a gradual decline in levels until the next application. Following the final MCU application, levels eventually decline to baseline levels over an unknown period of time. MCU use could be repeated every few years in a particular apartment, or occur in several different apartments within a particular building. As a result, there are potentially recurrent exposures to the occupants of neighboring apartments each time a building resident uses MCU.

Described in the following paragraphs are the existing exposure limit guidelines for ethyl benzene, xylenes, and TDI. Methods used to derive guidelines when none exist also described.

ATSDR has established minimal risk levels (MRLs) for many potentially toxic substances. An MRL is an estimate of daily human exposure that is unlikely to be associated with any appreciable non-cancerous health risk over a specified duration of exposure [1]. However, values greater than the MRL do not necessarily pose a health threat. Data from human and animal studies determine the no-observed-adverse-effects-level (NOAEL) and the lowest-observed-adverse-effect-level (LOAEL) for a substance. The NOAEL or LOAEL is divided by an uncertainty factor (UF) to determine the MRL. MRLs are reported for exposures that are acute (<14 days), intermediate (15–364 days), and chronic ( $\geq 365$  days) [1].

ATSDR has established MRLs for both ethyl benzene and xylenes [2,3], but has not established an MRL for TDI. However, EPA has developed a Reference Concentration (RfC) for TDI [4]. A RfC is an estimate of a daily exposure to humans (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects in a lifetime. The RfC is usually derived from NOAELs or LOAELs [4].

The American Conference of Governmental Industrial Hygienists (ACGIH) has developed occupational threshold limit values (TLVs). These TLVs include the TLV short-term exposure limit (STEL) for exposures lasting no more than 15 minutes, and the TLV time-weighted average (TWA) for exposures lasting for up to 8–10 hours/day, 40

hours/week for many months or years [5]. These TLVs are often similar to or the same as the National Institute of Occupational Safety and Health (NIOSH) and Occupational Safety and Health Agency (OSHA) exposure limits values [6].

Occupational exposure levels (OELs) are designed to protect healthy workers, not the general population. As a result, they are not intended to identify potential health risks from residential or other non-occupational exposures. Nevertheless, when exposure guidelines for the general public are unavailable, OELs can be valuable resources when used in conjunction with other information. Exposure limits for the general public are typically lower than the corresponding occupational limits because the general public includes individuals that are potentially more sensitive, such as the very young or the elderly.

NIOSH has established levels considered immediately dangerous to life or health (IDLHs) for ethyl benzene, xylenes, and TDI. An IDLH level is the level at which exposures of 30 minutes or more can cause death or permanent health effects [7].

The Wisconsin Department of Health and Family Services (DHFS) used OELs to develop screening guidelines for residential vapor intrusion [8]. The *Guidance for professionals for addressing residential vapor intrusion issue* was developed in collaboration with environmental health scientists from the EPA, ATSDR, and the Wisconsin Department of Natural Resources [8]. To identify VOC levels warranting further evaluation, the DHFS developed a residential VOC screening level using 2.4% of the ACGIH TLV-TWA. This approach adjusts exposures anticipated for a 40-hour work-week to address full-time exposures (7 days/week and 24 hours/day). It includes an additional safety factor of 10 for sensitive populations. These adjusted levels are considered to be protective for most short-term exposures [8]. However, the guidance emphasizes that if people are experiencing symptoms consistent with those expected for the contaminant present, it must be assumed that they could be related to chemical exposure and should be evaluated by a physician.

Another approach for deriving health-based guidelines for a variety of media (e.g., air, food, water) is to select a NOAEL or LOAEL from a suitable animal or human study and divide by a series of uncertainty factors (UFs). This approach is used by the EPA and other federal agencies to develop health-based guidelines for non-carcinogenic substances [9,10]. A UF of 10 is used to account for differences between individuals, such as differences between healthy adults and those with medical conditions, the very young or the elderly. Additional UFs of 5–10 may be added as needed to account for differences between humans and animals, for less-than-lifetime or less-than-chronic exposures, or for use of a LOAEL instead of a NOAEL [9].

The California State Environmental Protection Agency, Office of Environmental Health Hazard Assessment (OEHHA), has developed acute (1-hour) inhalation Reference Exposure Levels (RELs) for 31 hazardous, airborne substances, including xylenes [11]. A REL is the level below which adverse human effects are unlikely to occur for exposures up to one hour. These OEHHA risk assessment guidelines were developed to protect the individuals who live or work in the vicinity of plants or factories where emissions of air

toxicants occur intermittently, routinely, or predictably at levels considerably below those associated with spills or other industrial accidents [11]. These OEHHA guidelines were developed for ambient air exposures. But similarities between those potential exposure situations and the episodic indoor exposures resulting from nearby use of MCU make the REL a potentially useful guide for evaluating VOC emissions related to MCU use.

### **Exposure Limits for Ethyl Benzene**

The intermediate MRL for ethyl benzene is 1.0 ppm. A MRL for acute exposures has not been established. The MRL is derived from an animal-based NOAEL of 100 ppm [2]. The occupational TLV-STEL is 125 ppm and the TLV-TWA is 100 ppm. These values are based on irritant and central nervous system (CNS) effects [5]. The IDLH level is 800 ppm [12]. Ethyl benzene has a very low odor threshold of 1–2 ppm, so most individuals would detect its presence at levels well below those that would cause symptoms [2].

There are very limited data available regarding effects of ethyl benzene exposure in children [2,13]. However, there is a growing body of evidence supporting the role of indoor air pollutants in the development of asthma in young children [14,15,16,17]. The most consistently implicated VOCs are toluene and benzene, but ethyl benzene exposure has also been identified as potentially causing an increased asthma risk [14,16,17].

### **Exposure Limits for Xylenes**

The acute MRL for xylenes is 1.0 ppm and is based on a LOAEL of 100 ppm [3]. This LOAEL is based on increased reaction times in human adult, male volunteers exposed to 100 ppm for 4 hours [3]. The occupational TLV-STEL and TLV-TWA are 150 and 100 ppm, respectively, and are based on irritant and neurological effects [6,7]. The IDLH is 900 ppm [18]. The California 1-hour REL for xylenes is 5.07 ppm ( $2.2 \times 10^4 \mu\text{g}/\text{m}^3$ ) [11]. The odor threshold for xylenes is also very low (1.0 ppm) [3].

Limited data are available regarding health effects of xylene exposures in children [3,13]. Still, the existing data suggest that pregnant women, fetuses, and very young children could be unusually susceptible to the toxic effects of xylenes [3]. For pregnant women exposed to xylenes, ingestion of aspirin could increase the effects of xylenes in both the mother and the fetus. The ability of fetuses and very young children to metabolize certain xenobiotics (chemicals that are not naturally found in the body), including possibly xylenes, is reduced because of their immature enzyme detoxification systems [3].

### **Exposure Limits for TDI**

It is not clear what level and duration of exposure induces TDI sensitization. Most of what is known about TDI-induced asthma is based on animal studies and occupational exposures. After extensive literature review of empirical occupational data, one author concluded that the majority of TDI-induced asthma may arise from short-term exposures in excess of 20 ppb [19]. He also reported that the incidence of TDI-induced asthma was very low (0.7%) when time-weighted average (TWA) concentrations averaged less than 5 ppb. The annual incident rates were above 1% for average TWA concentrations greater than 5 ppb [19]. An internationally recognized authority on TDI speculates that the

amount of exposure required to induce sensitization could fall well below 20 ppb [20]. Canadian researchers concluded that isocyanate-induced asthma appears to be more related to long-term exposures at low concentrations than to short-term exposures at higher concentrations [21]. Although opinions differ as to which type of exposure is most often responsible for inducing sensitization, existing evidence supports that either acute exposures to relatively high levels or chronic exposures to lower levels are the culprits. No documented evidence suggests that sensitization in humans develops after short-term, low-dose exposures [19,20,21].

Recent reports associate adult, non- or para-occupational exposures with TDI sensitization and asthma, but data regarding levels of exposure were not included [22,23]. The absence of exposure data minimizes the usefulness of these reports.

The TLV-STEL for TDI is 20 ppb, while the TLV-TWA is 5 ppb [5]. The IDLH is 2.5 ppm [24]. No MRL has been established; however, the inhalation RfC for TDI is 0.0098 ppb (7.0 E-5 mg/m<sup>3</sup>) [4]. This value was based on chronic lung function decline and derived from a NOAEL of 0.9 ppb and a LOAEL of 1.9 ppb. Both the NOAEL and LOAEL are based on 8-hour TWA occupational exposures.

### **ATSDR Exposure Limit Guidelines for Ethyl Benzene, Xylenes, and TDI**

The existing exposure limit guidelines for non-occupational indoor air exposure to ethyl benzene, xylenes, and TDI include the MRL (or RfD) and the IDLH. Levels below the MRL can generally be considered safe [1]. But levels above the MRL do not necessarily pose a health threat. ATSDR sought to identify exposure limit guidelines for ethyl benzene, xylenes, and TDI that addressed the potential health threat associated with the anticipated exposure scenarios in this EI.

The anticipated exposure scenarios included a rapid rise to peak levels of VOC and TDI lasting several minutes to hours after an MCU application. This dramatic rise in levels would likely be followed by gradually declining levels over several hours, with an eventual and gradual return to baseline levels.

Where possible, ATSDR used existing exposure guidelines to address these anticipated exposure scenarios. For each chemical, ATSDR identified three minimum levels of concern, depending on the duration of exposure. These included a minimum level of concern for prolonged exposures (several hours), for exposures of one hour or more, and for exposures of 15 minutes or more. Exposures above these levels of concern could pose a potential health threat, but exposures below these limits would need further evaluation to determine the influence of other factors, such as duration and location.

#### ***Ethyl Benzene and Xylenes***

For prolonged exposures, ATSDR used the Wisconsin DHFS vapor intrusion guide to identify a minimum level of concern of 2.4 ppm for ethyl benzene and xylenes. This value is derived by multiplying the TLV-TWA of 100 ppm (the same for both chemicals) by 2.4% (0.024). We selected this guide because it is a published document developed in collaboration with environmental health scientists from several federal public health

agencies. The levels derived with this method are considered to be protective for most short-term exposures, which are the types of exposures expected for this EI [8]. Values above 2.4 ppm would not necessarily indicate a potential health threat, but would warrant closer evaluation of circumstances, such as specific location and duration. Levels below 2.4 ppm but above the MRL would also be similarly evaluated.

For exposures lasting one or more hours, ATSDR selected the California OEHHA acute REL for xylenes for exposures of either xylenes or ethyl benzene [11]. Because an REL has not been established for ethyl benzene and the OELs for both chemical are similar, ATSDR used the same REL for both chemicals. Levels between 2.4 and 5.0 ppm would be evaluated for potential health effects based on duration and location of exposure.

Because of the anticipated peak levels, ATSDR also defined a guideline for higher levels of shorter durations. We set the short-term guideline for a maximum level of 12.5 ppm for up to 15 minutes. This guideline is based on the more conservative occupational STEL for ethyl benzene (125 ppm) rather than on the STEL for xylenes (150 ppm) [5]. The value of 12.5 ppm is obtained by dividing 125 ppm by a safety factor of 10 to protect sensitive populations.

### ***TDI***

The main concern regarding TDI for this EI is the potential for exposure to levels that cause sensitization. There are no other known community sources of TDI that might have resulted in previous TDI exposures high enough to induce sensitization. Such sources could include foam manufacturing plants or automotive paint shops that have uncontrolled emissions.

The lowest documented TDI level causing asthma exacerbations in sensitized adults is 1.0 ppb. A higher level of exposure is required for sensitization to develop, although opinions differ as to which type of exposure is most often implicated. Some authorities implicate short duration exposures of at least 20 ppb (possibly less), while others implicate chronic exposures to lower levels [19,20,21]. No documented evidence suggests that sensitization occurs from short-term, low dose exposures [19,20,21].

The lower detection limit for TDI involving the ASTM method associated with the ISO-CHEK® device is 0.15 ppb [25]. The NOAEL is 0.9 ppb and is based on chronic exposure data. This NOAEL, along with available exposure data, provide a reasonable guideline for determining a minimum exposure for sensitization from short-term, episodic exposures in sensitive populations such as young children. ATSDR defined 1.0 ppb as the minimum level of concern for exposures lasting 15 minutes or more. We also defined the instrument detection limit of 0.15 as a screening level. Levels of 0.15 ppb or above would not necessarily indicate a health hazard, but would warrant careful evaluation of other factors such as duration and whether the exposure location occurred in a living space.

These exposure limit guidelines for evaluating the potential health threat from xylenes, ethyl benzene, and TDI are based on an extensive evaluation of published data. The



guidelines are summarized in Table A-1. These levels are intended only as guidelines, not levels above which a health threat exists. In addition, these guidelines pertain only to potential non-cancer health threats. These chemicals are not classified as carcinogens by either the International Agency for Research on Cancer (IARC) or by the USEPA.

Because neither animal nor human studies show that exposures cause cancer, xylenes are classified as *not classifiable* (Group C) substances. But the studies were not large enough to rule out carcinogenicity [3,26]. The IARC has classified ethyl benzene as *possibly carcinogenic* (Group 2B), while the USEPA says ethyl benzene is *not classifiable* as a human carcinogen. No human studies have shown that ethyl benzene exposure results in cancer. Two animal studies suggest, however, that ethyl benzene could cause tumors in animals [2,26].

The IARC classifies TDI as *possibly carcinogenic to humans* (Group 2B). No human studies have shown that TDI exposure causes cancer. Still, studies show that oral exposure to TDI causes tumors in female rats [26].

**Table A-1. ATSDR Exposure Limit Guidelines for Ethyl Benzene, Xylenes, and TDI**

Chemical	MRL	Screening Level	Exposures >1 hour	Exposures >15 minutes
Ethyl Benzene	1.0 ppm*	2.4 ppm	5.0 ppm	12.5 ppm
Xylenes	1.0 ppm†	2.4 ppm	5.0 ppm	12.5 ppm
TDI	NA	0.15 ppb	1.0 ppb	1.0 ppb

\* Intermediate exposure duration (14–365 days)

† Acute exposure duration (0–14 days)

NA - Not available

---

## References for Appendix A

1. Agency for Toxic Substances and Disease Registry. Minimum Risk Levels (MRLs); Jan 2003. Available at: <http://www.atsdr.cdc.gov/mrls.html#bookmark02> Accessed Feb 2004.
8. Agency for Toxic Substances and Disease Registry. Toxicological profile for ethyl benzene (update). Atlanta: US Department of Health and Human Services; 1999 July. p. 11–113.
9. Agency for Toxic Substances and Disease Registry. Toxicological profile for xylenes (update). Atlanta: US Department of Health and Human Services; 1995 August. p. 13–142.
10. US Environmental Protection Agency Integrated Risk Information System (IRIS). 2,4-/2,6-Toluene diisocyanate mixture (TDI); CASRN 26471-62. Available at: <http://www.epa.gov/iriswebp/iris/index.html>. Last accessed August 2004.
11. American Conference of Government Industrial Hygienists. Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH; 2003.
12. National Institute for Occupational Safety and Health. NIOSH Pocket Guide to Chemical Hazards. Atlanta: Centers for Disease Control and Prevention; 1997 June.
13. National Institute for Occupational Safety and Health. Documentation for immediately dangerous to life or health concentrations (IDLHs). Available at: <http://www.cdc.gov/niosh/idlh/idlh-1.html> Last accessed 2004 February.
14. State of Wisconsin, Department of Health and Family Services, Division of Public Health. Guidance for professionals: chemical vapor intrusion and residential indoor air. Feb 13, 2003. p. 1–16. Available at: [http://dhfs.wisconsin.gov/eh/Air/fs/VI\\_prof.htm](http://dhfs.wisconsin.gov/eh/Air/fs/VI_prof.htm). Last accessed 2004 August.
15. Calabrese EJ and Kenyon EM. Introduction to the problem and review of current approaches, and an approach for the rapid development of scientifically defensible AALs. In: Air Toxics and Risk Assessment. Michigan: Lewis Publishers, Inc.; 1991. pp 3–13 and 51–71.
16. US Environmental Protection Agency. Reference Dose 9RfD: Description and Use in Risk Assessments. In: Integrated Risk Information System (IRIS); 1993. Available at: <http://www.epa.gov/iris/rfd.htm>. Last accessed 2004 August.
17. California Environmental Protection Agency. Air toxics hot spot program risk assessment guidelines, Part I: The determination of acute reference exposure levels for airborne toxicants. Sacramento: Office of Environmental Health Hazard Assessment; 1999. Available at: [http://www.oehha.ca.gov/air/hot\\_spots/index.html](http://www.oehha.ca.gov/air/hot_spots/index.html). Last accessed 2004 August.

18. National Institute for Occupational Safety and Health. Documentation for immediately dangerous to life or health concentrations (IDLHs) for ethyl benzene. Atlanta: Centers for Disease Control and Protection; 1995. Available at: <http://www.cdc.gov/niosh/idlh/100414.html>. Last accessed 2004 February.
19. E-mail communication with Dr. Robert Geller, MD, FAAP, ACMT, Pediatric Medical Toxicologist and Participating Physician, Emory SE Pediatric Environmental Health Specialty Unit. Atlanta: Emory University School of Medicine; 2004 April 5.
20. Rumchev K, Spickett J et al. Association of domestic exposure to volatile organic compounds with asthma in young children. *Thorax* 2004;59:746–51.
21. Thurston GD and Bates DV. Air Pollution as an underappreciated cause of asthma symptoms. *JAMA* 290(14):1915–17.
22. Jones AP. Asthma and domestic air quality. *Soc Sci Med* 1998;47(6):755–64.
23. Johnson CC, Ownby DR et al. Environmental epidemiology of pediatric asthma and allergy. *Epidemol Rev* 2002;24:154–75.
24. National Institute for Occupational Safety and Health. Documentation for immediately dangerous to life or health concentrations (IDLHs) for xylenes. Atlanta: Centers for Disease Control and Prevention; last updated 1996 August 16. Available at: <http://www.cdc.gov/niosh/idlh/95476.html>. Last accessed 2004 February.
25. Ott GA. Occupational asthma, lung function decrement, and toluene diisocyanate (TDI) exposure: a critical review of exposure-response relationships. *Appl Occup Environ Hyg* 2002;17(12):891–901.
26. Bernstein, JA. Overview of diisocyanate occupational asthma. *Toxicol* 1996;111:181–89.
27. Lemiere C, Romeo P, Chaboillez S, Tremblay C, Malo JL. Airway inflammation and functional changes after exposure to different concentrations of isocyanates, *J Allergy Clin Immunol* 2002;110(4):641–6.
28. DeZotti Z, Muran A, and Zamborn F. Two cases of paraoccupational asthma due to toluene diisocyanate (TDI). *Occup Environ Med*, 2000;57:837-839.
29. Orloff K, Batts-Osborn D, Kilgus T, Metcalf S, Cooper M. Antibodies to toluene diisocyanate in an environmentally exposed population. *Environ Health Perspect* 1998;106(10):665–66.
30. National Institute for Occupational Safety and Health. Documentation for immediately dangerous to life or health concentrations (IDLHs) for toluene diisocyanate. Atlanta: Centers for Disease Control and Prevention; 1995. Available at: <http://www.cdc.gov/niosh/idlh/584849.html>. Last accessed 2004 February.

31. Mega Specialty Iso-Check. Isocyanate sampling cassette for 2,4 TDI, 2,6 TDI, 1,6 HDI, and MDI. Chelmsford; 1996.
32. International Agency for Research on Cancer. Available at: <http://www.iarc.fr/>. Last accessed 2005 March.

**Appendix B: ATSDR Exposure Investigation Protocol**

**Airborne Exposures to Moisture Cure Urethane (MCU)  
in Multi-Family Residential Buildings**

**New York, New York**

**March 2004**

## Table of Contents

- I. INTRODUCTION
  - Background
  - Justification
  - Investigators/Collaborators
  - Investigation Objectives
  
- II. METHODS
  - Exposure Investigation Design
  - Target Population
  - Air Monitoring and Air Sampling Procedures
  - Air Monitoring Data
  - Air Sampling Data
  - Questionnaire
  - Quality Assurance
  - Data Analysis, and Interpretation
  - Limitations
  
- III. RISK/BENEFIT INFORMATION
  
- IV. INFORMED CONSENT PROCEDURES
  
- V. COMMUNITY INVOLVEMENT
  
- VI. RESULTS
  - Reporting Results to Participants
  - Final report
  
- VII. CONFIDENTIALITY
  
- VIII. TIMELINE
  
- IX. REFERENCES
  
- X. APPENDICES
  - Appendix A: Questionnaire
  - Appendix B: Consent Form

## INTRODUCTION

### Background

In September 2003, the Agency for Toxic Substances and Disease Registry (ATSDR) received a request from the New York City Department of Health and Mental Hygiene (DOHMH) to further characterize air pathway exposures from residential applications of moisture curing polyurethane. The request was prompted by the results from a preliminary investigation they had conducted March 2003.

This product, also known as moisture cure urethane (MCU), is widely used on wood floors in multi-family residential buildings within a predominantly Hasidic community. Residents in that community have complained of strong odors, respiratory distress and other symptoms during and after the application of MCU to floors in other apartments within the same building. A local rabbi had enlisted the assistance of the New York City DOHMH to investigate the possible link between the MCU applications and those complaints. Those results are discussed below [1].

MCU is typically used commercially in situations where its properties provide advantages over other sealants. These applications include bowling alleys, indoor basketball courts, marine environments (e.g., piers, bridges and ships), concrete surfaces, structural steel, and other industrial uses [2].

MCU's superior durability and high gloss has led to it becoming the wood floor treatment of choice among families in the residential buildings mentioned. The popularity of MCU within that community has been spread by word-of-mouth.

MCU contains isocyanates, typically toluene diisocyanate (TDI), as a curing agent to create the hardness of the final urethane finish. MCU also contains volatile organic chemicals (VOCs), including xylene, ethyl benzene, and acetates, as well as urethane polymers. The volatile materials evaporate during MCU application and curing. The curing process is reported to take approximately 48 hours; once cured, the MCU coating is considered inert and non-hazardous [1,2]. However, the duration of off-gassing is not well-documented. The occurrence of symptoms among residents during MCU application and after the MCU is dry and supposedly cured, brings to question whether the 48 hour time period for complete curing is accurate.

According to DOHMH, the occupants of the apartments in which the wood floors are being treated with MCU temporarily relocate during the treatment process. The occupants of other apartments within the same building, including those immediately adjacent to the apartment where MCU is applied, often do not relocate. There is concern that these families, which include many children as well as pregnant women, are being exposed to airborne contaminants that are potentially at levels that may pose a health hazard.

In the preliminary investigation, DOHMH sampled the air at three locations inside a 4-story apartment building following MCU application in two of the apartments. DOHMH reported the aggressive use of ventilation for the first hour after MCU treatment. Air samples were collected for one-to-three hour periods in areas of the building other than the two treated apartments. These areas included hallways outside the treated apartments and a bedroom in another apartment. The results showed trace levels of TDI as well as elevated levels of ethyl benzene and xylene. TDI levels of 0.26 and 0.87 parts per billion (ppb) were found in air samples collected over a 2-3 hour period. In samples collected for approximately one hour, ethyl benzene was detected at levels up to 35 parts per million (ppm); total xylenes were detected at levels of up to 53 ppm [1].

### **Justification**

VOCs and TDI emissions are known to be associated with the MCU applications [3,4]. The DOHMH sampling results demonstrated that VOCs and TDI emissions were occurring outside of the apartments in which the MCU was applied [1]. However, the sampling durations and locations most likely did not capture maximum concentrations of these compounds. Furthermore, the duration of time the compounds persisted after application was not determined. Knowing the characteristics of concentrations in air (peak and time weighted average), as well as the duration of TDI and VOC emissions is essential for determining whether a health hazard exists.

The signs of acute-duration exposure to high levels of ethyl benzene are primarily respiratory irritation, eye irritation, burning and lacrimation, and neurologic (dizziness, headache). These signs usually do not occur below levels of 1000 ppm and resolve without sequelae [5]. The NIOSH immediate danger to life or health (IDLH) level is 800 ppm [6]. The no observed adverse effect level (NOAEL) for humans is 100 ppm and is based on developmental effects in animals following ethyl benzene inhalation. There have been no documented deaths from exposure to ethyl benzene alone [5].

Xylene can exist in three isomeric forms; o-xylene, m-xylene, and p-xylene. These isomers possess similar properties, including toxicity and are often referred to as total xylenes [7]. In this document “xylene” refers to total xylenes.

Central nervous system (CNS) effects as well as eye and respiratory tract irritation are the primary human effects caused by exposure to xylene. Mild CNS effects, including decreased reaction time, decreased short-term memory, lightheadedness, and unsteadiness can occur from exposures of 100 ppm for 5-6 hours [7]. Acute exposures (3-5 minutes) at 200 ppm can cause eye, nose and throat irritation. Death has been documented from exposure of 10,000 ppm for several hours [7]. The IDLH is 900 ppm and is based on acute inhalation toxicity data in animals [8]. The NOAEL is 100 ppm and is based on CNS effects [7].

TDI exposure can not only exacerbate existing asthma and other chronic respiratory conditions, but can also actually cause asthma [[9,10,11]]. In fact, TDI is a leading cause of occupational asthma worldwide [10,11]. Although the mechanisms by which TDI



causes asthma are not completely understood, increasing evidence supports an interrelationship between the human immune response, the airway epithelium, and genetic susceptibility [11].

Exposure to TDI can cause some people to become sensitized to it in a way that is, at least in part, similar to becoming sensitized, or “allergic” to ragweed or animal dander. Once sensitization has developed, later exposures to even minute amounts can cause reactions that may range from mild to very severe. Severe asthma exacerbations in individuals sensitized to TDI have been documented from exposures as low as 1 part per billion (ppb) [10].

Most of what is known about TDI-induced asthma is based on occupational exposures. However, there are recent reports of TDI sensitization and asthma associated with non-occupational exposures [12,13].

Children (and fetuses) may be more susceptible than adults to adverse effects from chemical exposures including TDI, ethyl benzene and xylene [5,7,14,15]. TDI exposures in children are of particular concern because of the potential for developing TDI sensitization and subsequent asthma.

TDI, ethyl benzene and xylenes are heavier than air and tend to sink to lower heights in a room [5,7,9,16]. Children are of lower stature than adults and also have a faster normal breathing rate. These differences may result in a child inhaling more of the contaminant than an adult who is in the same environment with a subsequent increase risk for related adverse health effects [5,7,14,15].

The local rabbi’s efforts to convince community members not to use MCU on their floors have been relatively unsuccessful, despite an accumulation of anecdotal evidence suggesting associated adverse health effects, particularly respiratory effects in children. An exposure investigation (EI) is needed to determine if residents of an apartment building are being exposed to potentially harmful levels of TDI or VOCs when MCU is applied to floors in other apartments in the same building. In this EI we will conduct short-term air monitoring and sampling for TDI and VOCs in private apartments and shared hallways when MCU is being applied in other apartment(s) in the same building. Monitoring and sampling will continue during a period of 2-5 days. Results will be analyzed and evaluated for their health hazard potential.

### **Investigators/Collaborators**

ATSDR, with the assistance of the Regional ATSDR Office, the DOHMH, and the NYSDOH will conduct the investigation. Specific agency’s roles are as follows:

- DOHMH will be the local health contact for this Exposure Investigation (EI). They will schedule and participate in community meetings and will assist ATSDR with participant recruitment.

- Through an interagency agreement with ATSDR, the U.S. Environmental Protection Agency Environmental Response Team (EPA ERT) Response, Engineering, and Analytical Contract (REAC) personnel will collaborate with ATSDR and DOHMH on testing the indoor concentrations of VOCs and TDI.
- DOHMH and NYSDOH will assist ATSDR and REAC in evaluating air distribution within the apartment building during the EI to determine optimal sites for air monitoring and sampling.
- EPA ERT's REAC personnel will set up the appropriate equipment and conduct the residential indoor air monitoring and sampling.
- ATSDR will fund laboratory analysis via an interagency agreement with Division of Federal Occupational Health (DFOH).
- ATSDR, along with the DOHMH and NYSDOH, will evaluate air testing results and interpret the associated potential health impact.
- ATSDR will prepare an individual report for each participating household as well as the draft and final report of the investigation findings. DOHMH and NYDOH will review the draft documents and provide comments.

### **Investigation Objectives**

This EI has three objectives. First, is to characterize the concentrations, including peak concentrations and time-weighted average values, of TDI and VOCs in common areas, such as hallways, within the residential apartment building and in 2-3 other apartments during the application and curing of MCU in another apartment(s).

Second, is to evaluate if the exposures are occurring at levels that pose a health threat to the residents, and particularly to children, whom we assume are the most vulnerable [see appendix X for criteria].

Third, is to determine when, following application of the MCU, the TDI level in the treated apartment is no longer detectable, and when the VOC levels are within baseline levels.

## **METHODS**

### **Exposure Investigation Design**

This EI will consist of environmental air monitoring and sampling for specific by-products of MCU and administering household questionnaires to help evaluate the

results. Air monitoring and sampling will be conducted in common areas within the apartment building, and in 2-3 individual apartments that are relatively close to the apartment(s) where the MCU has been applied. Monitoring and sampling in these areas will begin prior to application of MCU and will continue for 2-5 days, depending on how many coats are applied.

Air monitoring will also be conducted in the treated apartment after MCU has been applied to determine when TDI is no longer detectable and the VOC levels are within baseline levels measured in apartments. Air samples will also be collected, if possible.

Household questionnaires, which will be available in Yiddish and English, will be interviewer-administered to an adult member of each household in which monitoring and sampling are being conducted. This will not include the household(s) in which the MCU has been applied. The questionnaire is designed to characterize the household members and to identify the presence of chemicals in the home that may affect testing results.

### **Target Population**

The target population for this investigation is Hasidic families with children living in an apartment building in which the floors of one or more apartments are being treated with MCU. The typical apartment building is four stories with four to eight apartments, although some buildings have as many as 20 stories and up to 200 apartments. The population that will be potentially affected by the outcome of this EI is much larger, however. This Hasidic community, located in a 20 square block area, consists of 8,000 to 10,000 families. On average each family has from 7 to 11 children.

ATSDR and DOHMH will enlist the support and assistance of the local Hasidic rabbi to identify a residential building whose floors are slated for MCU application. The agencies will identify common areas in the building that are potential exposure points for residents, and with the rabbi's assistance, will recruit residents who are willing to have sampling conducted in their apartments during and after MCU application elsewhere in the building. Families whose apartments are located on the same story (level), on the story below, and on the story above the treated apartment(s) will be preferentially selected. Additionally, since the definitive curing time for MCU has not been established for these residences, residents whose apartment floors were treated will also be recruited for possible sampling for up to a week or longer after MCU application.

### **Air Monitoring and Air Sampling Procedures**

Screening for background VOC levels will occur prior to the application of MCU in the building. Once the application process begins, environmental monitoring and sampling for VOCs and TDI will be conducted simultaneously in two common areas in the building and in a living space within each of at least two apartments. The monitoring and sampling locations will be as close as possible to the area(s) where MCU is being applied and will be set up as stationary devices. The stationary monitors will continuously read VOC and TDI levels. Periodic sampling for these compounds will serve to support the

accuracy of the monitors' readings and to identify the specific VOC and diisocyanate compounds.

Within a room or common area, sampling and monitoring will be conducted at a height about three feet from the floor. This so called "breathing zone" approximates the height of a standing child or seated adult. TDI and the VOCs of concern are denser than air. However, due to uncertainties regarding the air flow dynamics within the building, air monitoring and sampling will be conducted at a location on the story above the treated apartment, if possible, in addition to locations on the same story and on the story below the treated apartment.

Prior to the application of MCUs in the building, REAC personnel will verify that the monitors are operating properly and will check background levels. REAC personnel will attempt to monitor baseline levels of air contaminants before the MCU application process begins. The monitors will continue to run for 2-5 days. REAC personnel will wear appropriate respiratory protection.

Table 1 below summarizes the monitoring and sampling equipment that will be used. For sampling, the type of laboratory analysis to be requested is also included.

**Table 1. Summary of Monitoring and Sampling Equipment and Sampling Analyses**

<b>Type of Testing</b>	<b>VOCs</b>		<b>TDI</b>
Screening	RAE Systems MultiRAE	Photovac MicroFID	N/A
Stationary Monitoring	RAE Systems MultiRAE	Photovac MicroFID	Zellweger (SPM™) tape meter
Sampling	SUMMA® canister with TO-14 analysis	Tenax® tube with NIOSH 1501 analysis	Isochek™ cassette with ASTM isocyanate method

Air Monitoring Procedures

*VOCs*

A programmable photoionization detector (PID) and a programmable flame ionization detector (FID) will be used for the initial screening at various locations and subsequent stationary monitoring for total VOCs. The PID detects p-xylene, m-xylene, and ethyl benzene. The FID detects ethyl benzene as well as o-xylene, m-xylene, and p-xylene. Both instruments typically have a response time of less than one minute with a detection limit near 1 ppm. The stationary monitors will run continuously during the application process and for several hours afterward.

In addition to the VOCs of interest, PIDs can detect chemicals such as acetaldehyde and acetone, commonly found at low levels inside homes. Similarly, FIDs also detect methane. Since readings may be a result of cross-detection of different chemical, both instruments will be used to help avoid misinterpreting the readings.

The PID, RAE Systems MultiRAE, will be used to monitor the air for total VOCs. This instrument samples every 15 minutes; data are collected on a TVA 1000 data logger. The detection range is 0 to 2,000 ppm (with 0.1 ppm resolution for 0-200 ppm) and the instrument is calibrated with 100 ppm isobutylene. The Photovac MicroFID with a TVA 1000 data logger will also be used to monitor for total VOCs. Its detection range is 0.1 to 50,000 ppm (within  $\pm 0.5$  ppm) and is calibrated using 50 ppm methane.

### *TDI*

Four to five Zellweger single point monitor (SPM™) tape meters will be used to monitor the air for TDI. These instruments sample the air every five minutes. If air levels approach the upper detection limit of the tape, the instrument automatically samples more frequently (up to every 2 minutes). At the end of the monitoring period, all data will be downloaded from an attached data logger. The tape meter monitors all isocyanates with a 2-5 minute response time. It contains a tape impregnated with a reagent that turns pink or purple in the presence of TDI. An optical detector measures the reflectance of the tape to determine the TDI level. For a 5-minute monitoring period, the instrument has a detection limit of 2 ppb. The tape meter provides a digital reading that is continuously recorded on a datalogger. The monitors will run continuously during the application process and for several hours afterward.

Each meter will be equipped with a TDI ChemKey and TDI Chemcassette tape (Zellweger Analytics Catalogue Identification Number 700309) with a detection range of 2-60 ppb. Tape meters are calibrated at the manufacturer and no field calibration is required. Unused tapes will be maintained at a temperature of less than 32° F to prevent chemical reagent loss. Tapes will also be wrapped in aluminum foil to prevent exposure to sunlight and premature photo-reaction.

### Air Sampling Procedures

Table 2 shows the estimated number of samples to be collected and shipped for laboratory analysis.

**Table 2. Summary of Exposure Investigation Samples for Laboratory Analysis**

Analyte	Number of Samples	Number of Blanks	Total Number of Samples
VOCs (Grab)	10	2	12
VOCs (Time-weighted)	10	6	16
TDI	13	2	15

### *VOCs*

Grab and time-weighted air samples will be collected and analyzed for VOCs. Grab sampling will be conducted according to Method TO-14A: Determination of Volatile Organic Compounds (VOCs) in Ambient Air Using Specially Prepared Canisters with Subsequent Analysis by Gas Chromatography [17,18]. When the real-time monitors indicate the presence of VOCs, a grab sample of indoor air will be drawn into a SUMMA<sup>®</sup> canister. Sample collection will involve opening a valve and drawing air into an evacuated chamber for a 1-minute interval. The sample chambers will be handled and shipped to a qualified laboratory according to proper chain of custody and storage procedures. Samples will be shipped to a laboratory for VOC analysis. Analysis will involve gas chromatography and mass spectrometry (GCMS) with a cryogenically cooled trap reducing the water vapor and concentrating the VOCs [19]. This method provides detection limits in the 1–2 ppb range for most VOCs.

The time-weighted air samples will be periodically collected using a personal pump to draw air into 600 milligram (mg) charcoal adsorption tubes (the first tube with 400 mg and the second with 20 mg charcoal). These samples will be collected for a period of time based on the PID instrument readings. This approach will serve to avoid charcoal saturation resulting in unreliable laboratory results. The tubes will then be shipped to the laboratory using strict chain of custody procedures. The contents will be analyzed for VOCs using NIOSH method 1501 (GC/FID) with a limit of detection of 0.01 mg/sample.

### *TDI*

Short-term (e.g., 15-minute) air samples will be collected for TDI using Isochek<sup>™</sup> cassettes. Samples will be collected when tape meter readings are above 2 ppb. Cassettes will be shipped to Omega Laboratories for TDI vapor and aerosol analysis. One blind blank sample will be included in the sample shipment.

TDI and other isocyanates will be collected according to the ASTM D5932-96(2002) Standard Test Method for Determination of 2,4-Toluene Diisocyanate (2,4-TDI) and 2,6-Toluene Diisocyanate (2,6-TDI) in Air (with 9-(N-Methylaminomethyl) Anthracene Method) (MAMA) in the Workplace [20]. This method covers the determination of gas and aerosol 2,4-TDI and 2,6-TDI in air samples collected from workplace and ambient atmospheres. It is a modification of a standard Swedish method in which 9-(N-methylamino-methyl)-anthracene (MAMA) and glycerol impregnated cassette filters capture the different TDI chemical species and render them non-reactive [21]. The method detection limit is 0.15 ppb [21].

### **Air Monitoring Data**

All stationary PID and FID readings will be continuously logged and reported as time-weighted (15-minute) averages. The tape meter will continuously record measured TDI levels. The chemical selectivity of tape meters depends on reagent chemistry as well as relative humidity. TDI tapes are known to be sensitive to other chemicals that may be present, such as ozone, hydrogen chloride, and hydrogen cyanide [22]. To rule out interference from these chemicals, the associated monitoring results will be compared with corresponding TDI laboratory results.

### **Air Sampling Data**

The TO-14 laboratory method to be used in analyzing the VOC samples specifically identifies ethylbenzene, o-xylene, and m,p-xylene. Results are quantified according to the respective ion's mass weight [17].

Isocyanates are very reactive chemicals, with TDI among the most reactive. During both sampling and analysis, it is difficult to capture TDI and render it non-reactive so that it can be measured accurately. The ASTM isocyanate method calls for speciating the TDI isomers and quantifying them using high performance liquid chromatograph (HPLC) equipped with ultraviolet (UV) and fluorescence detectors [23].

### **Questionnaire**

ATSDR will gather additional information about the households being tested using a questionnaire [Appendix A]. The purpose of the questionnaire is to characterize the household members and to identify the presence of chemicals that may affect testing results. The questionnaire will be interviewer-administered to an adult member from each of the two to three households in which air monitoring and sampling are being conducted, but that did not have MCU applied. Part I of the questionnaire will be administered before or during set up of the testing equipment. Part II will be administered during the day of testing after the MCU has been applied. The questionnaire will be available in Yiddish and English. The community rabbi may assist in administering the questionnaire.

The questionnaire consists of 31 possible questions, 10 of which will be asked only if the answer to the preceding question was “yes”. Questions to characterize the household members focus on the number and ages of the household members, pregnancy status, presence of respiratory or cardiac conditions, and whether anyone noticed fumes, odors or experienced symptoms temporally related to the application of MCU in another apartment, as well as the duration and nature of any symptoms, if present. Questions to identify the presence of other chemicals target hobbies done in the home, new carpets or recent carpet or furniture cleaning, and the use of various paints are intended to help interpret any background VOC levels found.

### **Quality Assurance**

Before screening and stationary monitoring begins, REAC personnel will verify that the air monitors are operating properly and will check background levels of air contaminants. During monitoring, REAC personnel will periodically verify that monitors are operating properly.

At least one blank sample will be used for each sampling method. These blanks will show whether or not the samples were contaminated during shipping or if the laboratory analysis is potentially flawed. Blank samples will be given a false sample ID and location, so the laboratory will be blinded to the sample’s identity, as appropriate. Analytical accuracy will be evaluated using chemical recovery data and instrument calibration results.

ATSDR will use chain-of-custody forms to document sample collection, storage, shipment, and the description of requested analyses. The original forms will be sent along with the samples to the laboratory and ATSDR will maintain copies of the forms.

### **Data Analysis and Interpretation**

There are significant data gaps regarding exposure guidelines for TDI and VOCs in the general population, particularly in children and fetuses. While occupational exposure levels are not appropriate for community exposure/health outcome assessments, they are valuable guides when used in conjunction with relevant peer journal case reports and research and other reference values when interpreting the significance of community exposures. The EI data will be analyzed and public health conclusions reached for several different purposes both during and after the exposure investigation using occupational references values as well other published literature and reference values as guidelines.

#### *1. Potential for recommending temporary relocation during MCU application:*

Tapemeter and PID results will be frequently reviewed during the MCU application event to ensure that residents are not being exposed to unacceptably high levels of TDI and/or VOCs.



---

Referring to Table 3, if levels of TDI exceed any of the following either in an apartment or in a common space (e.g., hallway), the decision will be made regarding recommending that residents in that area temporarily relocate to an alternate location:

- a. greater than 20 ppb TDI for two consecutive tapemeter readings, or
- b. between 10 and 20 ppb for 15 minutes, or
- c. between 5 and 10 ppb for 4 hours

In a living space, if VOCs exceed 150 ppm for 15 minutes with no decreasing trend, temporary relocation will be recommended. If VOCs reach this level in a common area (e.g., hallway), efforts will be made to ventilate the area (e.g., open windows and doors) and restrict traffic until levels are reduced.

*2. Safe for reoccupancy (for residents whose apartment has had the MCU applied or residents who temporarily relocated):*

Again, referring to Table 3, reentry will be recommended when tapemeter readings show non-detectable levels of TDI and PID readings approach background levels of VOCs.

*3. Review of the laboratory analysis of air samples collected and 15-minute peak values for TDI and VOCs logged from each air monitor during the EI:*

The health evaluation of the air sampling and monitoring results will take into account the origin of the sampling or monitoring data (e.g., from a common hallway or from a non-treated apartment), as well as the MCU activities during the sample collection (e.g., during MCU application or post-application). For example, a grab sample collected in the midst of MCU application will be evaluated differently than an 8-hour time-weighted sample collected two days after the application is complete.

Short-term air sampling and air monitoring results for TDI will be evaluated based on the level of 1 ppb as representing a potential health hazard. This level has been shown to precipitate asthma reactions in sensitized individuals [10].

Grab sample results for ethylbenzene and xylene will be evaluated using occupational ceiling and short-term exposure limit (STEL) values [24,25], and levels normally found in the environment (background levels). Time-weighted sample results for ethylbenzene and xylene will be evaluated using ATSDR Minimal Risk Levels (MRLs) [26], background levels, and other guidelines. These reference values are summarized in Table 3.

**Table 3. Summary of reference values used in the EI for evaluating the public health significance of TDI and VOC levels**

<b>Real-time Data</b>				
	<i>TDI</i>	<i>Total VOCs</i>	<i>Ethyl benzene</i>	<i>Xylene</i>
Criteria for recommending temporary relocation	>20 ppb* for 2 consecutive readings, or 10 ppb <sup>†</sup> for 15 minutes, or 5 ppb <sup>‡</sup> for 4 hours	In a living space: >150 ppm for 15 minutes with no decreasing trend	N/A	N/A
Criteria for recommending re-occupancy	ND	Approaching background levels	N/A	N/A
<b>Air sampling results</b>				
Levels of health concern	≥1 ppb	N/A	Intermediate MRL = 1.0 ppm  STEL = 125 ppm	Acute MRL = 1.0 ppm  STEL = 150 ppm

\* American Conference of Governmental Industrial Hygienists short-term ceiling limits [25]

<sup>†</sup> Emergency Response Planning Guide [16]

<sup>‡</sup> NIOSH 8-hour TWA [24]

## Limitations

This EI has two main limitations. The first is that identifying peak exposure concentrations of TDI and VOCs in areas near the apartment(s) being treated with MCU is dependent on selecting locations for monitoring and sampling where concentrations actually are the highest. The second is that data collected for this EI will only show the short-term, indoor air concentrations of TDI and VOCs that are measured during the time of the investigation. These data may be suggestive of, but may not be generalizable for, exposures associated with future applications of MCU in similar situations.

## RISK/BENEFIT INFORMATION

There are virtually no risks associated with the exposure investigation. The potential benefit is that participants will learn whether they and/or their children are being exposed to levels of TDI and/or VOCs that are high enough to pose a health problem when MCU is applied to floors of other apartments in their building. The results of the testing may also help ATSDR or other agencies, such as the NYC DOHMH, determine what health

education is needed and whether recommendations prohibiting the continued use of MCUs in the multi-family apartment buildings are warranted.

The only personal identifiers collected will be a household adult name and apartment address. Names will be used to ensure a point of contact for reporting results of testing and to correlate a family to an address. Addresses are needed to correlate the location of the apartment relative to where MCU is being applied and to the location of air monitors and air samples. In addition, addresses will be used when evaluating complaints of symptoms or odors. These personal identifiers will not be included in any data sets produced for the study and will not be used for any other purpose.

There is no cost to participants. Participants will receive no reimbursements or incentives.

## **INFORMED CONSENT PROCEDURES**

Potential participants will be informed of the purpose of the exposure investigation and any benefits or risks to them should they choose to participate. It will be stressed that participation is strictly voluntary, and that if they choose to participate, they may withdraw from the investigation at any time without penalty.

If apartment residents indicate a willingness to allow air sampling in their home, ATSDR personnel will explain what the exposure investigation will entail, and will obtain written, informed consent [Appendix B]. The consent form will be available in Yiddish and English. Participants will also be asked questions from a short household questionnaire as part of the investigation [Appendix A]. The community rabbi may assist with the informed consent procedures and the questionnaire.

## **COMMUNITY INVOLVEMENT**

The rabbi for the local community will be the primary link with the community and, therefore, an integral part of the investigation. The rabbi has agreed to assist ATSDR with informing the community about the investigation, recruiting participants for the EI, and explaining the testing results. The community will be updated on the progress of the study and the preliminary results when data collection is completed. The results of the investigation and any recommendations will be presented to the community in a community meeting after data collection is completed and the results have been finalized. The final written exposure investigation report will also be provided in Yiddish and English.

## **RESULTS**

### **Reporting Results to Participants**

ATSDR will evaluate the real-time data to determine if VOCs and TDI are present during MCU application events at levels with potential public health implications. If action levels are reached, ATSDR will immediately notify the DOHMH and recommendations for relocating will be initiated. Participants and other building residents will be notified when it is reasonable to return to their homes following a recommended relocation. Upon completion of the investigation, ATSDR will send a letter (in Yiddish and English) to each participant describing individual air monitoring and sampling results along with an explanation of their significance.

### **Final Report**

At the conclusion of this investigation, ATSDR, with review by DOHMH and NYSDOH, will prepare a written summary in the form of an exposure investigation along with an overall public health interpretation. If contaminants are found at levels of health concern, appropriate local, state, or federal environmental and health agencies will be notified. The report will be available to the neighboring residents, the community, and other federal, state, or local environmental and public health agencies. Depending on the findings, recommendations for follow-up activities may include additional sampling, educating home owners and occupants on mitigating exposures, discontinuing residential use of MCU, and further study.

## **CONFIDENTIALITY**

Individual test results, without personal identifiers, may be made available to the public. Confidentiality will be protected according to federal and state laws [27]. All records and computer files will be locked and password protected, respectively.

## **TIMELINE**

ATSDR anticipates that sampling will occur in winter 2004 and will occur over a period of 2-5 days. The precise timing will depend on the scheduling of an MCU application event, as well as the number of coats that will be applied. If necessary, the DOHMH and the New York State Department of Health (NYSDOH) will conduct further air testing on subsequent days to help determine the duration of contaminant off-gassing in the treated apartment(s) and surrounding areas.

---

## REFERENCES

1. The City of New York Department of Health and Mental Hygiene. Environmental Investigation of Chemical Ingredients of Moisture Cure Urethanes Used as Wood Floor Coatings Environmental & Occupational Disease Epidemiology Program. May 20, 2003.
2. Environmental Protective Coatings Inc.  
<http://www.enviroprotectcoatings.com/epcprintimages.php>  
Accessed on Oct. 17, 2003.
3. Harco Chemical Coatings, Inc., March 2002. Moisture cure urethane VOC- Material Safety Data Sheet (MSDS); manufacturer's code 3100, 3101, 3102, 3110.
4. Benjamin Moore & Co., Dec 1997. Material Safety Data Sheet for coatings, resins, and related materials NPCA 1-84; product code: M78, CM78, moisture cure urethane.
5. ATSDR 1999. Toxicological profile for ethylbenzene (update). U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. July 1999, pp. 11-113.
6. NIOSH 1995. Documentation for immediately dangerous to life or health concentrations (IDLHs) for ethylbenzene. March 1, 1995.  
<http://www.cdc.gov/niosh/idlh/idlh-1.html> Accessed on Feb. 12, 2004.
7. ATSDR 1995. Toxicological profile for xylenes (update). U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. Aug 1995, pp. 13-142.
8. NIOSH 1995. Documentation for immediately dangerous to life or health concentrations (IDLHs) for xylenes. March 1, 1995.  
<http://www.cdc.gov/niosh/idlh/idlh-1.html> Accessed on Feb. 12, 2004
9. BASF Corporation Polyurethane TDI Handbook 2000.  
<http://www.basf.com/businesses/polymers/urethanes/pdfs/chemicals/Other/2000tdihandbook.pdf> Accessed on Feb.4, 2004.
10. Lemiere C, Romeo P, Chaboillez S, Tremblay C, Malo JL. Airway inflammation and functional changes after exposure to different concentrations of isocyanates, J Allergy Clin Immunol Oct 2002, 110(4):641-6.
11. Liu Q and Wisnewski AV. Recent developments in diisocyanate asthma, Annals of Allergy, Asthma, and Immunol, May 2003;90:35-41.

12. DeZotti Z, Muran A, and Zamborn F. Two cases of paraoccupational asthma due to toluene diisocyanate (TDI). *Occup Environ Med*, 2000;57:837-839.
13. Orloff K, Batts-Osborn D, Kilgus T, Metcalf S, and Cooper M. Antibodies to Toluene Diisocyanate in an Environmentally Exposed Population, *Environmental Health Perspectives*, 1998;106(10):665-666.
14. Salam MT, Li YF, Lanholz B, and Gilliland FD. Early life environmental risk factors for asthma: findings from the Children' Health Study, *Environ Health Persp*, 2004 (in press). On-line Dec 9, 2003: <http://dx.doi.org>.
15. Belanger K, et al. Symptoms of wheeze and persistent cough in the first year of life: associations with indoor allergens, air contaminants, and maternal history of asthma, *Am J Epidem*, Aug 2003;158:195-202.
16. American Industrial Hygiene Association 2002. Emergency Response Planning Guidelines (for Toluene 2,4- (2,6-) Diisocyanate (TDI)), AIHA Press, Fairfax, VA.
17. U.S. EPA. Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, U.S. Environmental Protection Agency, Center for Environmental Research Information, National Risk Management Research Laboratory, Office of Research and Development, Cincinnati, Ohio, EPA/625/R-96/010b (NTIS PB99-172355), January 1999
18. NIOSH, 1994. Analytical Methods, compendium of methods, DHHS (NIOSH) Publication 94-113 (August, 1994). <http://www.cdc.gov/niosh/nmam/nmammenu.html/> Accessed on Oct. 17, 2003.
19. EPA, 1990. Quality Assurance/Quality Control Guidance for Removal Activities. Sampling QA/QC Plan and Data Validation Procedures. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/G-90/004.
20. Omega Specialty Iso-Check; Isocyanate sampling cassette for 2,4 TDI, 2,6 TDI, 1,6 HDI, and MDI, Chelmsford, 1996.
21. Sangö, C. and Zimerson, E; A New Reagent for Determination of Isocyanates in Working Atmospheres by HPLC using UV or Fluorescence Detection., *J. Liq. Chromato.*, 1980,9,802-808.
22. Zellweger Analytics, Inc.; Response Verification Procedures for Chemcassette-Based Toxic Gas Monitoring Systems, 1997.
23. ASTM. American Society for Testing and Materials. D5932-96(2002) Standard Test Method for Determination of 2,4-Toluene Diisocyanate (2,4-TDI) and 2,6-

- 
- Toluene Diisocyanate (2,6-TDI) in Air (with 9-(N-Methylaminomethyl) Anthracene Method) (MAMA) in the Workplace. [http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE\\_PAGES/D5932.htm?E+mystore](http://www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/D5932.htm?E+mystore) Accessed on October 17, 2003.
24. NIOSH, 1997. NIOSH Pocket Guide to Chemical Hazards. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health. June 1997.
  25. ACGIH 2003. Threshold limit values for chemical substances and physical agents and biological exposure indices. American Conference of Government Industrial Hygienists, Cincinnati, OH, 2003.
  26. Agency for Toxic Substances and Disease Registry Minimum Risk Levels (MRLS) Jan 2003. <http://www.atsdr.cdc.gov/mrls.html#bookmark02> Accessed on Feb. 4, 2004.
  27. US DOJ, 1974. "Privacy Act of 1974," the Office of Information and Privacy in coordination with the Office of Management and Budget. House Comm. on Gov. Operations and Senate Comm. on Gov. Operations, 94th Cong., 2d Sess., S. 3418 (Public Law 93-579) 1974. [http://www.usdoj.gov/04foia/04\\_7\\_1.html](http://www.usdoj.gov/04foia/04_7_1.html)

**Appendix A  
Household Questionnaire  
Monitoring Air Exposures to Moisture Cure Urethanes  
New York, New York**

**Part I.**

Today's Date: \_\_\_\_\_

1. Name: \_\_\_\_\_  
  (Last)  (First)  (MI)
2. Apartment #: \_\_\_\_\_
3. Do you own or rent your home?                         Own                         Rent
4. Number of years living in this home: \_\_\_\_ years
5. Have any rooms in your home been recently painted?                         Yes     No
6. If yes, when? \_\_\_\_\_ What type of paint?     Latex     Oil-based     Other \_\_\_\_\_
7. Have any carpets or upholstery been spot cleaned within the last 12 months?  
  Yes   No
8. If yes, when? \_\_\_\_\_ Name of cleaner(s) used? \_\_\_\_\_
9. When was the last time Moisture Cure Urethane was applied to your apartment floors, if ever? \_\_\_\_\_
10. When was the last time Moisture Cure Urethane was applied to any apartment in your building? \_\_\_\_\_
11. Are there any stored chemicals in your home? Please circle all that apply:  
                  None   Paint   Solvents   Gasoline   Spot cleaners   Other \_\_\_\_\_
12. Are there any smokers in your household? Please circle one response:  
                  None  
                  Rarely (only guests)  
                  Moderate (light smokers or only one heavy smoker)  
                  Heavy (more than one heavy smoker)
13. Are hobbies done in your home using any of the following? Please circle all that apply:  
                  Model glues   Paint   Spray paint   Paint thinner   Other \_\_\_\_\_
14. How many adults live in your household? \_\_\_\_\_
15. Ages of adults: \_\_\_\_\_
16. How many children live in your household? \_\_\_\_\_





## **Appendix B**

### **Consent Form**

#### **Monitoring Air Exposures to Moisture Cure Urethane**

##### **New York, New York**

###### **Introduction**

We are from the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is an environmental public health agency with the federal government. We are working with the New York City Department of Health and Mental Hygiene to test the air in your apartment building to see if there are fumes that might make you sick. We are doing this because fumes may be getting into the air in other parts of the building after someone uses moisture cure urethane (MCU).

MCU is put on wood floors to protect them. MCU is made of many chemicals. Some of these go into the air while MCU is drying.

We are worried that breathing the fumes from xylene, ethyl benzene, and toluene diisocyanate (TDI) might make people sick. They might get headaches, dizziness, eye irritation, trouble with balance, and skin or breathing problems. People who already have lung problems, like asthma or emphysema may get sicker. Breathing TDI can also give someone asthma.

Families leave their home for about a week when they put MCU on their floors. When they return home the fumes are not in the air anymore. Some people have felt sick after MCU was put on the floor in someone else's apartment. We worry that fumes from MCU made them sick.

We are asking you to help us find out if these fumes are getting into the air in other people's apartments. You can help us by letting us test the air in your apartment. The testing will take place over 2-5 days. It needs to start just before MCU is put on the floor in someone else's apartment.

###### **Participation**

Being part of this project is your choice. If you choose to be part of it, you can change your mind and stop at any time without problems. If you do not want to be part of this project, you can still get the final report of the testing. If you decide to be part of this project, you must sign this consent form.

###### **Procedures**

People who work for the Environmental Protection Agency (EPA) will help us with the air testing. If you are part of this project, we will visit your home to set up the air monitors. This will take about 30 minutes. There are four monitors; the largest is about

the size of a brief case. The other three monitors are each about the size of a shoe box. They sound like a fish tank air pump.

The EPA workers will start the monitors a short while before the MCU is put on the floor in another apartment. The monitors will run for about 2-5 days, depending on what we see. The EPA workers will briefly check the monitors 4-6 times a day to be sure they are working okay and to see what the levels of the fumes are. They will also take about 5-8 air samples over 2-5 days, using a tool that looks like a bicycle air pump. It will take up to 30 minutes each time they take a sample. We will take away all the monitors as soon as the testing is done.

### **Questionnaire**

We will ask you some questions to help us understand the results of the testing better. This will take about 15 minutes.

### **Risks**

We don't think you will be hurt by being part of this project. You may find it inconvenient to have the monitors set up and inside your home for a few days.

### **Benefits**

You will benefit by learning if you or your children are breathing fumes that might make you sick. We will use the results of the testing to decide if it is safe to use MCU in apartment buildings like yours.

### **Results**

We will know some of the results the day of the testing. We will get the other results in about two months. If we learn something that you need to know right away, we will tell you as soon as we find out. We will send you all your results in writing as soon as possible.

### **Confidentiality**

We will protect your privacy as much as the law allows. We will not use your name or personal information in our reports. We will keep any information that identifies you or your family in a locked cabinet in our office or protected by password in a computer file. After we put the information from paper files into the computer file, we will destroy the papers. We will share the test results only with other federal, state, and local public health and environmental agencies. These agencies must also protect your privacy.

Please ask if you have any questions.

### **Points of Contact**

If you have any other questions or feel that you or your family were harmed by being part of this project, please call Gail Scogin or Dr. Karen Marienau at the Agency for Toxic Substances and Disease Registry toll-free at 1- (888) 422-8737. You can also call Chris D'Andrea with the New York City Department of Health at (212) 788-4290.

**Written Consent**

Someone has explained this project to me. All of my questions have been answered to my satisfaction. I DO agree to be part of the air testing described above.

I, (print name) \_\_\_\_\_, agree to have indoor air in my apartment monitored and sampled for chemicals that might be coming from MCU used elsewhere in my apartment building.

Signature: \_\_\_\_\_ Date: \_\_\_\_\_

Address: \_\_\_\_\_

Street

Apartment #

City

State

Zip Code

Phone #: \_\_\_\_\_

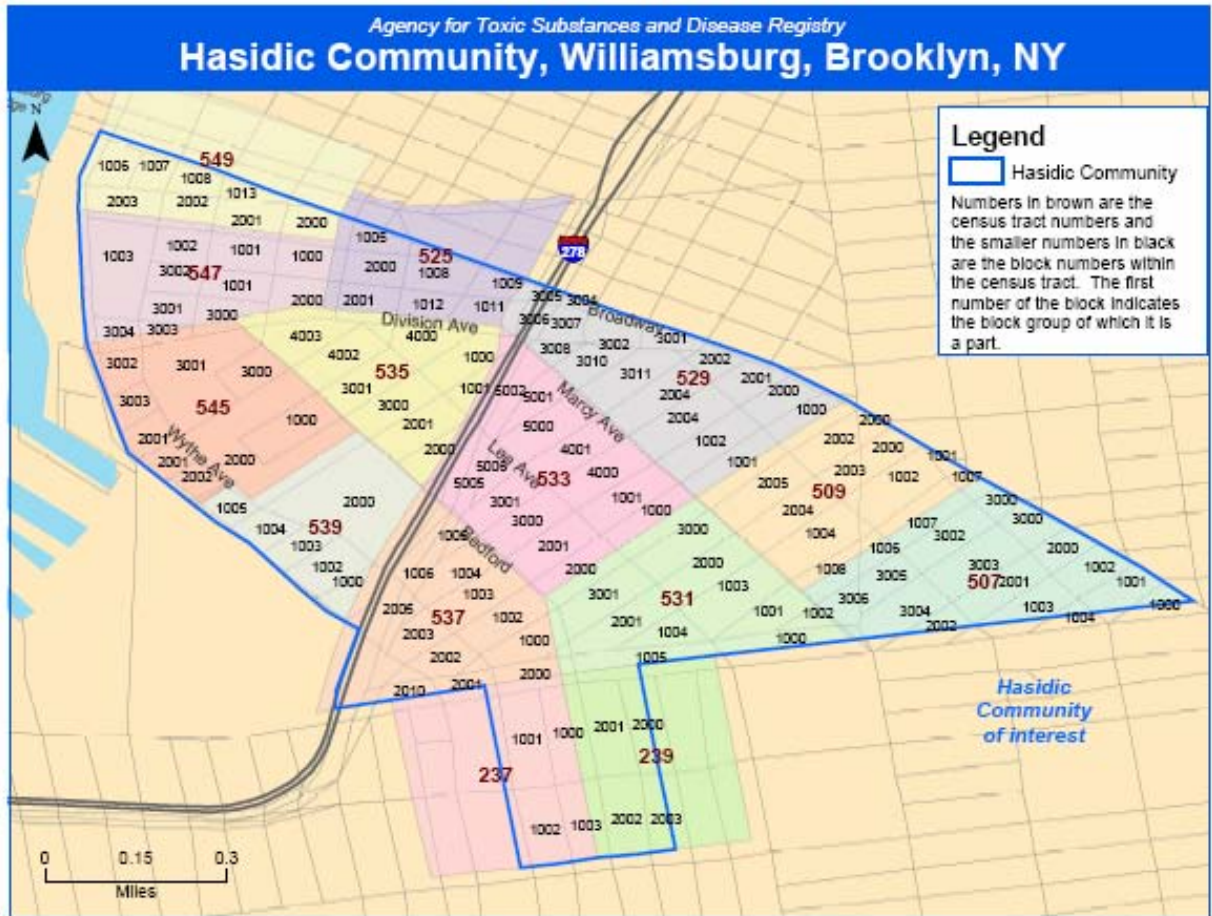
Witness: \_\_\_\_\_

(print name)

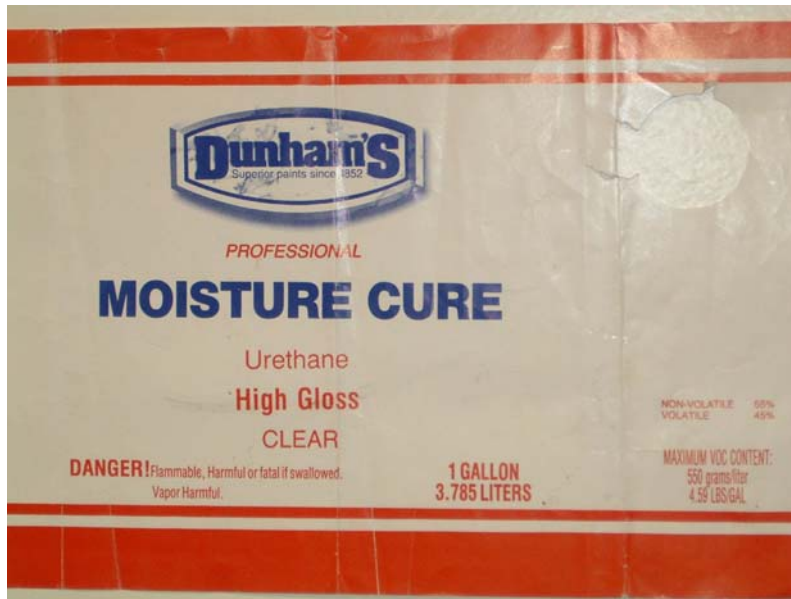
\_\_\_\_\_

(signature)

## Appendix C: Map of the Hasidic community in Williamsburg, Brooklyn, New York



**Appendix D: Labels from Moisture Cure Urethane containers in use during the EI**



**Label from TC Dunham MCU container used at Location 1**



**Label from HARCO MCU container used at Location 8**