June 30, 2014

Dr. Meredith Williams
Deputy Director
California Department of Toxic Substances Control
1001 I Street
Sacramento, CA 95814

Re: Supplemental Comments on the Draft Initial List of Priority Products and *Spray Polyurethane Foam Systems Containing Unreacted Diisocyanates*

The American Chemistry Council Diisocyanates (DII) Panel, Aliphatic Diisocyanates (ADI) Panel, and the Center for the Polyurethanes Industry's (CPI) Spray Foam Coalition (hereinafter referred to as "ACC") are pleased to have the opportunity to submit comments to the California Environmental Protection Agency's Department of Toxic Substances Control ("DTSC" or "the Department") regarding the nomination of *Spray Polyurethane Foam Systems Containing Unreacted Diisocyanates* as an initial draft priority product under the Safer Consumer Products regulations ("Regulations").[1]

ACC urges the Department to consider our comments and remove SPF Systems from the list of Priority Products. In the immediate future, the erroneous and misleading SPF System Product Profile and related materials must be removed from the DTSC website. We look forward to continued and productive collaboration with the Department as it determines next steps under the Safer Consumer Products regulations. If you have any questions or need additional information, please contact either Sahar Osman-Sypher at (202) 249-6721, Sahar_Osman-Sypher@americanchemistry.com, or Lee Salamone at (202) 249-6604, Lee_Salamone@americanchemistry.com.

Sincerely,

Sahar Osman-Sypher
Director, Diisocyanates/Aliphatic Diisocyanates Panels

Sincerely,

Lee Salamone
Senior Director, Center for the Polyurethanes Industry/Spray Foam Coalition

[1] The DII Panel includes U.S. manufacturers of TDI and/or MDI: BASF Corporation, Bayer Material Science, The Dow Chemical Company, and Huntsman Corporation. The ADI Panel is comprised of the U.S. manufacturers of hexamethylene diisocyanate (HDI), isophorone diisocyanate (IPDI) and methylene dicyclohexyl diisocyanate (H12MDI). CPI membership includes raw material producers, systems suppliers, processing machinery and equipment manufacturers, as well as users of polyurethane materials that manufacture products made of or from polyurethanes. The Spray Foam Coalition represents spray polyurethane foam systems houses and their suppliers.

Supplemental Comments on the Draft Initial List of Priority Products and *Spray Polyurethane Foam Systems Containing Unreacted Diisocyanates*
June 30, 2014

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APPENDIX

I. Introduction

On March 13, 2014, the California Department of Toxic Substances Control announced its draft list of initial Priority Products under the Safer Consumer Products Regulations. *Spray Polyurethane Foam Systems Containing Unreacted Diisocyanates* ("SPF Systems" or "Priority Product") was identified as one of three initial Priority Products. Subsequent to the March 2014 announcement, DTSC initiated a public comment period that included three public workshops and a call for written public comments to be submitted no later than June 30, 2014. The following comments are being submitted in response to this request. In addition, our participation at all three public workshops with remarks made on the record, as well as two written submissions (letter to D. Raphael dated April 28 and technical comments addressed to M. Williams dated April 29, and included as Appendix A) are responsive to DTSC's request for stakeholder input.

The current rationale offered by DTSC for including SPF Systems on the draft list of initial Priority Products under the Regulations, as outlined in the Priority Product Profile dated March 13, 2014 ("Product Profile" or "PPP"), does not adequately explain how SPF Systems present the potential for "significant or widespread adverse impacts"[2] and raises significant questions as to the viability of any further action by the Department. As this regulatory standard is not met, there are important concerns as to whether regulating SPF Systems as a final Priority Product is defensible under the Regulations.

In its explanation for the selection of SPF Systems, DTSC relies on secondary and tertiary sources to support its conclusions regarding the potential health and environmental impacts of SPF Systems. A number of the sources cited by DTSC are studies or anecdotes that involve isocyanates not actually used in the manufacture of SPF Systems. In total, the Product Profile does not support the conclusion that SPF Systems present the potential for significant or widespread adverse impacts.

Furthermore, the determination that SPF Systems present the potential for significant or widespread adverse impacts is neither reasonable nor foreseeable. The conclusions regarding potential adverse impacts appear to be the result of an arbitrary and capricious approach lacking an objective, scientific systematic process. To date – from the selection of the Priority Products to the drafting of the Product Profile – DTSC has failed to properly consider independent experts and other data. Further, DTSC has not corrected the inaccuracies contained in its documents, press statements and public website despite being presented with accurate information that directly contradicts the assertions in the Product Profile. This misinformation continues to unfairly disparage SPF Systems in and outside of California – a product that is well-studied, understood and managed by both industry and numerous public agencies.

[2] SCP §69503.2(a)(2): § 69503.2. Product-Chemical Identification and Prioritization Factors. (a) Key Prioritization Principles. Any product-chemical combination identified and listed as a Priority Product must meet both of the following criteria: (1) There must be potential public and/or aquatic, avian, or terrestrial animal or plant organism exposure to the Candidate Chemical(s) in the product; and (2) There must be the potential for one or more exposures to contribute to or cause significant or widespread adverse impacts.

Finally, DTSC attempts to identify alternative products in the Product Profile for SPF Systems without presenting comprehensive information on the alternative products themselves. Without the benefit of a full and thorough analysis, the Department risks suggesting alternative products that may not provide the same benefits as the SPF and contain regrettable substitutions[3] – an outcome the Regulations are designed to prevent. The list of alternative products has damaged the marketplace for SPF Systems - as articulated by California-based businesses at the DTSC public workshops in May and June - and has given competing technologies an advantage that is not founded on risk or life cycle evaluations.

Due to the lack of accurate and reliable information supporting DTSC's conclusion that SPF Systems present a potential for significant or widespread adverse impacts, we request that the Department immediately remove SPF Systems from its draft list of initial Priority Products.

The following comments provide additional information on SPF products, including but not limited to information on the product chemistry, product types and uses, health and safety data, and a detailed account of the industry-led research, product stewardship and training programs. The comments also provide information specifically to rebut several of the inaccuracies appearing in the Product Profile and clearly demonstrate the lack of scientific support for the listing of SPF Systems on the initial Priority Product listing.

[3] Consumers are likely to assume that the listed alternative products are "safer" products – an unintended consequence of identifying alternative products without a full review of the alternatives. Section 69505.5(a) of the Regulations emphasizes the importance of the *Identification of Product Requirements and Function of the Chemical of Concern* in the alternative analysis. DTSC should re-examine the efficacy of identifying alternative products when listing Priority Products in order to comply with the spirit of the Regulations.

II. Safer Consumer Products Regulation Implementation Process

The Department's implementation of the Regulations and the lack of industry involvement prior to the March 2014 announcement of the initial Priority Products have led to the publication of misinformation regarding SPF Systems in press statements, relevant documents and the DTSC public website that is wrongfully disparaging the product inside and outside of California. The Department has admitted that it consulted with other agencies and interested stakeholders during its selection process, but neglected to consult with industry at any level. The arbitrary and capricious nature of the Department's process is troubling and calls into question the level of rigor that went into the analysis and ultimate selection of the draft list of initial Priority Products.

A. Lack of Systematic Process for Identifying Priority Products

At each of the public workshops, the Department has cited its authority to select Priority Products based on a list of product-chemical identification and prioritization factors. The Department has made clear that there is no "formula" to its selection process. However, without clearly articulating how the factors were applied to the selection of the Priority Product, the Department fails to inform the public and specifically interested parties of the relevant science-based data and other considerations used to identify and select the Priority Product.

The Product Profile should clearly state which factors the Department applied in its selection process and how those factors satisfy the key prioritization principles for the listing of Priority Products.[4] Furthermore, the Regulations require DTSC to consider both hazard and exposure.[5] The Product Profile should provide a comprehensive discussion on how the Department weighed the hazard traits of the Candidate Chemicals in the Priority Product and the potential exposure to the Candidate Chemicals in order to demonstrate how the Priority Product meets both of the prioritization principles.

DTSC should deliver a more transparent and detailed account of the selection process for SPF Systems in order to provide adequate notice to interested parties and clarity to the general public. The Regulations do not grant the Department the authority to list Priority Products without justification sufficient to meet the standards listed therein.

B. Lack of Industry Involvement

The Regulations require DTSC "to consider the extent and quality of information available" as a factor to identify and prioritize product-chemical combinations.

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[4] The Key Prioritization Principles are as follows; and, any product-chemical combination identified and listed as a Priority Product must meet both of the following criteria: (1) There must be potential public and/or aquatic, avian, or terrestrial animal or plant organism exposure to the Candidate Chemical(s) in the product; and, (2) There must be the potential for one or more exposures to contribute to or cause significant or widespread adverse impacts. Section 69503.2(a)(1)-(2), Safer Consumer Products Rule.

[5] *See* SCP § 69506.5(b)(2) discussing DTSC responsibility to request information from the responsible entity to allow DTSC to determine acceptable exposure risk to the Candidate Chemical.

The Department has stated that it did not consult with industry prior to March 2014.[6] The Department also concedes that its materials, including the Priority Product Profile for SPF Systems, contain inaccurate information.[7] The Department did not complete an appropriate survey of available sources of information and was therefore unaware of the full suite of resources detailing the extensive database of science regarding SPF Systems that is readily available, resulting in a Product Profile riddled with misinformation and errors.

The Department should have engaged with businesses that supply to or make SPF insulation in order to satisfy requirements of the Regulations, particularly given the nature of the Department's task – to synthesize complex product chemistries, toxicology, and other value chain information held by industry – in the format of a Product Profile. Specifically, the Department did not fulfill the requirement "to consider the extent and quality of information that is available,"[8] when it failed to consult with industry, and therefore the Department should remove SPF Systems from the draft list of initial Priority Products.

C. Immediate Negative Impact on the Marketplace

As noted above, the Department's materials released the date of the announcement included inaccurate and disparaging information regarding SPF Systems. Such information was presented to the public at an official press event attended by several high ranking officials, including the former Director of DTSC. The same information was published in a document endorsed by the Department and referenced multiple times in press statements and online forums, giving undeserved credibility to the documents. The Department presented the information in such a way as to lead to the erroneous conclusion that DTSC's concern was with SPF foam as a material. Only through subsequent public workshops was it clarified that the Department's concern lies with isocyanates relative to the sprayed application of SPF systems during the time the material is applied and is curing (a relatively short period lasting between 30 minutes to 2 hours for two-component SPF). Included in the misleading information published by the Department was a list of suggested alternative products, which the Department admits to having incorporated without full information on the products or a review as to whether they contain other Candidate Chemicals. The immediate and foreseeable impact of the Department's actions in March 2014 was to discourage the use of SPF Systems. The result should have been foreseeable as numerous Department officials have stated that DTSC's goal under the Regulations is to "signal the marketplace."

The Department should have foreseen the impacts that its Priority Product announcement – which included incomplete and unverified information regarding SPF Systems – would have on

[6] As an example, at the public workshop in Sacramento, California, on May 7, 2014, DTSC officials acknowledged the Department's failure to consult with industry prior to publishing the Product Profile. The comments should be reflected in the transcript of the public workshop proceedings.

[7] As an example, DTSC made several incremental modifications to its presentation in the SPF breakout sessions at each public workshop. Per the DTSC officials, the modifications were made because the Department recognized that the Product Profile contains inaccurate information. The comments should be reflected in the transcripts of the public workshop proceedings.

[8] SCP §69503.2(b)(1)(C): "Availability of Information. The Department shall consider the extent and quality of information that is available to substantiate the existence or absence of potential adverse impacts, potential exposures, and potential adverse waste and end-of-life effects. . . . "

the identified products. As a result of the Department's failure to adequately address the misinformation published in the Priority Product Profile and other sources, the negative impact on the SPF Systems marketplace has persisted since March 2014. Therefore, the Department must take the immediate steps of removing all incorrect information published on its website and remove SPF Systems from the list of Priority Products.

D. Lack of Coordination with Other State and Federal Agencies

SPF Systems are well understood by numerous state and federal agencies. Within California, the Energy Commission has proposed updates to Title 24 energy efficiency requirements that will leverage SPF's unique performance attributes and allow builders, business owners and homeowners to achieve higher energy efficiency in buildings and lower the state's energy use and greenhouse gas emissions. The benefits of SPF Systems and the relationship between the product and other California regulations are explained in greater detail below. However, the Priority Product Profile for SPF Systems does not indicate whether DTSC consulted with the Energy Commission on its selection or if DTSC considered the potential implications for listing this well-understood product which is highly valued by the Energy Commission.

As explained in greater detail below, the SPF industry has worked with the U.S. Environmental Protection Agency ("US EPA"), as well as other federal agencies, on a voluntary basis to continually improve the best practices and training for use of SPF Systems. US EPA has also published a Chemical Action Plan for methylene diphenyl diisocyanate (MDI) (the isocyanate contained in SPF Systems that DTSC is concerned about).[9] It is worth noting that Chemical Action Plans are not regulatory actions; they are a description of actions that EPA is considering relative to a named chemical. In response to the questions posed by EPA in the Chemical Action Plan, industry provided extensive information to US EPA including data on the exposure potential and the safe handling and use practices for SPF Systems. These data are readily available in EPA's public docket and we are incorporating several of the many relevant references (later in this document) to be used to inform the DTSC in their decision making.[10] In the time following the publication of the Chemical Action Plan, EPA has not taken nor publicized any intention to take any regulatory action relative to MDI. Years of open discussions and collaboration between industry and federal agencies has resulted in the improvement of information available to users of SPF products as well as increased refinement in the science of measuring SPF chemicals.

Another federal agency that has initiated action on isocyanates is the U.S. Occupational Safety and Health Administration ("US OSHA"). OSHA has initiated a mandatory National Enforcement Program ("NEP") for isocyanates, including the isocyanates used in the manufacture of SPF Systems.[11] "The goal of the NEP is to reduce employee exposure to isocyanates…and will be accomplished by a combined effort of inspection targeting, outreach to

[9] U.S. EPA action plan information for MDI and related compounds *available at*: http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/mdi.html.
[10] Public comment document for US EPA MDI action plan *available at*: http://www.regulations.gov/#!docketDetail;rpp=10;po=0;D=EPA-HQ-OPPT-2011-0182.
[11] U.S. Department of Labor. OSHA Instruction: National Emphasis Program – Occupational Exposures to Isocyanates. Effective June 20, 2013. *Available at*: https://www.osha.gov/OshDoc/Directive_pdf/CPL_03-00-017.pdf.

employers, and compliance assistance." [12] The NEP covers businesses with one (1) or more employees that use isocyanates, including businesses related to SPF Systems.[13] The NEP applies to states that do not operate their own enforcement program. If a state does operate its own enforcement program, as California does, the program can be no less stringent than the NEP. Therefore, per the NEP, the California-specific enforcement program (State Plan) as described in a January 28, 2014 Memorandum, is obligated to conduct inspections and enforcement activities as well.[14] Given to the scope of the NEP, the State Plan reaches "independent contractors" as well, which addresses and eliminates concerns raised by the Department that subpopulations of SPF applicators and businesses can escape rigorous workplace safety requirements. Further workplace regulation of SPF Systems would be duplicative and otherwise provide no meaningful increase in safety for "independent contractors" or employees of larger businesses in the isocyanate industry. The NEP Fact Sheet included as Appendix B provides more detail on this mandatory enforcement initiative.

The numerous overlaps with state and federal regulatory programs potentially conflict with and preempt the Department's actions. Further, the Priority Product Profile for SPF Systems fails to demonstrate the contention that SPF Systems are inadequately regulated under state and/or federal regulations, and fails to state how regulating SPF Systems under the Regulations would provide greater protection. The Department should perform an analysis of the existing protections for the spray application of MDI relative to SPF Systems and provide a justification as to why additional protections under the Regulations are not preempted.

[12] OSHA Instruction, National Emphasis Program – Occupational Exposure to Isocyanates (Directive Number: CPL 03-00-017), June 20, 2013.
[13] *See* Directive CPL 02-00-05, Enforcement Exemption and Limitations under the Appropriations Act, referenced in the Isocyanates NEP.
[14] Memorandum *available at*: http://www.dir.ca.gov/dosh/Inspection-Procedures-for-Isocyanates.pdf.

III. Inaccurate and Misleading Information in Priority Product Profile

On April 29, 2014, ACC provided the Department with a comprehensive set of comments that detailed the numerous inaccuracies contained in the Priority Product Profile for SPF Systems. ACC has repeatedly requested that the Department use the information contained in the April 29th comments to correct the inaccuracies in the Priority Product Profile.[15] As of the date of these comments, despite several public assertions that the Department would proceed with accurate information (stated by Department representatives at each of the public workshops held in May and June 2014), the Priority Product Profile has not been corrected and still contains all the inaccuracies addressed in the previous comments. Furthermore, the information presented by DTSC during the SPF breakout sessions at each of the public workshops that contains inaccurate, and at times conflicting, information was posted to the DTSC website. This confusion is further a demonstration that adequate resources and thought have not yet been applied to the selection process. ACC here reiterates its request that the Priority Product Profile and other materials containing the inaccurate information (including fact sheets and Q&A's) be removed from the Department's website while further analysis is ongoing.

A. The Scope the Product Profile is Overly Broad

The scope of the SPF Systems Product Profile is overly broad and the Department has not articulated the specific consumer product(s) it may intend to evaluate. SPF insulation is available in a number of products types and delivery methods (i.e., high-pressure two-component SPF, for both wall insulation and roofing, low-pressure two-component SPF, one component foam for sealing) with significant and relevant differences making each a distinct product for purposes of the Regulations.

All references to other applications of polyurethane that are not specifically SPF Systems are outside the scope of the SPF Systems Priority Product Profile and should not be considered or discussed. Additionally, only MDI that is used in the manufacture of SPF insulation products should be referenced in the Product Profile. The physicochemical properties and exposure profiles of MDI, toluene diisocyanate (TDI) and hexamethylene diisocyanate (HDI) are materially different. The Product Profile only describes the physicochemical properties of TDI and HDI. The Department does not demonstrate how the physiochemical properties and the uses of TDI and HDI result in exposure profiles comparable to those of MDI. References to TDI and HDI, and related sources of information cited in the Product Profile, should be removed.[16]

Furthermore, the Department incorrectly assumes toxicological studies involving TDI or HDI are relevant for MDI and wrongly relies on case studies involving TDI or HDI as evidence in its case against MDI. Case studies may contain irregularities and variables, and should not be used as primary or sole sources of information used as evidence for a different chemical or exposure scenario. Finally, the scientific record on isocyanates is robust and the Department should not be permitted to rationalize their reliance on TDI or HDI studies on the false conclusion that

[15] As summarized in the letter to D. Raphael dated April 28, 2014, DTSC offered to consider and correct factual errors in the Product Profile.
[16] DTSC has removed references to TDI and HDI in documents related to the public workshops. However, the references to TDI and HDI, and the related citations, remain a part of the Product Profile.

evidence or information regarding MDI is lacking. Therefore, references to TDI and HDI, and the associated sources of information cited in the Priority Product Profile, should be removed.

Because of its overly broad scope, the SPF Systems Priority Product Profile does not give interested parties reasonable notice as to what product-chemical combination the Department intends to regulate and does not provide an adequate basis for evaluating SPF Systems as a Priority Product under the Regulations. The Department should not proceed with a rulemaking to list "Spray Polyurethane Foam Systems Containing Unreacted Isocyanates" as a chemical of concern/priority product combination and should remove the faulty documents from its public website.

B. SPF Systems Do Not Present the Potential for Widespread or Significant Adverse Impacts

The Department relies on secondary and tertiary information regarding isocyanates not used in SPF Systems to justify its selection of "Spray Polyurethane Foam Systems Containing Unreacted Isocyanates" as a Priority Product. Full and complete information regarding potential exposure, regulatory requirements and best practices for risk mitigation to the isocyanate used in SPF Systems demonstrates low potential for significant or widespread adverse impacts as required by the Regulations.

The Department has stated in public workshops and comments that it is concerned with the potential exposure to unreacted MDI during and after the SPF application process. Extensive product stewardship efforts are in place to address the safe handling and use of MDI in SPF application. Installation of SPF insulation in homes, schools and other public buildings is a not a potential source of exposure to isocyanates when industry recommendations are followed.

The exposure potential of isocyanates is well understood for all SPF systems and forms the basis for safe handling practices. Studies on high-pressure two-component systems have shown that airborne concentrations of MDI are non-detectable within thirty (30) minutes to two (2) hours after application for indoor applications of SPF, and therefore, there should be no non-occupational MDI exposure. Lesage (2007) found that airborne MDI could not be detected approximately 1 hour following application of SPF inside residential structures.[17] The results also showed no removable isocyanate was detectable on the foam surface fifteen (15) minutes after application. In a subsequent study by IRSST (2009) using analytical techniques with lower detection limits, airborne MDI could not be detected approximately two (2) hours following SPF application inside the building.[18] More recently, work conducted inside three residential structures found that airborne MDI could not be detected approximately one (1) hour following high pressure SPF application (Robert et al., 2013).[19] In this study, active ventilation was used during and following SPF application. Recently, in a study conducted by the Center for the

[17] Lesage, J., Stanley, J., Karoly, W.J., & Lichtenberg, F.W. (2007). Airborne MDI Concentrations Associated with Application of Polyurethane Spray Foam in Residential Construction. *J. Occup. Environ. Hyg., 4,* 145-155.
[18] IRSST (2009). Occupational Health and Safety Research Institute. 4,4'-Diphenylmethane diisocyanate (MDI) safety practices and concentration during polyurethane foam spraying. R-629. (IRSST, Ed.).
[19] Robert, W., Anderson, J., Wood, R., Bogdan, M. (2013). Ventilation and Re-occupancy of a Residential Home Sprayed with High Pressure Polyurethane Foam. Paper presented at the CPI Polyurethanes Technical Conference, Phoenix, 23-25 September.

Polyurethanes Industry (Wood, 2013), airborne MDI could not be detected approximately 30 minutes following SPF application in a controlled environment.[20] Similar to the Robert et al. study, active ventilation was used during and following SPF application. Despite all these available primary sources on the topic, DTSC apparently failed to consult any of them prior to listing the Priority Product and creating the Product Profile. As a result, DTSC failed to meet the requirements under the Regulations to consult all reasonably available, reliable sources of information.

It should be noted that the exposure studies cited above for high-pressure SPF discuss interior applications only. Roofing operations are outdoor applications and different engineering controls and PPE recommendations are made. Comments made here regarding exposure measurements, reoccupancy and re-entry are relative to interior applications only. Additional studies and data related to roofing applications may be provided at a later date.

The low-pressure two-component SPF industry has used industrial hygiene monitoring to show that levels of airborne MDI are below the occupational exposure limit (OEL) during application of the product and very low to non-detectable in the surrounding areas (the components are dispensed as a froth, not as a spray). MDI monitoring studies compiled and reported by (CPI-SPFA DIY Workgroup, 2009)[21] and (Bloom, 2012)[22] present representative data. Repeated studies monitoring for airborne MDI one-hour after application has shown no detectable levels (Wood, 2013) (Bloom, 2012). Work conducted in residential structures found that airborne MDI could not be detected approximately thirty (30) minutes following low pressure SPF application in a crawl space (Massaro et al., 2013).[23] There are also many additional studies that have investigated exposure potential with low-pressure two-component SPF systems that should be considered as part of DTSC's evaluation. A summary of these additional studies and a copy of the Massaro paper are included as Appendix C.

For one-component foam, industrial hygiene monitoring has shown airborne concentrations of MDI are non-detectable at the time of application. Once the cans are filled with the components at the manufacturing site, reactions occur in the can reducing the amount of unreacted isocyanates, leaving pre-polymers. These materials react as soon as they are expelled from the can, thus post-application chemical exposure potential is extremely low. The application of these materials does not involve actual spraying but instead the material is delivered as a foam bead which further reduces any potential for aerosolization and airborne exposure to unreacted isocyanates. Once applied, due to the reactivity of the isocyanates, the surface of any foam is considered entirely reacted once it is tack free and has formed a thin film of material. As the surface of the foam or film reacts to form the polymer chains it is physically tacky. Once the surface is tack-free it is considered entirely reacted and of sufficient robust state to resist damage from touching; thus tack-free time is a diagnostic time that characterizes cure. Various studies completed by manufacturers show that during application of one component foam, MDI levels

[20] Wood, R. (2013). CPI Ventilation Research Project Update. Paper Presented at the CPI Polyurethanes Technical Conference, Phoenix, 23-25 September. *Available at*: http://polyurethane.americanchemistry.com/Resources-and-Document-Library/Evaluation-of-Particulates-Generated-During-Trimming-and-Cutting-of-Spray-Polyurethane-Foam-Insulat.pdf.
[21] Low Pressure Spray Foam Webinar by the CPI-SPFA DIY Workgroup December 1, 2009.
[22] Bloom, C. (2012) Low Pressure SPF. Presented at ACC Workshop on TDI/MDI for EPA Staff.
[23] Included in Appendix C.

range from non-detectable to thousandths less than the OSHA PEL of 0.20 mg/m3 (Fishback, 2012).[24] There is no data to suggest that dust from these applications contains unreacted chemicals when properly applied either. To protect consumers, these products have precautionary labeling in accordance with Federal Trade Commission (FTC), Consumer Products Safety Commission (CPSC) and the Federal Hazardous Substances Act (FHSA) requirements.

The Department's attempt to extrapolate data related to occupational exposures and apply it to estimate exposures for the general public during the use of certain products is problematic. The Department cites Verschoor and Verschoor (2014) for the proposition that isocyanates in consumer products are a leading cause of non-occupational asthma. A review of the Verschoor and Verschoor paper reveals a number of inaccuracies and false assumptions. The use of this review article as a basis for determining effects is flawed. The Department is using a secondary reference instead of reading and referencing the available primary references which would not lead to the same conclusions. The Verschoor and Verschoor paper is a review and personal opinion paper on exposure. No new or convincing data is presented. Most references are misquoted, taken out of context, or completely inaccurate. A comprehensive and detailed "Letter to Editor" will be offered to the journal that published the paper. At the time of the submission of this letter to the journal, ACC will supplement these comments and provide the Department with a copy. In the meantime, we recommend that the Department obtain the primary references and review the information to correct the Product Profile.

Overall, the data demonstrate that unreacted MDI is non-detectable within thirty (30) minutes to two (2) hours after application of SPF with two component systems for interior applications. In the case of one component SPF systems, MDI is non-detectable at the time of application. Industry recommendations and regulatory requirements discussed in detail below appropriately manage the risk of MDI exposures to acceptable levels. SPF Systems do not present the potential for significant or widespread adverse impacts and therefore do not meet the regulatory threshold for listing.[25]

C. Occupational Asthma Rates for MDI are Declining

As demonstrated above, the Department relies on secondary and tertiary information to support its conclusion that SPF Systems present a potential for significant or widespread adverse impacts. The Department fails to present reliable and adequate information regarding exposure to the Candidate Chemical to justify its selection of the Priority Product. Likewise, reliable and peer-reviewed data demonstrates that occupational asthma rates for MDI are in fact declining, not rising as hypothesized by the Department. Publicly available information also demonstrates that isocyanates are not a leading cause of occupational asthma in California. Furthermore, the Department fails to present reliable and adequate information to demonstrate a connection

[24] Fishback, T. (2012). Polyurethane Foam Sealants. Presented at ACC Workshop on TDI/MDI for EPA Staff. ACC headquarters, Washington, DC. February 15. Available on the EPA MDI Chemical Action Plan Docket: EPA-HQ-OPPT-2011-0182.

[25] *See* SCP §69503.3(b)(4)(A) stating relevant factors to consider for evaluating potential exposures to the Candidate Chemicals include "how often and how long the public or the environment is exposed to the Candidate Chemical in the product for each scenario involving product use."

between SPF Systems and exposure to the Candidate Chemical that would provide a reasonable basis for concluding that the Priority Product presents the potential for widespread or adverse impacts.

Various national data collection programs on worker exposure and disease incidence present a consistent picture, showing a reduction of diisocyanates-related asthma cases over the last decade in Finland, Ontario, Germany, Belgium and France against a background of increasing production and use around the world. The underlying reason for the reduction in isocyanate-related asthma is multi-factorial, including better compliance with exposure standards, improved work practices, use of less volatile isocyanate forms (e.g., prepolymers) and better medical surveillance programs (*See* Appendix D).

To understand the prevalence of disease in an industry, a reasonable approach is to use the national statistics and estimates of workers in the industry. For example, in the Canadian Province of Ontario, Buyantseva et al. reported a reduced annual rate of successful isocyanate-related claims of occupational asthma for the period 1998-2002 (7.4 claims/year) compared to 1980-1993 (30.5 claims/year).[26] Using the CareEx data of 12,000 isocyanates workers in Ontario, one can derive a prevalence of 0.06 % (7.4/12000).[27] According to the NIOSH work-related asthma (WRA) statistics in the U.S., isocyanates are number 8 in frequency of reported cases with total numbers 2 to 3.5 times lower than the top 3 categories.[28]

Data collected by the State of California demonstrate that the number of occupational asthma cases associated with MDI are very low and, again, do not provide a reasonable basis for concluding that SPF presents the potential for significant or widespread adverse impacts.

- The California Department of Public Health indicates that in the period of 1993-2008, 0.5% of work-related asthma cases reported diisocyanates exposure at work.
- The California Department of Public Health's surveillance of work-related asthma indicates that since 1993, there have been a total of 10 cases reported associated with MDI.

California is one of several states to receive funding from NIOSH to conduct surveillance of work-related asthma. The California Department of Health Services' Sentinel Event Notification System for Occupational Risks (SENSOR) program was developed to identify primary and secondary cases of work-related asthma, characterize exposures and disease, and devise prevention strategies. The CA Department of Public Health's most recent publication from May 2013, Asthma in California, A Surveillance Report,[29] contains data on work-related asthma associated with isocyanates.

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[26] Buyantseva, L. V., Liss, G. M., Ribeiro, M., Manno, M., Luce, C. E., & Tarlo, S. M. (2011). Reduction in diisocyanate and non-diisocyanate sensitizer-induced occupational asthma in Ontario. *J.Occup.Environ.Med., 53* (4), 420-6.
[27] *Available at* http://www.carexcanada.ca/en/toluene_diisocyanates/occupational_estimate/.
[28] *Available at* http://www2a.cdc.gov/drds/WorldReportData/FigureTableDetails.asp?FigureTableID=2607&GroupRefNumber=F09-01.
[29] Asthma in California, a Surveillance Report, *available at*: http://www.cdph.ca.gov/programs/ohsep/Documents/Asthma_in_California2013.pdf

From the report, during 1993-2008, isocyanates do not make the top 17 list of agents causing work-related asthma (page 102).

Number and Percent of WRA Cases Reporting Exposures at Work, California 1993–2008

Exposure	N	%
Dust	775	19.1
Chemicals, NOS	681	16.8
Cleaning Chemicals	507	12.5
Smoke, NOS	408	10.0
Mold, NOS	321	7.9
Indoor Air Pollutants	313	7.7
Paint, NOS	254	6.3
Air Pollutants from Construction	170	4.2
Stress	158	3.9
Perfume	152	3.7
Pesticides, NOS	133	3.3
Glues	96	2.4
Cigarette Smoke	83	2.0
Asphalt	83	2.0
Diesel Exhaust	78	1.9
Bleach	77	1.9
Fiberglass	76	1.9

Note: Up to three exposures reported for each case; NOS=Not Otherwise Specified

Data Source: California WRAPP Surveillance Data, 1993–2008 (N=4,677)

In the same report, exposure to isocyanates (of which MDI is only a portion), comprises only 0.5% of cases reported from 1993-2008 (page 104).

Number and Percent of WRA Cases Reporting Asthmagen Exposures at Work, California 1993–2008

Asthmagen Exposure	N	%
Bleach	77	1.6
Chlorine	59	1.3
Latex	50	1.1
Ammonia	43	0.9
Formaldehyde	37	0.8
Glutaraldehyde	28	0.6
Sulfuric Acid	27	0.6
Diisocyanates	23	0.5
Rat Antigens	22	0.5
Epoxies	19	0.4
California Redwood Dust	17	0.4
Quaternary Ammonium Compounds	16	0.3
X-ray Chemicals	13	0.3
Flour	12	0.3

Note: Up to 3 exposures reported for each case; asthmagens are known asthma inducers as defined by the Association of Occupational and Environmental Clinics, www.aoec.org.

Data Source: California WRAPP Surveillance Data, 1993–2008 (N=4,677)

In addition, a recent (27 May 2014) personal communication with Jason Wilken, Ph.D., LT, United States Public Health Service (USPHS), confirms that there have been a total of 10 reported cases of asthma related to MDI from 1993-2014.

> *"Thank you for contacting HESIS regarding state-based surveillance of work-related asthma. You had requested data specific to methylene bisphenyl diisocyanates (MDI) in California. The following information was provided by CDPH's Work-Related Asthma Prevention Program: Since the time when state-based surveillance of work-related asthma for 1993-2006 was published (http://www2a.cdc.gov/drds/worldreportdata/SubsectionDetails.asp?ArchiveID=1&SubsectionTitleID=23), we have identified 2 additional cases in California for that time period, bringing our total to ten.*
>
> *"Of these ten, three were associated with plastics molding and two were associated with exterior wall molding; therefore, 5 of the 10 known cases were associated with molding. Of the remaining 5 cases, two were associated with packing/packaging. Of the remaining three, one was a carpenter, one a janitor, and we do not have an occupation identifiable for the final case. The industries associated with these cases (i.e., NAICS coding) are "All Other Plastics Product Manufacturing" (3), "Other Concrete Product Manufacturing" (2), "Machinery Manufacturing" (1), "Other Computer Peripheral Equipment Manufacturing" (1), Repair and Maintenance (1), and "Specialty Trade Contractors" (1); one record does not have an associated industry listed.*
>
> *"We have not identified any cases of work-related asthma attributed to MDIs from after 2006."*

The Product Profile also states that work-related asthma ("WRA") is under-reported. It can be argued that the number of cases may be over-reported since the guidance on diagnosis of occupational asthma (Bernstein and Jolly, 1999)[30] is not always followed. Most of the data comes from the Behavioral Risk Factor Surveillance System Asthma Call-Back Survey (BRFSS/ACBS). In California, approximately 5,000 interviews are conducted and respondents who answer positively to asthma questions are called back to answer a more detailed questionnaire. The report on the survey suggests that to be considered WRA, there must be a doctor's diagnosis of asthma and symptoms that started after a possible workplace exposure. However, industry experts believe many times the doctor does not follow the appropriate diagnosis scheme to confirm the agent causing the symptom, instead they consider a breathing-related disorder to be asthma and secondly suggest (not confirm) a work substance to be the cause.

The statement that "diisocyanates are the leading attributable cause of asthma in the workplace" made in the Product Profile is without substantiation or data. CDC Surveillance data demonstrate that isocyanates are not the leading cause of occupational asthma nationally or locally in California.[31] Isocyanates are found in the bottom three of the top ten frequently reported agents

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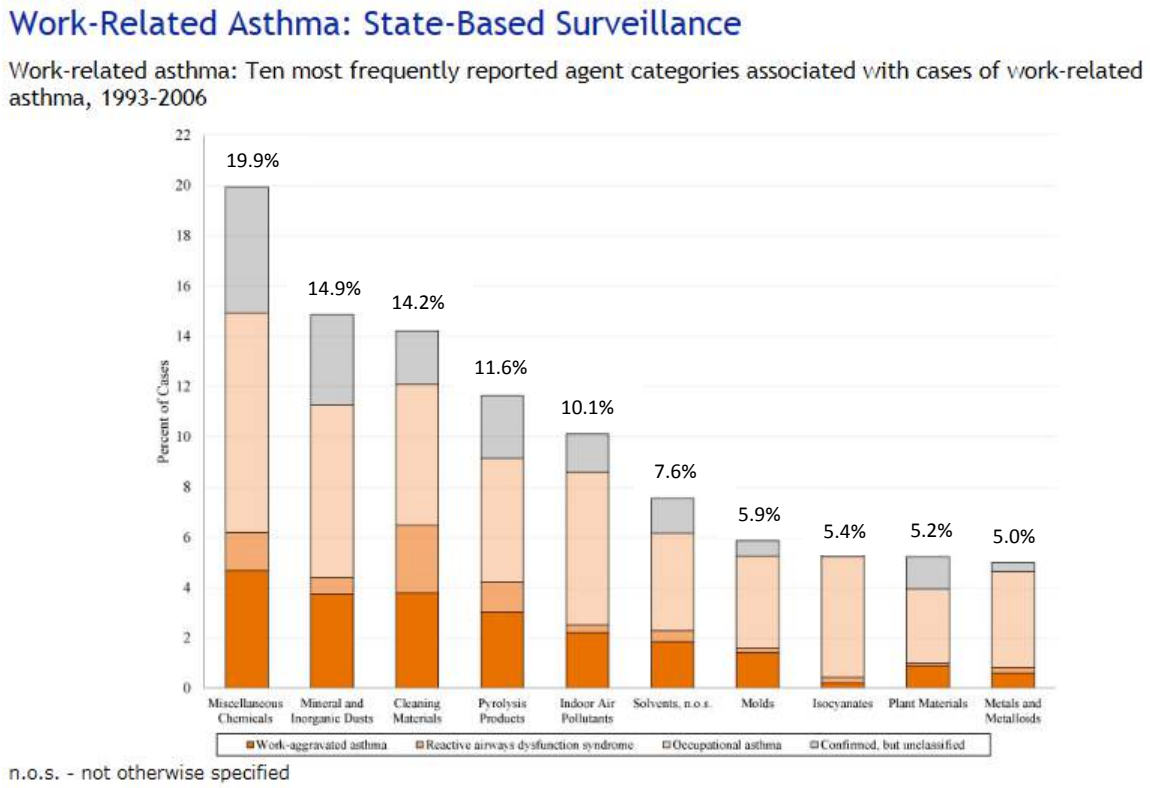
[30] Bernstein, D. I. and Jolly, A. 1999. Am J Indus Med. Current Diagnostic Methods for Diisocyanate Induced Occupational Asthma. 36:459-468.

[31] The National Institute for Occupational Safety and Health (NIOSH). Work-Related Lung Disease Surveillance System (eWoRLD). 2012. Work-related asthma: ten most frequently reported agent categories associated with cases of work-related asthma, 1993-2006, *available at*: http://www2a.cdc.gov/drds/worldreportdata/FigureTableDetails.asp?FigureTableID=2607&GroupRefNumber=F09-01.

associated with work-related asthma but comprise only 5% of the top ten reported agents. In addition, MDI is only one of the isocyanates that are grouped into this category, which makes the number of MDI work-related asthma cases even lower.



Notes:

1. Graphic representation *available at*: http://www2a.cdc.gov/drds/worldreportdata/FigureTableDetails.asp?FigureTableID=2607&GroupRefNumber=F09-01.
2. Table values above *available at*: http://www2a.cdc.gov/drds/worldreportdata/FigureTableDetails.asp?FigureTableID=2611&GroupRefNumber=T09-05A.

In summary, industry-wide data and the information collected by the State of California do not indicate the MDI exposure from SPF is leading cause of occupational asthma. Therefore, the information does not support Department's decision to target the product-chemical combination because SPF Systems do not present the potential for significant or widespread adverse impacts.

D. Industry Product Stewardship Programs are Intended to Maximize Worker Safety

In the Priority Product Profile, the Department highlights the existing and ongoing SPF industry product stewardship programs as a demonstration of the high hazard of the materials in question and justification for selecting the Priority Product. The Department's discussion of industry-led product stewardship programs using pejorative terms sends the message to other California

businesses that such programs, along with all of industry's related voluntary work with the Federal agencies, are not meaningful or valued by the State. The SPF industry has developed extensive product stewardship programs in an effort to maximize worker safety and understanding of best practices for the handling of chemical products. In addition, product manufacturers provide programs that include a focus on training their distributors and end-users, give guidance on proper PPE, contain online modules for health and safety training, provide application and ventilation guidelines, provide instruction on product labeling practices, and ensure that critical chemical health and safety information is available to the end-users. Product stewardship programs represent an understanding that all products must be handled and applied correctly in order to maximize public safety and mitigate exposure to acceptable levels. The isocyanates industry's programs for product stewardship are well-regarded globally.

Product stewardship programs should be considered as factors that mitigate concerns of exposure to the Candidate Chemical, certainly not *per se* evidence of a product or chemical's inherent hazard level. In fact, the Regulations direct the Department to consider how a product is managed and how existing controls limit exposure to the Candidate Chemical in the Priority Product.[32]

The Center for the Polyurethanes Industry offers a host of product stewardship literature for manufacturers and users of polyurethane products and services. These documents, videos and training programs, available free on CPI's websites,[33] allow members, users and others to draw on the collective experience of the raw material manufacturers, SPF systems houses, and polyurethane producers who are CPI members. The programs include material on general polyurethane product safety, worker protection considerations, fire safety guidance, toxicity information, waste disposal considerations, and general information on relevant regulations and laws. The following are a small selection of the many public resources available on SPF product stewardship:

- *Guidance for Working with MDI and Polymeric MDI: Things You Should Know*
  An easy-to-read, brochure which provides information about important health and safety considerations when working with MDI or Polymeric MDI.
- *Guidance for the Selection of Protective Clothing for MDI Users*
  Presents useful information on selecting the appropriate personal protective equipment (PPE) and the performance characteristics of gloves, coveralls, splash suits, and other protective suits commonly used when working with MDI.
- *Polyurethane and Thermal Degradation*
  Heating of polyurethanes or polyurethane containing-articles may be necessary during processing and/or product applications. This document highlights the products that may be of concern when polyurethanes are thermally degraded, and some worker safety and health precautions to consider.

[32] SCP §69503.3(b)(4)(A) "Information that DTSC might consider in evaluating potential exposures to Candidate Chemical(s) in products under this factor include[ ]…[h]ow a product containing the Candidate Chemical(s) is managed to control exposure to the public and/or the environment."
[33] CPI documents, videos, and training programs are available at: www.polyurethane.org and www.spraypolyurethane.org.

- *Guidance for Selecting a Contractor for the Installation of SPF in School Buildings*
  This guidance is intended to provide useful information to school administrators, design planners, facilities managers and others on how to select and work with professional spray foam contractors to help achieve a successful SPF installation. This document provides tips and guidance to help everyone involved in the process and to inform decision makers about the benefits, potential hazards, and ways to achieve a successful SPF installation. This information may also be helpful for design professionals and energy service companies involved in roofing system or insulation selection for school building projects.
- *Working Safely with Low-Pressure SPF Insulation*
  This video provides general guidance for professionals on how to apply low-pressure SPF. It is intended as a supplement to other job safety information already available such as specialized training Safety Data Sheets (SDS), product label information and other materials.
- *Disposal of Used SPF Drums*
  This article describes procedures for the disposal of empty drums at the end of a spray foam job.
- *Guidance for Developing a Written Respiratory Protection Program*
  This guidance document provides regulatory background and a model respiratory program form that addresses the Occupational Health and Safety Administration's Respiratory Protection Program Standard (29 CFR §1910.134) that applies to all respirator use in general industry and construction workplaces. The program provides guidance on appropriate respirators, respirator use, storage, fit and evaluation.
- *Guidance on Ventilation During Installation of Interior Applications of High-Pressure Spray Polyurethane Foam*
  This document provides general guidance on ventilation during the installation of interior applications of SPF in new residences and buildings and during renovation and weatherization projects in existing homes and buildings.
- *Guidance on Best Practices for the Installation of SPF*
  The SPF Installation Guidance is intended to provide an overview of best practices to help professional installers use SPF effectively and efficiently to insulate homes and commercial buildings. It discusses considerations for the use and handling of materials as well as steps that help make the jobsite safe and secure. It also addresses health and safety hazards and offers steps to avoid potential issues. Steps and tips for installing, measuring, and inspecting SPF are included to supplement those offered by manufacturers.
- *Spray Foam Coalition Code of Conduct*
  In 2014, all active Spray Foam Coalition systems house members created and signed a Code of Conduct. This is the first commitment of its kind in the SPF industry. It reflects the member companies' commitment to the continuous improvement in health, safety and product stewardship of spray polyurethane foam products.

The broad scope of SPF product stewardship programs is evidence of the extent to which SPF Systems are understood and managed by the industry. It is not, as is being suggested by DTSC, a reflection of the potential for significant or widespread adverse impacts and such an

interpretation can only serve to chill similar industry efforts to improve and make safer the handling, application, and use of chemicals.

E. No Known Alternatives Exists for Isocyanates in SPF Systems

The Product Profile notes that there is currently no known commercially available substitute for isocyanates in the production sprayed foam-in-place polyurethane insulation or roofing that will provide the qualities required for this application. The functional attributes of the application include, but are not limited to, low thermal conductivity, physical strength, adhesion to substrates, installation efficiency, low water permeation, and durability. These multiple attributes are conferred on the final product in one step, making SPF a multi-attribute, single application product which saves time and labor associated with construction.

The additional "alternative" materials identified by the Department are insulation options, but no one "alternative" is able to replace all the multiple functions that SPF alone performs. For example, the insulation factor, or R-value, of these "alternative" materials is typically lower than SPF insulation, the "alternative" materials require the use of additional products to achieve the all-in-one performance attributes of SPF, and the "alternative" materials are less resistant to moisture and exhibit other physical properties that may cause long-term durability issues resulting in more frequent replacement, added costs and other negative environmental impacts Considered in this way, there is no single product that can serve as an alternative for the insulating, air sealing, and moisture barrier product SPF.

In terms of an alternative for the Chemical of Concern (unreacted diisocyanates), we are unaware of a chemistry that provides an alternative for isocyanate use in SPF. Alternative non-isocyanate based "spray polyurethane foam" is not known to exhibit the qualities and range of performance attributes listed above, nor has it been shown to be commercially viable. Its prospects for use in the rigid foam area appear extremely limited due to the reported difficulties in obtaining a fast curing system. Furthermore, considering the expected growth and investment in the insulation industry, the failure of the non-isocyanate based "spray foam" manufacturers to commercialize their products may provide evidence that the products are not commercially viable alternatives to isocyanate-based SPF insulation.

We strongly object to the Department listing "alternative materials" in the SPF Systems Priority Product Profile until full assessments of the "alternative materials" are documented and a determination is made that the materials provide for comparable performance, availability, and environmental and health impacts. Irrespective of the disclaimer that was added to the SPF Systems Product Profile on May 28, 2014 (more than two months after the original Product Profile was published), the current list of "alternative materials" in the Product Profile continues to confuse the marketplace while providing an unfair advantage in the marketplace to other insulation options. The public could be misled or get the mistaken impression that the Department has conducted an analysis and determined the materials to be "safer" alternatives to SPF Systems.

IV. SPF Product and Market Information

This section provides information related to the different SPF products, including a description of the SPF application methods, health and safety information for two-component applications, market information, product uses, performance attributes, and industry economic information.

A. Product Types

This subsection provides information on the different product categories for SPF – high-pressure, roofing, low-pressure and one-component foam. Each of the SPF products is distinct and constitutes a different product. A chart of available SPF products and application methods is included in Appendix E.

High-Pressure SPF Insulation

High-pressure SPF is formed via an exothermic chemical reaction between approximately equal amounts of methylene diphenyl diisocyanates (MDI) and MDI-based isocyanates with a polyol blend, referred to as the A-side and B-side, respectively. The A-side is typically a mixture of 50% monomeric MDI and 50% pMDI. The B-side, or resin, is a proprietary mixture of polyols and other chemicals that have specific roles in the reaction process or impart important characteristics to the finished foam insulation. It is important to note that high-pressure SPF products (open-cell insulation, closed-cell insulation, and roofing) have distinct physical properties and should be considered different products.

Low-Pressure Two-Component SPF

Low-pressure two component SPF products deliver a smaller volume of foam compared to high-pressure two-component SPF products, and typically are used to cover smaller surface areas. In addition, low-pressure foams do not aerosolize the two primary chemicals, but instead the chemicals are combined in a static mixer and polymerize before release. These systems are also delivered at low pressure and lower temperatures (in the form of a froth) which further reduce the potential for exposure to airborne unreacted diisocyanates. These application factors combine to reduce significantly the already low inhalation exposure potential than is typically associated with the high-pressure SPF systems. Extensive exposure monitoring data are available that have defined the exposure potential to MDI during application of SPF with low-pressure systems and highlight that the levels are below occupational exposure guidelines (*See* Appendix C).

One-Component Foam

One component foam ("OCF") products deliver a smaller volume of foam compared to high-pressure two-component SPF products, and typically are used to cover smaller areas such as gaps and cracks. In one component systems, the A and B side of the product are combined at the manufacturing site and reactions occur in the container prior to use thereby reducing the amount of unreacted isocyanates when compared to two component systems and leaving pre-polymers. These materials react as soon as they expelled from the can and cure very quickly, thus post-

application chemical exposure potential is extremely low. Furthermore, the application of these materials does not involve actual spraying but instead the material is delivered as a foam bead, which reduces any potential for aerosolization and airborne exposure to unreacted isocyanates.

Monitoring data on exposure potential show that during application of one component foam, MDI levels are non-detectable with detection limits well below the OSHA PEL of 0.20 mg/m3 (Fishback 2012).[34] Therefore, the application and use factors combine such that there is no exposure that would result in the potential for significant adverse effects which is supported by the long history of safe use for these products.

B. Health and Safety Information: Two-Component SPF Insulations

The Department has indicated, through comments and presentations at the public workshops, that it is concerned with potential exposure to unreacted MDI during the application process. Personnel may be exposed to airborne concentrations of both the A-side containing MDI and pMDI (and the B-side) during application. Access to the work area during these tasks should be appropriately restricted to personnel whose job responsibilities require them to be in the work area, and who are trained in the hazards of exposure to the chemicals and are using the appropriate PPE properly. It is important to note that requirements – including PPE re-entry and re-occupancy times, and ventilation – for indoor and outdoor applications of SPF may vary.

It is important to note that the time period within which concentrations of A-side chemicals (MDI and pMDI) may be present in the work area after application may be significantly different than the cure times for SPF insulation. There are various ways to describe the SPF curing process. Depending on the characteristics of the foam, the heat dissipated during the exothermic reaction, and ambient conditions, including temperature and humidity, it may take 24 hours for some types of foam to fully cure (i.e., optimum physical properties of the foam are achieved). As noted by the US EPA in the Chemical Action Plan for MDI, completely cured products are fully reacted and therefore are considered to be inert and non-toxic.

In multiple published studies, the amount of unreacted isocyanate has been documented to be below the limit of detection on the surface of the foam within fifteen (15) minutes and below the limit of detection in the air within two (2) hours after application.

Furthermore, supplier recommended times for re-entry and re-occupancy also may be different for indoor applications of SPF. Re-entry times refer to the time after application when applicator or other trade workers may re-enter the work area without PPE. Re-occupancy times refer to the time after application when other building occupants may reoccupy the work area without PPE. The evaluation reports for specific SPF insulation products often include the recommended re-occupancy time, which can vary with product type and other factors (24 hours is typical for high-pressure SPF). Re-entry and re-occupancy times are not a proxy for the amount of unreacted isocyanates in the work area.

[34] Fishback, T. (2012). Polyurethane Foam Sealants. Presented at ACC Workshop on TDI/MDI for EPA Staff. ACC headquarters, Washington, DC. February 15. Available on the EPA MDI Chemical Action Plan Docket: EPA-HQ-OPPT-2011-0182.

Current SPF industry best practices are as follows and markedly limit potential MDI exposures to occupants and bystanders. The guidance below applies only to SPF application inside the building envelope. Requirements for outdoor application of SPF, including roofing, may vary significantly.

1. The building should be vacated during SPF application;
2. Where the building cannot be vacated, the spray application area should be contained/isolated and ventilated;
3. The spray area should be ventilated for a period of time following SPF installation;
4. Building occupants should not return until after the manufacturer's recommended re-occupancy time (typically 24 hours for high-pressure and 1 hour for low-pressure) has elapsed.

The potential risk from exposure to a chemical is dependent on several factors, including the route of entry, the dose, the frequency and duration of exposure, and the individual's susceptibilities. Due to the potential exposure to A-side (and B-side) chemicals above the applicable occupational exposure limits during the SPF application process, industry best practice recommendations include, but are not limited to, the following steps to control and reduce exposure to acceptable levels.[35]

Engineering Controls: Proper containment and ventilation techniques can help prevent workers and building occupants from potential chemical exposure due to SPF application. Containment creates a contained workspace while the ventilation system removes SPF chemicals from the work area by drawing the air out of the workspace though the use of a fan. Active ventilation is achieved by using one or more fans to draw air to or from the workspace and creates a negative pressure inside the workspace. The exhaust from the workspace is routed to an appropriate location outside and away from the building and occupied places. Guidance for engineering controls for outdoor applications may differ.

Site Preparation: Careful consideration of many factors goes into planning an SPF installation. For example, site preparation may include consideration of: design of containment and ventilation methods; ordering HVAC systems shut down during application; establishing a work zone around the workspace to provide notice to and protect other trades; designation of an area for putting on and removing PPE.

Occupant Outreach: In some instances, it may not be possible to completely vacate a building during SPF application. SPF applicators develop an appropriate occupant outreach strategy to communicate necessary information about potential health hazards associated with SPF to building owners.

Personal Protective Equipment (PPE): Generally, PPE is required for applicators, helpers, and other adjacent workers who may enter a spray foam application work area during and after the application process. Specific information on PPE requirements is contained within specific company safety programs as well as the SDS for the product.

[35] Best practices and industry recommendations are widely available at www.americanchemistry.com/polyurethanes and www.spraypolyurethane.com.

A PPE evaluation prior to beginning work is a useful tool to determine the appropriate PPE for the job task. The following factors should be considered when selecting PPE for a job task:

- The type of product selected. Not all types of SPF require the same level of PPE.
- Location of the job tasks, such as outdoors versus indoors, whether the work will take place in an enclosed space, the type of ventilation available, the ambient temperature and relative humidity, wind speed and direction, as applicable.
- Potential for inhalation exposure or eye or skin contact with SPF chemicals based on the job tasks.
- The quantity of SPF chemicals applied and the delivery method (aerosolized versus bead application).
- Characteristics of the PPE that may affect the wearer's ability to complete a task such as gloves that permit dexterity and respiratory protection that allows adequate peripheral vision.

The use of appropriate protective clothing is necessary whenever there is the possibility of direct contact with SPF chemicals. The appropriate protective clothing varies depending upon the potential for exposure and the type of product in use. Applicators and helpers typically wear disposable coveralls to keep spray and mist from contacting skin and clothing. In order to protect the skin, it is recommended that the PPE be worn so as to protect all skin. When not wearing a hood respirator, it is recommended that PPE be selected that includes an attached hood or spray head cover. For tasks where there is a potential for splash, it is recommended that a suit coated with an impermeable coating such as PVC be considered.

Gloves made of nitrile, neoprene, butyl or PVC generally provide adequate protection against A-side materials.[36]

Appropriate eye protection helps prevent eye contact from splashes of liquid chemicals, accidental sprays of reacting foam, aerosols and vapors that are likely to be present during spraying, and airborne particulate associated with sanding and grinding. The type of eye protection needed depends on the nature of the activity. Persons handling liquid SPF chemicals in open containers can protect their eyes by wearing safety goggles or safety goggles in combination with face shields. During application of SPF, eye protection may be provided by virtue of wearing a full-face or hood respirator.

Engineering controls, such as local exhaust ventilation, can be used to control SPF chemical exposures. Administrative controls, such as work schedules and work practices, are used concurrently to minimize exposure. Respirators are needed when air concentrations continue to exceed occupational exposure limits when engineering and administrative controls are implemented (*See* Appendix F).

Air-purifying respirators (ARP) and powered air-purifying respirators (PAPR) are generally appropriate when spraying high pressure spray polyurethane foam in exterior applications.

[36] *See* PMDI User Guidelines for Chemical Protective Clothing Selection, Alliance for the Polyurethane Industry (API) Technical Bulletin AX178, January 2002.

Supplied air respirators (SAR) are typically used in interior applications[37] for high pressure SPF applications. ARP are generally appropriate for applicators of low-pressure SPF.

The OSHA Respiratory Protection Standard[38] requires employers to have a written respiratory protection program for employees required to use respiratory protection. The Standard outlines requirements for respirator selection, respirator maintenance, annual fit testing, medical surveillance, and annual training.[39]

OSHA requires employers to provide medical evaluations administered by a physician or licensed healthcare professional for all employees required to wear respirators. Employees must receive approval prior to fit testing and subsequent issuance of the respirator. OSHA also requires that employees complete a successful fit test using a respirator of the same make, model and size as the respirator issued.[40] Fit testing must be repeated annually thereafter. In addition, annual training is required under the OSHA standard for all personnel required to wear respiratory protection.

PPE care and maintenance are critical considerations for proper PPE and are covered by industry best practices and manufacturer recommendations. Single-use or disposable PPE is disposed of in accordance with local or state environmental regulations. Reusable PPE should be decontaminated after exiting the work area. Manufacturer recommendations cover the regular cleaning and disinfection requirements for reusable PPE.

Industry best practices recommend inspecting PPE periodically to help identify equipment or components that need to be replaced, repaired, or refilled. Respirators are inspected per OSHA Respiratory Protection Standard. Generally, an APR inspection includes inspecting the mask and cartridges for damage and adhering to the end-of-service life indicator or the respirator filter/cartridge/canister change-out schedule. For PAPR, the inspection includes the elements of the APF inspection as well as the blow unit and battery.

The risk associated with exposure to A-side chemicals (and B-side chemicals) is well understood and managed by existing industry best practices, manufacturer guidelines and recommendations, and workplace safety standards and regulations.[41] Employees as well as self-employed SPF applicators have access to industry best practices through a number of resources that are offered by the industry. Training and certification programs offer initial and continual education on the proper methods for handling and installing SPF insulation. As a result of the promotion and dissemination of these industry best practices, manufacturer recommendations, and workplace safety standards and regulations, SPF roofing, insulation and sealants are well-understood and well-managed products, and the risk of exposure to chemicals is managed to acceptable levels.

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[37] Refer to the NIOSH *Respirator Decision Logic* (2004) for more information regarding respirator selection.
[38] OSHA Respiratory Protection Standard: 29 CFR 1910.134.
[39] To assist site managers in developing their own Respiratory Protection Programs, the Center for the Polyurethanes Industry (CPI) of the American Chemistry Council has created a Model Respiratory Protection Program for reference and guidance, available online at www.americanchemistry.com/polyurethane.
[40] OSHA requirements available at: 29 CFR 1910.134(f).
[41] SCP §69503.3(b)(4)(G) permits DTSC to consider engineering and administrative controls that reduce exposure concerns associated with the Priority Product.

Therefore, SPF Systems products do not present the potential for widespread or significant adverse impacts.

C. Market Information

This subsection provides information on the market structure for SPF in California. The market structure for each SPF product type is unique and the differences are relevant to the Regulations. The information below summarizes well-known industry practices; companies make sales and distribution decisions individually.

High-pressure SPF for insulation and roofing is manufactured by SPF systems houses. There are three (3) SPF systems house manufacturer facilities in California. While the SPF systems houses may sell directly to professional insulation contractors, the high-pressure SPF systems can be sold through distribution. The distribution businesses, located in California or the surrounding states, then sell the high-pressure SPF systems to professional insulation contractors. Notably, high-pressure SPF systems are only available to professional insulation contractors. High-pressure SPF systems require extensive professional equipment, often transported in a dedicated trailer or "rig," and adequate facilities to store and maintain the equipment. Chemical suppliers and systems houses offer comprehensive chemical handling and product training to insulation contractor businesses.

Low-pressure SPF systems are used by professional insulation contractors or other building trades who are performing weatherization projects or small-scale home renovation projects. Low-pressure SPF systems may be sold directly to professional insulation contractors or other professional construction trades or through distribution. The distribution businesses would then sell the low-pressure SPF systems to the professional construction trades. Both systems houses and industry trades offer comprehensive handing and product training materials to the users of low-pressure SPF systems.

One component foam (or foam in a can) is available to professional contractors and the general public through construction retail stores. The product is sold and marketed with comprehensive product use instructions and appropriate labeling.

D. SPF Product Users & Uses

As described above, high-pressure SPF systems are sold to and used by professional insulation contractors and roofing contractors only. Additionally, the sale of high-pressure products to a specific business may be – and often is - predicated upon completion of mandatory health and safety training and certification. High-pressure SPF systems are used for large-scale wall insulation, commercial roofing projects, insulated commercial storage tanks, insulated food storage facilities in the agricultural industries, and other commercial applications that include the space, aeronautical and marine industries.

Low-pressure SPF systems are sold to and used by professional insulation contractors and other building trades. While some low-pressure SPF systems are designed for small-scale insulation or

home remodeling projects (*e.g.*, use for replacing torn-out insulation in a bathroom remodeling project or home window replacement project), other low-pressure SPF systems are for more complex industrial applications and require specialized equipment and trained applicators.

One component foams are sold to and used by professional building trades and general consumers. OCF may be used to seal a common crack or gap in a home. OCF may also be used to comply with building and fire code requirements that cover sealing gaps around wires and pipes in a home or commercial building.

E. Product Benefits and Performance Attributes

This subsection provides information on the distinct benefits and performance attributes of SPF products. Each SPF product type is used for different purposes and offers unique performance attributes that are valued across industries and applications. Based on the unique and multi-functional properties of SPF products, there are currently no commercially available alternatives that offer the same all-in-one product attributes.

A Life Cycle Assessment (LCA) is available for open and closed-cell SPF insulation in buildings.[42] The LCA results show that SPF products can save more energy and reduce environmental impacts during the life cycle of the insulation products in a building compared to the relatively minor energy and environmental impacts associated with making the insulation.

Thermal Insulation: SPF provides exceptional thermal insulation performance under a wide range of operating temperatures. Thermal insulation performance, measured as an R-value, depends on maintaining a still layer of air or gas within the insulation. R-value is a term used to rate an insulation's ability to resist conductive heat transfer. The higher the R-value, the more effective the insulation's ability is to reduce conductive heat flow.

All SPF products are inherently air impermeable at typically installed thicknesses, which effectively eliminates internal air movement within the insulation. When installed correctly, SPF resists heat transfer better than many other insulation materials, which have R-values typically in the range of 3.5 - 6.5 per one inch of thickness. Air-impermeable SPF insulation results in a consistent thermal performance over a wide range of operating temperatures.

Closed-cell SPF, in addition to being air-impermeable, provides an R-value in the range of 6 - 7 per inch. Like double-pane glass windows, the closed-cell foam structure entraps an insulating gas that enables it to achieve this range of R-values in limited spaces.

Air Barrier**:** All SPF insulation is inherently air-impermeable at typically-installed thicknesses, qualifying it as an approved air-barrier material. Model and adopted energy codes, including California Title 24, typically require air-impermeable materials to be installed in direct contact with all sides of air-permeable fibrous insulations to provide similar performance.

SPF is mixed on the jobsite, expanding in place to fill all nooks and crannies in the building envelope, providing consistent air seal for all cracks, gaps and penetrations in the surface where

[42] A copy of the SPF LCA is *available at*: http://www.sprayfoam.org/technical/energy-the-environment.

it is applied. The use of SPF for the building envelope, in combination with low-pressure SPF sealants around window and door penetrations, will create an air-barrier assembly on any wall, roof, ceiling or floor. Some non-SPF assemblies may require caulking at seams and joints to create a complete air barrier system for the building enclosure.

Vapor Retarder: All building enclosures constructed in colder climates require some type of vapor retarder to control moisture and reduce the occurrence of water condensation. Regardless of what insulation type is used, without proper application of a vapor control layer, water condensation can develop leading to mold, mildew, rot and corrosion of building materials. Fibrous insulations, as well as open-cell SPF, are inherently moisture-permeable and require an additional vapor retarder layer on the 'warm-in-winter' side of the building envelope in colder climates. Vapor retarder materials can include facings, paints and plastic films. Paints and films provide a continuous vapor retarder layer.

Open-cell foams used in colder climates rely on the use of certain vapor retarding paints (Class II) or simply latex paint (Class III) to provide a continuous vapor retarder. Closed-cell foams, by the nature of their cell structure, inherently provide a Class II vapor retarder at a thickness of 1.5 to 2.0 inches, without the addition of any facing, paint or film. This means one product can provide insulation, air barrier and vapor barrier all in one.

Water Resistance: The cell structure of closed-cell SPF insulation provides water resistance in the event of a flood. Closed-cell foams are the only insulation recognized as flood resistant by FEMA. For this reason, FEMA recommends the use of closed-cell insulation in applications where water contact is likely – such as on basement or crawlspace walls – to mitigate losses in a flood event and prevent mold growth. A significant advantage of using closed-cell foams in wet areas is that they typically do not need to be removed and replaced after a flood event.

Structural Enhancement: The closed-cell SPF expands in place to create a rigid foam material. When mixed and applied in the field, closed-cell SPF adheres to almost any clean, dry substrate material, such as wood, steel or concrete. Several independent studies have shown that closed-cell SPF provides structural enhancement to walls and roofs, increasing resistance to racking and wind uplift loads.[43]

Durability: The adhesion properties of SPF make it an ideal choice in many overhead applications because it does not require labor-intensive wire supports, netting, or fasteners to remain in-place. In addition, the stable cellular structure of SPF does not sag or settle over time, maintaining its performance over the life of the building.

F. SPF Economic Information

[43] Test results are reported in "Testing and Adoption of Spray Polyurethane Foam for Wood Frame Building Construction" (May 25, 1992) prepared by NAHB Research Center for The Society of the Plastics Industry/Polyurethane Foam Contractors Division. Test results are reported in a letter from Bob Dewey, Mechanical Engineer, NAHB Research Center to Mason Knowles, The Society of the Plastics Industry/Spray Polyurethane Foam Division (November 18, 1996).

As described above, the unique, multi-attribute performance qualities of SPF insulation make the product a valuable tool in reducing energy consumption. According to industry estimates, ten percent (10%) of the 35,000 new single-family homes constructed in California in 2013 were insulated with SPF. The resulting energy savings from these homes can add up to $3.3 million each year or approximately $900 in savings for each California household. The annual energy savings are equal to removing 800,000 tons of greenhouse gas equivalents from the environment of the 60-year life span of the homes. The environmental and economic benefits of SPF rise significantly for California when the savings from existing home construction or renovation projects, commercial construction projects (new and existing buildings), and industrial applications are factored in.

Industry statistics collected for the CPI Spray Foam Coalition for high-pressure SPF products show total product (closed-cell, open-cell, and roofing insulations) shipments for California totaled 13,064,000 pounds in 2013, up from 9,484,000 pounds in 2008 – a thirty-eight percent (38%) increase over the six (6) year period. Product shipment or sales information for low-pressure SPF products or OCF products is not available from the Spray Foam Coalition.

According to industry estimates, there are approximately 1,500 jobs in California related to the application of high-pressure SPF. The California high-pressure SPF market is a $63 million annual market, according to industry estimates. Similar information for low-pressure SPF products or OCF products is not available at an industry level. There are 3 systems house manufacturers with facilities related to high-pressure SPF in California. ACC is unaware of any manufacturing facilities located in California for low-pressure SPF products or OFC products.

We note that, while the market and economic information is provided here to inform the Department, it cannot be used as a determinative factor in assessing the potential for widespread or significant adverse impacts from SPF. The use of market information for exposure modeling would inaccurately assume each SPF product shipment or purchase results in, or creates the potential for, an exposure incident to unreacted isocyanates. As described throughout these comments, the risk of exposure to unreacted isocyanates is low due to existing regulations, worker training, products safety and stewardship programs, and the various chemistries of each individual SPF product and resulting curing times. Moreover, the Regulations contemplate the use of economic information as a "surrogate" for exposure when exposure data is not available.[44] As clearly articulated in industry comments to DTSC, SPF Systems and the Candidate Chemical are well understood and researched and exposure data has been provided. The use of economic information as a surrogate for exposure data in this instance is unnecessary and inappropriate.

[44] SCP §69503.3(b)(1)

V. SPF Industry Partnerships, Research & Training Initiatives

SPF is a well-understood product as a result of ongoing industry collaboration with federal regulatory agencies, voluntary research programs and industry-led worker training and certification programs. The Regulations require DTSC to analyze both the hazard and exposure to the Candidate Chemical as part of the product-chemical combination before making a determination whether to list a product-chemical combination as a Priority Product. While all products contain chemicals and ingredients that carry inherent levels of hazard, both the hazard and exposure regarding SPF Systems as a Priority Product are managed at appropriate levels. The partnerships and programs detailed below provide an optimal opportunity for industry to work with interested partners to continue to research and manage SPF products.

A. Existing Cooperation with Federal Agencies

This subsection provides information related to the existing collaboration and information exchange with various federal agencies to study, understand and manage SPF products. Due to the extensive and meaningful work completed to-date and ongoing in these cooperative relationships, we believe the regulatory scheme contemplated by DTSC will provide no meaningful or measureable increase in protection.

U.S.EPA

In 2009, the polyurethane industry, working together through CPI and the Spray Polyurethane Foam Alliance (SPFA), launched an enhanced product stewardship program to support further understanding of the benefits of SPF, safe use and handling, hazard communications, and marketing claims. This program focuses on the following practices and communications that can help to minimize potential for exposure of workers and building occupants to SPF chemicals.

- Worker Performance and Training. Develop and deploy health and safety training programs for professional SPF applicators;
- Outreach. Educate DIY'ers, consumers and the building/construction sector about best practices on key issues including the selection of a contractor; different types of SPF products; health and safety considerations for DIY'ers and consumers during and after SPF product installation; and
- Research. Develop research and support testing programs to improve understanding of potential exposure to chemical components for workers applying SPF and potential consumer/occupant exposure to SPF emissions.

As a result of this collaborative approach, CPI has developed a plethora of resources on product stewardship and safe handling information, including videos, regulatory compliance information, as well as training modules to address questions about raw materials related to environmental, health and safety, distribution, use, emissions, and waste issues.[45] Progress relating to these efforts is detailed in annual or semi-annual updates provided to EPA leadership and posted in

[45] Resources *available at*: www.spraypolyurethane.org.

EPA's MDI Action Plan Docket. Progress in training programs is reported monthly to EPA and industry stakeholders as both a metric for success and an impetus for continued progress.

U.S. OSHA

CPI promotes opportunities to provide guidance on safe use and handling of polyurethane products, and has developed extensive programs to educate and provide information and safety precautions to workers and others using isocyanates, including information about compliance with U.S. EPA and OSHA regulations. CPI works with the value chain and provides these extensive resources, including training opportunities, guidance documents, tools and videos, as well as professional development courses that can help manufacturers and facilities learn about important OSHA requirements, like workplace exposure limits that are established and enforced by OSHA. We have partnered with OSHA in the past on worker safety efforts and look forward to doing so again. This industry will continue to lead worker safety and product stewardship efforts and coordinate with OSHA on worker safety initiatives.

Further, CPI is currently working with the OSHA Office of Outreach Services and Alliance on establishing a national alliance between OSHA and CPI to develop a collaborative relationship. At this time, the alliance is intended to provide additional training resources to protect the health and safety of workers, particularly by: reducing and preventing exposures to diisocyanates; and understanding the rights of workers and the responsibilities of employees under the Occupational Safety and Health Act. This will be executed through effective training programs on health and safety procedures relative to diisocyanates regarding good practices, effective approaches and guidance through workshops, seminars and lectures. The Alliance is intended to include labor organizations as well.

Consumer Product Safety Commission (CPSC)

In 2014, CPI provided research SPF foam samples to the CPSC for its work with the National Institute of Standards and Technology (NIST) to support work to develop ASTM International standard methods for measuring emissions from SPF. This work is ongoing.

In summary, existing and ongoing research partnerships with US EPA and OSHA demonstrate the high degree to which SPF products are and continue to be understood and managed from a chemical safety perspective.

B. Industry-Led, Voluntary Research Programs

This subsection details the numerous voluntary research programs led by industry organizations that continue to build data for already well-understood products. At each stage of these research projects, EPA, OSHA, NIOSH and the US Consumer Product Safety Commission are offered the opportunity to be informed about the purpose of the projects, consulted on the methodology and provided with in-depth briefings on the results. CPI scientists and SPFA member contractors have provided educational opportunities and extensive briefings on industry safety and product stewardship efforts. The research programs led by industry organizations are in addition to the

millions of dollars invested annually through research and development budgets of product suppliers and manufacturers.

CPI continues development of data on SPF raw materials, engineering practices, and analytical methods. We are currently focusing our work on two projects: a ventilation research project and a product emissions testing project.

Ventilation Research Project

CPI's Ventilation Research Project is researching the impact of changes in ventilation rates on the concentration of SPF chemical vapor and particulates emitted during SPF application. CPI's Ventilation Research Project has completed Phase I (testing for spray equipment and development of three generic SPF formulations) and Phase II (monitoring chemical emissions during SPF application under controlled environmental conditions). This is a worker safety focused project.

The project has been expanded to document the decay rate of specific chemical vapors following SPF application. The purpose is to estimate the time required to restrict adult trade workers not wearing the recommended PPE from the work area in order to minimize exposure. CPI will continue to evaluate findings, and consider additional best practice guidance and further testing.

Papers presented at the annual Polyurethanes Technical Conference on this project are available online.[46]

Product Emissions Project

CPI's Product Emissions Testing Project (in support of standards being developed by ASTM Committee D22.05) is also well underway and reached an important milestone in 2013: the Standard Practice for Spraying, Sampling, Packaging, and Test Specimen Preparation of Spray Polyurethane Foam (SPF) Insulation Samples for Environmental Chamber Emissions Testing was fully approved by ASTM (ASTM D7859-13). For this project, CPI developed a research framework to evaluate emissions generated from SPF after application to help better understand product emissions from cured SPF chemicals following application. This project utilized the same generic formulations as the Ventilation Research Project. CPI continues our research to support an ASTM method to evaluate SPF samples in microchambers. As research is completed and draft standards are developed by CPI, they are balloted through the open ASTM process. EPA is one of many stakeholders involved in the ASTM Committee working on the method for microchamber emissions testing.

The following are current work items that have been opened at ASTM:

[46] Papers presented at the annual Polyurethanes Technical Conference on this project are available online at: http://polyurethane.americanchemistry.com/Resources-and-Document-Library#CPI.

- WK40293 - Test Method for Determination of Vapor-Phase Organic Compounds Emitted from Spray Polyurethane Foam (SPF) using Micro-Scale Environmental Test Chambers; and
- WK43872 - Test Method for Determination of Emissions of Methylene diphenyl diisocyanate (MDI) from Spray Polyurethane Foam (SPF) Insulation using Emission Cells or Micro-Scale Environmental Test Chambers

CPI members and partners have benefitted from the involvement of EPA staff and staff from other federal agencies who participate in updates on the status of the research and provide thoughtful feedback and suggestions on the research questions and protocols. We held a work shop in April 2014 to provide status reports and discussion with many of the federal agency partners invited: EPA, CPSC, NIOSH, and OSHA.

Papers presented at the annual Polyurethanes Technical Conference on this project are available online.[47]

C. Professional Development Courses and Training Programs

This subsection details the numerous professional development courses and training programs that are available throughout the SPF value chain. The SPF industry recognizes that a professional, well-trained workforce is key to the continued overall success of the SPF industry.

Professional Development & Certification

CPI supports professional development courses and certification programs for SPF professionals, including applicators, helpers, site managers and weatherization contractors. An example is the SPFA's Professional Certification Program (PCP).[48]

The SPFA PCP multi-level certification is a rigorous and extensive program for professionals who install SPF insulation and roofing. The program is developed, designed and operated in compliance with internationally recognized ISO-17024 standards. The program includes the following requirements:

- Complete CPI's High Pressure SPF training program (described below);
- Pass the PCP exams related to the levels of certification being pursued, including all lower level exams for those pursuing higher level exams.[49]
- Document spraying experience, and complete CPR, first aid and OSHA safety courses (OSHA 10- or 30-hour card) for higher levels of certification by SPFA; and
- Maintain certified status annually and recertify every five years with SPFA.

[47] Papers presented at the annual Polyurethanes Technical Conference on this project are available online at: http://polyurethane.americanchemistry.com/Resources-and-Document-Library#CPI.
[48] Additional information on the SPFA PCP is available at: http://www.sprayfoam.org/certification.
[49] Certification levels include: SPF Assistant; SPF Insulation Installer; SPF Insulation Master Installer; SPF Insulation Project Manager. Additional information *available at*: http://www.sprayfoam.org/certification/insulation-certification-program.

The PCP enables individuals who complete the program to demonstrate knowledge, skills and professional accomplishment. The program also enables homeowners, architects and builders to identify and employ SPF professionals who have learned the highest installation and safety standards by identification cards issued by SPFA upon successful completion of the PCP.

CPI Online Training Courses

CPI has two online chemical health and safety training programs which provide information about the use, handling and disposal of SPF, potential health hazards and control measures, including engineering controls and personal protective equipment (PPE). Since its release in 2010, more than 12,300 individuals have accessed the High-Pressure SPF Chemical Health and Safety Training either online or in an instructor-led setting in either English or Spanish. The launch of the Low-Pressure SPF Chemical Health and Safety training program in late 2012 - in English and Spanish - provides a national level, free basic chemical health and safety training program for professional SPF contractors and helpers, and weatherization professionals. Materials developed for the low-pressure training were produced with funds from an OSHA Susan Harwood Grant. Since its release in December 2012, more than 1,700 individuals have accessed the low-pressure training. In addition, the CPI training programs were approved for the Building Performance Institute's (BPI) continuing education units (CEU) and RCI, Inc. for Continuing Education Hours (CEHs).[50]

In summary, SPF Systems are well understood and managed products. The existing regulatory programs and industry best practices manage and limit the risk of exposure to the Candidate Chemical in the Priority Product to acceptable levels. SPF Systems should be removed from the list of Priority Products because regulating SPF as a Priority Product would not result in an increase in overall public health and safety.

[50] Both training courses are accessible to the public at www.spraypolyurethane.org.

VI. SPF Systems Should be Delisted

ACC believes the process used to date, including, but not limited to, the selection of Priority Products and the drafting of the SPF Systems Product Profile present significant questions as to the viability of future regulation of SPF Systems under the Regulations.

A. DTSC Failed to Articulate a Clear and Understandable Priority Product Selection Process

The process employed by the Department to select the initial list of Priority Products is not clearly articulated in documents published by the Department and appears arbitrary and capricious in nature. While the Department has alluded to conversations between DTSC and other agencies or stakeholders in which the topic of "isocyanates" was raised, it is unclear how SPF Systems was selected as the product-chemical combination for the initial list of Priority Products. The Department should articulate how it received information and who provided the information that led to selection of isocyanates as the Candidate Chemical and SPF Systems as the Priority Product. The Department should describe the process it undertook to verify that the suggestions or nominations it received from outside groups were based in science and fact. The Department should describe which criteria[51] SPF Systems met for selection as a Priority Product and how the Department weighted those factors against selection criteria SPF Systems do not meet.

The Department's process for selecting SPF Systems cannot be conducted within a black box. The lack of transparency prevents impacted stakeholders from ensuring they receive due process under the Regulations. The lack of transparency also denies the public of assurances that the Department is targeting products that do in fact present the potential for widespread or adverse impacts.

In summary, the Department should provide greater transparency of the process that was used to identify and select the candidate chemical and Priority Product. The voluminous inaccuracies in the Product Profile demonstrate that the Department's current findings are based on flawed assumptions and are evidence of a lack of due diligence.

B. The Information in the Priority Product Profile Provides an Improper and Inadequate Basis for Selecting SPF Systems

The Regulations mandate reliance on "reliable information"[52] as a predicate for justifying the selection of a product as a Priority Product.[53] The Product Profile does not meet this regulatory

[51] SCP §69503.2 specifying the factors DTSC will use to identify and prioritize product-chemical combinations as Priority Products.
[52] SCP §69501.1(a)(57).
[53] SCP §69503.2(b)(1)(C) stating DTSC should evaluate the quality of the information available based on the following factors: "1. The level of rigor attendant to the generation of the information including, when relevant, the use of quality controls; 2. The degree to which the information has been independently reviewed by qualified disinterested parties; 3. The degree to which the information has been independently confirmed, corroborated, or replicated; 4. The credentials, as well as education and experience qualifications, of the person(s) who prepared

requirement as reliable information is not used to justify the selection of SPF Systems. The information cited by the Department comes from secondary or tertiary sources, which are inadequate sources of information on which to base scientific determinations or conclusions. Moreover, the information relied on by the Department relates to studies or anecdotes of isocyanates not used in the production or manufacture of any of the SPF products contemplated by the Product Profile. Furthermore, the Department fails to demonstrate how this information about other isocyanates can serve as a basis for its determination that SPF Systems present the potential for widespread or significant adverse impacts.

The Regulations require that DTSC rely on information that is "reasonably available" to the Department related to exposures and adverse effects. The selection of information cited in the Product Profile demonstrates a clear failure to solicit and rely on information that was reasonably available. The Product Profile does not reference multiple sources of information that are reasonably available to the Department. As an example, the Centers for Disease Control and Prevention (CDC) maintains a public database of reported workplace or occupational asthma incidents on a state-by-state basis. Information for reported workplace asthma incidents in California is available. DTSC neither relied on the information contained in the public record nor explained its decision to dismiss the information despite the fact that the information was reasonably available to the Department.

Furthermore, the Department has acknowledged on numerous occasions that the SPF industry was not contacted for information on SPF products or the isocyanates used in the products prior to the publication of the Product Profile. As the Department failed to solicit information from the industry, it is difficult to conclude that the Department relied on information that was reasonably available to it in order to select SPF Systems.

Again, we would encourage DTSC to consider the data collected as part of the US EPA MDI Chemical Action Plan (also a reasonably available source of information).[54] These data provide important clarity on numerous aspects of SPF systems and products that are critical to consider as part of the Priority Product description and decision making including the chemistry of SPF, the different systems that are used to apply SPF, exposure potential to unreacted isocyanates when handling SPF, and existing programs that help ensure safe handling and use of SPF products.

In summary, the Department may not list SPF Systems as a Priority Product unless it determines that there is the "potential" for "significant or widespread adverse impacts." The "potential" for such "adverse impacts" must be "reasonably foreseeable based on reliable information" that is "reasonably available," as defined by the Regulations. The Department has failed to demonstrate that it relied on "reliable information" in its selection of SPF Systems and therefore the Department should eliminate SPF Systems from the initial list of Priority Products.

C. DTSC has Failed to Select a Proper Product-Chemical Combination

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and/or reviewed the information; and 5. The degree to which the information is relevant for the purpose for which it is being considered by DTSC."

[54] US EPA action plan information *available at*: http://www.epa.gov/oppt/existingchemicals/pubs/actionplans/mdi.html.

SPF Systems as defined by the Product Profile is not a consumer product. SPF systems containing "unreacted diisocyanates" refers to a chemical phase change the raw materials used in SPF systems undergo to become the cured, installed foam consumers purchase or contract for installation. If DTSC determines that SPF systems are in fact a consumer product under the definition of the Regulations, SPF Systems as defined by the Product Profile is overly broad and includes multiple SPF products that have relevant differences for purposes of the Regulations, as outlined above, and serve different purposes in the market.

In summary, DTSC should eliminate SPF Systems from the list of initial Priority Products because it is not a proper product-chemical combination under the Regulations.[55] To the extent DTSC determines – after reviewing all reasonably available and reliable information - that SPF Systems are a proper product-chemical combination, the scope of the Priority Product includes multiple product-chemical combinations and is therefore impermissible under the Regulations.[56]

D. The Further Regulation of SPF Systems is Duplicative and Preempted

SPF Systems are well-understood and managed products at both the industry and federal regulatory levels. Industry developed and adopted product stewardship programs, best practice guidance and worker training maximize the safe use and handling of SPF products. Federal regulatory bodies, including U.S. EPA and OSHA, manage the chemicals used in the manufacturer of SPF products and regulate the workplaces within the SPF industry value chain. Together with company-level training programs and outreach, the risk associated with SPF products is managed to an acceptable level. The likely duplication with workplace safety regulations promulgated and enforced by U.S. OSHA and its state counterpart CalOSHA preempt the regulatory scheme contemplated by the Department.

While ACC objects to the Department's assessment that there exists the potential for significant widespread or adverse impacts resulting from exposures to the Candidate Chemical contained in SPF Systems, current regulatory programs, as described above, address the same potential adverse impacts contemplated in the Product Profile.[57] The existing regulatory programs and industry efforts also provide equal or greater public health protections than would be provided for by listing SPF Systems as a Priority Product.[58]

Further, CalOSHA is the state agency responsible for the development and enforcement of occupational safety and health standards.[59] This jurisdiction remains intact unless another agency has been "specifically mandated to regulate the working environment within its aegis for the protection of the employees' health and safety."[60] Jurisdiction over these workplaces has not,

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[55] SCP 69503.
[56] *See* SCP 69501.(a)(24)(A) defining "consumer product" or "product" as a product or part of a product. The definition of SPF Systems proposed in the Product Profile includes multiple products; and therefore, is impermissibly broad.
[57] SCP 69501.1(b)(3)(A)
[58] SCP 69501.1(b)(3)(A)
[59] Cal. Lab. Code §50.7
[60] *United Airlines, Inc. v Occupational Safety & Health Appeals Bd.*, 32 Cal. 3d 764, 770 (1982).

through the Regulations, been transferred to DTSC and therefore the relevant occupational safety and health standards remain the purview of CalOSHA.

In summary, the regulatory scheme contemplated by the Department will not meaningfully increase the safety associated with the use of SPF products and therefore SPF Systems should be eliminated from the initial list of Priority Products.[61]. Furthermore, the action contemplated under the Regulations regarding SPF Systems is preempted by existing state and federal action and will needlessly and impermissibly duplicate and possibly introduce inconsistent requirements under California law.

E. Regulations and Priority Product Profile Fails to List Threshold Limits for Exposure

The Regulations specify that, when identifying a chemical, there must be the "potential for one or more exposures to contribute to or cause significant or widespread adverse impacts."[62] What must be demonstrated to meet that standard, however, fails to be defined, making it impossible for responsible entities and the general public to understand what requirements must be fulfilled to meet this threshold.

The Department identifies unreacted isocyanates in SPF Systems as having the potential to cause significant or widespread adverse impacts. Yet the Department fails to articulate, or reference, what would constitute permissible threshold limits for exposure to the Candidate Chemical in the Product Profile. The lack of defined threshold limits fails to adequately place interested parties on notice of the product-chemical combination the Department intends to regulate and fails to place any meaningful measurement or standard by which to compare SPF Systems to alleged "safer alternatives." It is difficult to imagine how the Department will determine if an alternative is suitable under the Regulations or contains "regrettable substitutions" without defined threshold limits for exposure to the candidate. The lack of defined threshold limits also calls into question whether the Department fully understands, or is able to articulate, the hazard traits of the candidate chemical or its hazards traits within the Priority Product. Furthermore, absent defined threshold exposure limits, the selection of the SPF Systems appears to be without a principled basis.

In summary, defined threshold exposure limits for the candidate chemical are a critical element of the Departments analysis of SPF Systems.[63] Therefore, the Department should eliminate SPF Systems from the initial list of Priority Products.

VII. Conclusion

ACC urges the Department to consider our comments and remove the SPF Systems from the list of Priority Products. In the immediate future, the erroneous and misleading SPF System Product Profile and related materials must be removed from the website.

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[61] *See* SCP 69501.1(b)
[62] SCP 69503.2(a)(2).
[63] SCP 69503.3(b)(4)(E) stating that frequency, extent, level, and duration of potential exposure to the Candidate Chemical are factors that may be assessed when evaluating the Priority Product.

Appendix A

ACC Letter to DTSC dated April 28, 2014
-AND-
ACC Technical Comments to DTSC dated April 29, 2014

American Chemistry Council | Center for the Polyurethanes Industry

April 28, 2014

Ms. Deborah O. Raphael
Director
California Department of Toxic Substances and Control
1001 I Street
Sacramento, CA 95814-2828

Dear Ms. Raphael:

Thank you for meeting with members and staff of the American Chemistry Council on April 15, 2014, to discuss the Department's recent listing of *Spray Polyurethane Foam Systems Containing Unreacted Diisocyanates* as an initial Priority Product under the Safer Consumer Product Regulations. We appreciate the opportunity to learn more about the Department's process and to provide you with some information about spray polyurethane foam (SPF) and unreacted isocyanates.

During the meeting, we identified many topics for further discussion and look forward to additional opportunities to meet with you and your staff to provide technical information regarding the manufacture, safe use, and benefits of the products as well as the extensive body of product stewardship, research and training programs that exist.

In response to the Department's offer to consider and correct factual errors in the March 2014 Priority Product Profile, we have identified important inaccuracies in the Priority Product Profile that was posted to your website in March 2014. As written, the Priority Product Profile unnecessarily distracts from the Department's ability to proceed constructively. In addition, these errors have resulted in marketplace confusion resulting in unjustified damage to the industry in California and beyond. A timely revision to the March version of the document will help focus the discussion.

Below are four points of misinformation currently included in the Priority Product Profile that we believe must be addressed promptly. A markup of the Priority Product Profile accompanies this letter to highlight the corresponding information that is inaccurate and demonstrate how these errors can be easily corrected (mostly via deletion of unrelated or inaccurate text).

1. TDI and HDI are not Used in SPF Systems

MDI and its oligomers are the only diisocyanates used in SPF systems. TDI and HDI are *not* used in and are *not* present in SPF systems. All references to these chemicals should be removed from the Priority Product Profile to avoid confusion and the dissemination of misinformation resulting from the discussion of irrelevant environmental, health and safety concerns.

2. Non-SPF Products Should be Eliminated from the Priority Product Profile

The scope of the Priority Product Profile document includes products and materials that are not SPF. It is misleading and incorrect to include products such as truck bed liners, coatings, and adhesives in the scope of this document and such references should be removed. Furthermore, by eliminating incorrect references and appropriately focusing the scope of review, the public workshops are likely to be more effective and targeted.

3. Airborne Concentrations of MDI are Non-Detectable Shortly After Application

Studies on two-component systems have shown that airborne concentrations of MDI are non-detectable within thirty minutes to two hours after application. For one-component foam in aerosol cans, industrial hygiene monitoring has shown airborne concentrations of MDI are non-detectable at the time of application. While it may take up to 24 hours for SPF to cure or develop all of its physical characteristics, MDI is generally non-detectable within 2 hours (air) and 15 minutes (surface) of application. It is not correct to equate the entire period of "curing time" to a time when people could be exposed to MDI. As can be seen in the attached, we recommend clarifying or deleting the statement on page 4.

4. Asthma Rates in the Polyurethanes Industry are Declining, Not Increasing

Although diisocyanates have been listed as one of the leading attributable causes of asthma in the workplace, various national data collection programs on worker exposure and disease incidence present a consistent picture showing a reduction of diisocyanates-related asthma cases over the last decade due to improved work practices and better medical surveillance programs. It is therefore *not* accurate to state that the asthma rates have remained stable. We request that this statement be deleted.

We are developing a more detailed set of technical comments discussing these and other areas of the Priority Product Profile, including supporting information and references. In the interim, please find attached our edits to the Priority Product Profile (March 2014). We have indicated text we suggest deleting in order to correct or eliminate the factual errors described above.

We appreciate your willingness to address these factual inaccuracies in the Priority Product Profile. We look forward to further constructive engagement with you and your staff. If you have any questions regarding this letter or the attachment, please feel free to contact me at (202) 249-6604 or my colleague Sahar Osman-Sypher, Director of the ACC Diisocyanates and Aliphatic Diisocyanates Panels at (202) 249-6721.

Regards,

Lee Salamone
Senior Director
ACC Center for the Polyurethanes Industry / Spray Foam Coalition

April 29, 2014

Dr. Meredith Williams
Deputy Director
California Department of Toxic Substances Control
1001 I Street
Sacramento, CA 95814

Re: Comments on the DTSC Priority Product Profile for "Spray Polyurethane Foam Systems Containing Unreacted Diisocyanates," March 2014

Dear Dr. Williams,

The American Chemistry Council Diisocyanates Panel, Aliphatic Diisocyanates Panel and the Center for the Polyurethanes Industry Spray Foam Coalition ("ACC") [1] are pleased to have the opportunity to submit comments to the California Environmental Protection Agency's Department of Toxic Substances Control ("Department" or "DTSC") regarding the recent "Spray Polyurethane Foam ("SPF") Systems Containing Unreacted Diisocyanates" Priority Product Profile issued in March 2014. The following bullets summarize ACC's general comments, while the attachment includes a more in-depth response and provides additional details regarding our concerns.

- The scope of the Priority Product Profile document is overly broad and the Department needs to clearly articulate the specific consumer product(s) it may intend to evaluate. All references to other polyurethane applications that are not SPF systems and therefore outside the scope of the Profile, such as truck bed liners, coatings, and adhesives, should be removed. As written, the Priority Product Profile document does not provide an adequate basis for evaluating the product or the Department's subsequent regulation.

- MDI and its oligomers are the only diisocyanates used in SPF systems. TDI and HDI are not used in SPF systems; therefore all references to the chemicals as components of SPF should be immediately removed from the Priority Product Profile to avoid confusion.

[1] The DII Panel includes U.S. manufacturers of TDI and/or MDI: BASF Corporation, Bayer Material Science, The Dow Chemical Company, and Huntsman Corporation. The ADI Panel is comprised of the U.S. manufacturers of hexamethylene diisocyanate (HDI), isophorone diisocyanate (IPDI) and methylene dicyclohexyl diisocyanate (H_{12}MDI). CPI membership includes raw material producers, systems suppliers, processing machinery and equipment manufacturers, as well as users of polyurethane materials that manufacture products made of or from polyurethanes.

Furthermore, the physiochemical properties of TDI and HDI are significantly different from MDI.

- If industry recommendations are followed, studies have shown that installation of SPF insulation in homes, schools and other public buildings is not a source of exposure to isocyanates. Studies on high pressure two-component systems have shown that airborne concentrations of MDI are non-detectable within 30 minutes to 2 hours after application.

- For one-component foam, airborne concentrations of MDI are non-detectable at the time of application. To protect customers, these products have precautionary labeling in accordance with Federal Trade Commission (FTC)/Consumer Product Safety Commission (CPSC) and the Federal Hazardous Substances Act (FHSA) requirements.

- SPF industry recommendations by manufacturers are intended to specifically limit or prevent potential MDI exposures to occupants and bystanders.

- There is currently no known substitute for isocyanates to produce rigid SPF insulation and roofing that provides the qualities required for these applications. The unique qualities of SPF insulation and roofing include:
    - higher energy efficiency through consistent thermal performance under a wide range of temperatures
    - low air permeability, qualifying SPF as an air barrier material
    - low moisture transmission, qualifying SPF as a vapor retarder material beneficial in colder climates
    - permanent adhesion to substrates and long-term durability - no settling or sagging
    - low water absorption* - FEMA-approved flood resistant insulation
    - high strength and stiffness* - providing structural enhancement for building assemblies

      **Closed-cell SPF only*

- Although diisocyanates have been mentioned as one of the leading attributable causes of asthma in the workplace, various national data collection programs on worker exposure and disease incidence present a consistent picture, showing a reduction of diisocyanates-related asthma cases over the last decade due to improved work practices and better medical surveillance programs.

- The Department's very narrow selection of peer-reviewed articles and information to support its position appears to demonstrate a bias.

- No demonstrated potential for community exposure to diisocyanates used in the industrial setting has been observed.

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

- Exposure of adults and children to diisocyanates in everyday life from fully cured products, such as SPF, is not supported by the evidence. Diisocyanates are not released from SPF in normal and correct use. Thus, the emphasis on a unique health concern affecting children potentially exposed to diisocyanates is not supported by scientific evidence.

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

- A review of the Verschoor and Verschoor 2014 paper reveals a number of inaccuracies and false assumptions. Thus use of this review article as a basis for determining health effects is flawed.

- TDI is not used in SPF systems. Furthermore, there is no evidence that TDI is carcinogenic in humans.

- TDI is not used in SPF systems. In addition, the current American Conference of Governmental Industrial Hygienists (ACGIH) limits are sufficiently protective of workers. ACC does not believe a reduction in the TDI TLV-TWA or TLV-STEL is supported by the data and research available to date, or that such reductions would reduce the incidence of occupational asthma.

- TDI is not used in SPF systems. Furthermore, the ACGIH rationale for the Biological Exposure Index for TDI is scientifically flawed and needs to address the importance of using a specific biomarker of TDI exposure.

ACC urges the Department to consider our comments and revise the Priority Product Profile accordingly. We look forward to continuing to work with the Department as it determines next steps with the state's Safer Consumer Products Regulations. If you have any questions or need additional information, please contact either Sahar Osman-Sypher at (202) 249-6721, Sahar_Osman-Sypher@americanchemistry.com, or Lee Salamone at (202) 249-6604, Lee_Salamone@americanchemistry.com.

Sincerely,

Sahar Osman-Sypher
Director, Diisocyanates/Aliphatic Diisocyanates Panels

Sincerely,

Lee Salamone
Senior Director, Center for the Polyurethanes Industry/Spray Foam Coalition

Attachment: ACC Critique of the California DTSC Priority Product Profile for Spray Polyurethane Foam Systems Containing Unreacted Diisocyanates

Pg. 2 - Scientific studies have shown that diisocyanates are the leading attributable cause of asthma in the workplace, and asthma is common among workers in the polyurethane industry.

<u>Comment:</u> Although diisocyanates have been mentioned as one of the leading attributable causes of asthma in the workplace, various national data collection programs on worker exposure and disease incidence present a consistent picture, showing a reduction of diisocyanates-related asthma cases over the last decade due to improved work practices and better medical surveillance programs.

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

The underlying reason for the reduction in isocyanate-related asthma is multi-factorial, including better compliance with exposure standards, improved work practices, use of less volatile isocyanate forms (e.g., prepolymers) and better medical surveillance programs (*See* Appendix 1). As several organizations have recognized, some specific tasks, notably spray painting, are associated with higher asthma incidence (McDonald et al., 2000; Karjalainen et al., 2002; Naylor and Curran, 2004; Cowie et al., 2005; Pronk et al., 2007; Buyantseva et al., 2011). Improving work practices in these applications could offer the opportunity to reduce cases of asthma even further.

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

is evidenced by the production site data where there is training, surveillance, and exposure controls. (*See* Appendix 1 for more information).

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

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

Pg. 2 - Exposure to unreacted diisocyanates and other chemical ingredients in SPF systems may harm both workers who are not using exposure controls or personal protective equipment, and consumers or bystanders at the time of application and after the materials have been installed.

Comment: Extensive product stewardship efforts are in place to address the safe handling and use of SPF applications. Installation of SPF insulation in homes, schools and other public buildings is not a potential source of exposure to isocyanates if industry recommendations are followed. Studies on two component systems have shown that airborne concentrations of MDI are non-detectable within thirty minutes - two hours after application. For one component foam in aerosol cans, industrial hygiene monitoring has shown airborne concentrations of MDI are non-detectable at the time of application.

Data demonstrates that no MDI exposure exists within thirty minutes to two hours after application. Lesage (2007) found that airborne MDI could not be detected approximately 1 hour following application of SPF in residential structures. In a subsequent study by IRSST (2009) using analytical techniques with lower detection limits, airborne MDI could not be detected approximately 2 hours following SPF application. More recently, work conducted in three residential structures found that airborne MDI could not be detected approximately 1 hour following SPF application (Robert et al., 2013). In this work, active ventilation was used during and following SPF application. Recently, in a study conducted by the Center for the Polyurethanes Industry (Wood, 2013), airborne MDI could not be detected approximately 30 minutes following SPF application. Similar to the Robert et al. study, active ventilation was used during and following SPF application.

Current SPF industry recommendations by manufacturers are as follows and can prevent potential MDI exposures to occupants and bystanders:
1) The building should be vacated during SPF application;
2) Where the building cannot be vacated, the spray application area should be contained/isolated and ventilated;
3) The spray area should be ventilated for a period of time following SPF installation;
4) Building occupants should not return until after the manufacturer's recommended re-occupancy time (typically 24 hours) has elapsed. (For additional information, see: *Guidance on Best Practices for the Installation of Spray Polyurethane Foam* and *Ventilation Considerations for Spray Polyurethane Foam*.

SPF Suppliers and many SPF distributors offer a 2-3 day material and equipment training program for their customers. After the applicator is trained by the supplier or distributor, the Spray Polyurethane Foam Alliance (SPFA) offers a voluntary ISO-compliant Professional Certification Program for all SPF applicators. This four-level program helps to assure that SPF applicators have the knowledge, skills and ability to apply SPF insulation and roofing systems with attention to quality and safety. No other insulation technology offers an industry-level certification program for its installers. For additional information, visit http://www.sprayfoam.org/certification.

CPI developed and launched SPF training programs which are available free to weatherization professionals, SPF applicators and helpers who work with low pressure and/or high pressure SPF. There are two (2) online courses, one focused on high pressure SPF and the other on low pressure SPF. Both provide information about the use, handling and disposal of SPF, potential health hazards and control measures, including engineering controls and personal protective equipment (PPE). The online courses are available in English and Spanish and can be taught in an instructor led setting as well. Since its release in 2010 more than 11,000 people have participated in the high-pressure health and safety training either in English or Spanish. More than 1,500 people have accessed the low-pressure health and safety training since it launched in December 2012 in English and Spanish. The low pressure training was developed with support of a Susan Harwood Grant (OSHA). Completion of CPI's high pressure training is a prerequisite for anyone who takes the SPFA PCP certification exam. For additional information, visit http://www.spraypolyurethane.org.

In addition, we question the inclusion of "other chemical ingredients in SPF systems." Other ingredients are out of the scope of this document and should not be referenced.

Pg. 3-4 - SPF systems typically contain MDI including MDI mixed isomers, polymeric MDI, and HDI. TDI may be found in SPF systems either as a minor component or as a residual constituent, particularly in systems containing polyurethane-based materials such as coatings, which may contain TDI.

Comment: HDI and TDI are not used in SPF systems. In order for the Priority Product Profile to be accurate, the Department should remove all references to HDI and TDI.

MDI and its oligomers are the only diisocyanates used in SPF systems. TDI and/or HDI could be used in roof coating systems. However, neither TDI nor HDI is included in SPF roofing systems. The SPF roofing systems and roof coating systems are completely separate systems independent of one another. Typically, the SPF roofing system is applied and fully cured, and then a separate roof coating system containing TDI and/or HDI may be applied as a top coat to meet certain performance characteristics such as resistance to harsh weather conditions.

Since neither TDI nor HDI are used in SPF systems, we request all references to the chemicals as components of SPF be removed from the Priority Product Profile to avoid confusion. Furthermore, the physiochemical properties of TDI and HDI are significantly different from MDI.

Pg. 4 - When the two sides are mixed in a spray applicator, a series of chemical reactions and physical processes occur, and a polyurethane foam is generated that will 'cure' into a rigid foam. In the process, human exposure to diisocyanates is likely. Curing time may range from hours to weeks depending on the type and conditions of application (U.S. EPA, 2013c).

<u>Comment:</u> If industry recommendations are followed, studies have shown that installation of SPF insulation in homes, schools and other public buildings is not a source of potential exposure to isocyanates. Studies on two component systems have shown that airborne concentrations of MDI are non-detectable within thirty minutes - two hours after application. For one component foam in aerosol cans, industrial hygiene monitoring has shown airborne concentrations of MDI are non-detectable at the time of application.

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

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

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

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

In conclusion, there is a big difference between curing as it relates to completion of the physical characteristics of the product and emissions of airborne isocyanate (air emissions) from the product as it begins to cure immediately after application. It may take some polyurethane products up to 24 hours to completely mature or develop all of its physical characteristics. However, MDI is generally non-detectable within the air (two hours) and on the surface (15 minutes) of the polyurethane product after application without engineering controls (ventilation). Of course, with engineering controls, re-entry time can be significantly decreased.

Pg. 5 - One-component SPF kits/cans: These SPF products are premixed as a one-component mixture under pressure. They are typically sealed in 16-ounce cans, and are widely available in home improvement centers, hardware stores, and other retail locations.

<u>Comment:</u> One-component SPF cans do not contain TDI nor HDI. Various studies completed by manufacturers show that during spraying of one-component foam, MDI levels are non-detectable to thousandths less than the OSHA PEL of 0.20 mg/m3. To protect consumers, these products have precautionary labeling in accordance with Federal Trade Commission (FTC)/Consumer Product Safety Commission (CPSC) and Federal Hazardous Substances Act (FHSA) requirements.

One-component SPF cans do not contain TDI nor HDI. Once the cans are filled with the components at the manufacturing site, reactions occur in the can reducing the amount of unreacted isocyanates and leaving pre-polymers. These materials react as soon as they are expelled from the can and cure very quickly, thus post application chemical exposure potential is extremely low. This is seen in the tack free times reported. Due to the high reactivity of the isocyanates, the surface of any foam is considered entirely reacted, as is a thin film of material. As the surface of the foam or film reacts to form the polymer chains it is physically tacky. Once the surface is tack-free it is considered entirely reacted and of sufficient robust state to resist damage from touching; thus tack-free time is a diagnostic time that characterizes cure. Various studies completed by manufacturers show that during spraying of a one component foam, MDI levels are non-detectable to thousandths less than the OSHA PEL of 0.20 mg/m3 (Fishback, 2012). There is no data to suggest that dust from these applications contains unreacted chemicals when properly applied. To protect consumers, these products have precautionary labeling in accordance with FTC/CPSC and FHSA requirements.

Pg. 10 - Diisocyanates are known to undergo thermal degradation and release toxic chemicals.

<u>Comment:</u> The Department has misquoted the source regarding thermal degradation. The source for this statement is referring to polyurethanes, not diisocyanates, undergoing thermal degradation.

The source that the Department is citing for the statement above is the CPI guidance document, "Polyurethanes and Thermal Degradation" (ACC, 2014). This document highlights the toxic products that may be of concern when polyurethanes are thermally degraded, and some worker safety and health precautions to consider. The Department has misquoted the document and should instead state the following, "When polyurethanes undergo thermal degradation, some potentially hazardous chemicals may be emitted." The source is available at: http://polyurethane.americanchemistry.com/Resources-and-Document-Library/6936.pdf .

Pg. 12 - Antibodies to TDI have been detected in some residents living near a facility that manufactured polyurethane foam, indicating that exposures may be occurring from environmental releases from the plant and sensitizing some individuals (Orloff et al., 1998; Darcey, 2002).

<u>Comment:</u>. The potential for community exposure to diisocyanates used in the industrial setting has been studied and no demonstrated potential for exposure has been observed. Furthermore, TDI is not used in SPF systems. Therefore, all references to the chemical as a component of SPF should be removed from the Priority Product Profile.

In 2007, the North Carolina Department of Health and Human Services (NCDHHS) and the Agency for Toxic Substance and Disease Registry (ATSDR) conducted a joint study of environmental exposure to TDI and potential community health effects. Data were collected from ten NC communities in four counties. Half were communities near facilities with reported TDI emissions (target areas) and half were communities where no TDI emissions were reported (comparison areas). The study results were released in May 2010 and did not find any significant health-related concerns associated with communities near plants using TDI. State and federal researchers concluded, "[w]e did not find a scientific connection between respiratory problems and exposure to TDI…Overall, we did not find that people living near the plants that emit TDI have recent or current exposure to TDI at levels of health concern." The publication on this study by Wilder et al. (2011) concluded that "[o]verall, air sample and antibody test results are not consistent with recent or ongoing exposure to TDI." The DTSC Priority Product Profile should be updated to reflect the findings from this study. The full TDI Community Health Report can be found online at: http://www.epi.state.nc.us/epi/oee/tdi/TDICommunityHealthReport.pdf.

In March 2009, EPA initiated its School Air Monitoring Project that monitored the air in 22 states around 62 schools that were located near industrial facilities or in urban areas. Seven schools in six states were selected for diisocyanates air monitoring. EPA released analyses for 5 of the 7 schools, concluding that diisocyanates were non-detectable and well below levels of concern. Therefore, EPA is no longer monitoring at those schools. For 2 of the 7 schools, which are located a ½ mile apart in the same city, results are still pending. EPA has decided to continue

air monitoring at these schools once the nearby facility is operating at a level closer to normal capacity. More information can be found on EPA website: www.epa.gov/schoolair.

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

Pg. 12 - Carcinogenicity of TDI: Most authoritative bodies generally accept that TDI is a reasonably anticipated human carcinogen (WHO, 1987; IARC, 1999; NIOSH, 2006). Oral exposure to TDI results in TDI hydrolysis in the gut, thereby generating toluene-2,4-diamine (TDA), a carcinogen. These oral route studies found that TDI exposure caused tumors at several different tissue sites in rats and mice (Timchalk et al., 1994; OEHHA, 2009, 2010).

Comment: TDI is not used in SPF systems. Therefore, all references to the chemical as a component of SPF should be removed from the Priority Product Profile. Furthermore, there is no evidence that TDI is carcinogenic in humans. Three epidemiological studies representing the combined long-term mortality experience of more than 17,000 polyurethane foam production workers, did not find an association between occupational exposure to diisocyanates and an increased risk of cancer. Inhalation exposures of rodents to TDI, the most relevant route of exposure, are not carcinogenic. Lifetime inhalation exposures of rats and mice to TDI vapor (150 ppb) did not elicit a carcinogenic response. Rodents tumors were observed only when contaminated TDI was administered by an aphysiological route (gavage) that favored the formation of a known rodent carcinogen (TDA), a reaction not known to occur under normal exposure conditions.

The claim that TDI is carcinogenic lacks foundation. In humans, three epidemiological studies with updates, representing the combined long-term mortality experience of more than 17,000 polyurethane foam production workers, failed to find an association between occupational exposure to diisocyanates and an increased risk of cancer (Hagmar et al., 1993a and 1993b, updated by Mikoczy et al., 2004; Schnorr et al., 1996; Sorahan and Pope, 1993, updated by Sorahan and Nichols, 2002).

In combined chronic inhalation toxicity and carcinogenicity studies, male and female rats, as well as male and female mice, were exposed for 6 hours/day, 5 days/week for approximately 2 years to TDI (80/20) vapor concentrations of 0, 5 or 150 ppb. Histopathology of the organs/tissues investigated showed that the type and incidence of tumors and the number of tumor-bearing rats were similar in both control and TDI treated groups. In summary, TDI was not carcinogenic in rats and mice after long-term inhalation to vapor concentrations of up to 150 ppb. Lifetime inhalation exposures of rats and mice to TDI vapor (150 ppb) did not elicit a carcinogenic response (Löser, 1983; Owen, 1984), despite the lesions noted in the upper and lower respiratory tract at this maximum tolerated concentration. The claim that TDI is carcinogenic is based on the increased tumor incidences observed by the NTP (1986) when TDI in corn oil was administered directly into the stomach of rodents by oral gavage. However, this study was flawed both technically (i.e., mishandling of the test material) and conceptually (i.e., gavage exposures) resulting in the formation of toluene diamine (TDA), a known animal carcinogen, both prior to and after TDI administration (NTP, 1986, Appendix I, Dieter et al.,

1990). Given the qualitative similarity between the carcinogenic responses seen in rodents exposed to TDI and TDA (NCI, 1979), the NTP (Dieter et al., 1990) concluded that the degradation of TDI to TDA could explain the carcinogenic effects noted with TDI. Quantitative support for this conclusion comes from two studies. In the first (Timchalk et al., 1994), rats were gavaged with either 60 mg/kg TDI in corn oil (same dose as used by NTP) or 3 mg/kg TDA. Urinary analyses indicated that both produced comparable metabolic profiles of free TDA, N-acetylated TDA, and TDI/TDA conjugates. This finding is consistent with about 5% of the TDI gavage dose (i.e., 3 mg/kg of the 60 mg/kg TDI dose) being converted to TDA. In the second (Sielken et al.,2012), a statistical comparison of the carcinogenic responses seen with TDI (NTP, 1986) and TDA (NCI, 1979) support the conclusion that the carcinogenic responses to TDI are consistent with 5% of the gavaged TDI being transformed to TDA either before and/or after exposure. The NTP (Dieter et al., 1990) dismissed concerns over its flawed study by stating that TDA would be similarly formed if exposures occurred via inhalation. This misconception persists in the scientific community despite data to the contrary.

The reactivity of TDI and its propensity to form TDA is different in pure aqueous versus complex biological systems. Whereas the formation of ureas and polyureas is the predominant reaction pathway in water at neutral pH, conjugation with biomolecules dominates in complex biological systems (Day et al., 1997; Mormann et al., 2006; Seel et al., 1999). The reactions of TDI in biological systems can be influenced by the pH of the *in vivo* environment. The pH neutral and macromolecule-rich environments associated with physiological exposures (i.e., inhalation, dermal, buccal) to TDI favor conjugation with macromolecules with no detectable free TDA (Mormann et al., 2006; Rosenberg and Savolainen, 1985; Timchalk et al., 1994). In contrast, the introduction of TDI directly into the acidic environment of the stomach (i.e., bolus dose by gavage) favors the formation of free TDA, which can be detected systemically (Jeffcoat, 1988; Kennedy and Brown, 1998; Timchalk et al., 1994). A testament to the influence of pH on the conversion of TDI to TDA is the laboratory practice of using acid hydrolyses to convert TDI/TDA conjugates in biological fluids to free TDA (Skarping et al., 1994). The *in vivo* conversion of TDI to TDA and the subsequent induction of a carcinogenic response only under aphysiological (i.e., gavage) exposure conditions is consistent with the observations that (a) the absence of epidemiological evidence of carcinogenicity in TDI exposed workers, (b) free TDA was not detected in the urine of TDI exposed workers before subjection to acid hydrolysis (Skarping et al., 1994), (c) the absence of carcinogenic effects in rodents exposed to TDI vapors at a maximum tolerated concentration of 150 ppb (30-fold higher than the ACGIH TLV), and (d) free TDA was not detected in rats following a 6-hour inhalation exposure to TDI vapor at 2 ppm (Timchalk et al., 1994), a concentration 400-fold higher than the TDI TLV.

In conclusion, there is no evidence that TDI is carcinogenic in humans or animals under physiological exposure conditions. Furthermore, since TDI is not used in SPF systems, we request all references to the chemical as a component of SPF be removed from the Priority Product Profile.

Pg. 12 - The polyurethane industry fully recognizes the hazardous nature of the SPF systems (ACC, 2014b). Through the American Chemistry Council and industry alliances and trade

associations, the industry has developed training materials and health and safety guidance for workers (ACC, 2014c; CPI, 2014).

Comment: The fundamental principle of toxicology is "the dose makes the poison," accepting that everything can be toxic at some dose. It is also well accepted that everything can be used in a safe manner. Health and safety are priorities for the polyurethanes industry, as evidenced by our commitment to product stewardship activities and our partnership with other user groups and associations and our ongoing efforts to provide information and conduct research regarding our products. Industry has been working with federal agencies for several years to improve the dissemination of product stewardship information on the safe use and handling of our products. The American Chemistry Council (ACC) Center for the Polyurethanes Industry (CPI) provides a number of guidance documents on safety considerations when using SPF as well as health and safety training programs.

In addition, the CPI Spray Foam Coalition, a group representing about 90% of the manufacturers of SPF systems in the U.S., has recently approved a Code of Conduct that further demonstrates the member companies' commitment to the safe use of SPF throughout the value chain and helps provide a framework to drive continuous improvement in chemical health and safety and product stewardship. This is the first commitment of its kind in the SPF industry. The Code of Conduct is available here: http://polyurethane.americanchemistry.com/Spray-Foam-Coalition/Spray-Foam-Coalition-Code-of-Conduct.pdf.

Pg. 12 – Frequent violations have occurred and been documented for the Occupational Safety and Health Administration (OSHA) regulated workers (Rundman, 2013).

Comment: We believe this statement is misleading because isocyanate-related violations are not frequent.

Under the NEP, we have only been aware of one violation for a facility being above the PEL. Other violations have been for programs like hazard communications, PPE, and respirator standard. These sorts of violations are common in many OSHA inspections.

Pg. 13 - Inhalation exposures in excess of the OSHA permissible exposure limit have been documented among workers during spray-on applications of truck bed liners, foam roofs, and insulation foam (NIOSH, 1996a, 2005, 2006; U.S. EPA, 2011b; Karlovich, 2010; Hosein and Farkas, 1981; Crespo and Galan, 1999; Lesage et al., 2007).

Comment: The reference to the Karlovich paper to support the statement that "inhalation exposures in excess of the OSHA permissible exposure limit have been documented" is completely inaccurate.

The reference to the Karlovich paper to support the statement that "inhalation exposures in excess of the OSHA permissible exposure limit have been documented" is completely inaccurate The paper did not in fact report any overexposure to an OSHA PEL. We ask that this reference be removed from the Product Profile Document as it does not support the statement. Furthermore, we urge the Department to remove any references to other polyurethane

applications such as truck bed liners (TBL) as that is outside the scope of the document. TBL is a completely different application than SPF and should not be used to characterize SPF.

Pg. 13 - Dermal exposure has been associated with isocyanate sensitization and/or asthma, even when airborne isocyanate concentrations were below occupational exposure levels (U.S. EPA, 2011a, b).

<u>Comment:</u> Diisocyanates can cause allergic contact dermatitis (dermal sensitization) but it appears to be a rare occurrence. The role that dermal contact with diisocyanates plays in the development of occupational asthma remains unresolved for humans. Regardless of the route of induction of "sensitization," inhalation exposures are necessary to exhibit a respiratory response. MDI has low volatility and is not available as respirable particles unless heated or sprayed.

Diisocyanates are considered as dermal sensitizers and can cause allergic contact dermatitis in some individuals. It appears to be a rare event, however, as there are minimal case reports of diisocyanate contact dermatitis. The ability of diisocyanates to induce respiratory sensitization in some individuals, and asthma in some cases, is also a known potential adverse health effect in humans after inhalation exposure to concentrations above workplace exposure limits. Although there is still no validated experimental animal model accepted by regulatory agencies that adequately reflects the respiratory sensitization process and constellation of symptomology associated with occupational diisocyanate asthma, several researchers have shown respiratory changes (e.g., alterations in respiratory rate, non-specific hyperreactivity, influx of inflammatory cells) and/or antibody production in animals after dermal induction exposure and subsequent inhalation challenge with MDI or TDI. (e.g., Pauluhn and Poole 2011; Rattray et al.; 1994**,** Pauluhn, 1994**;** Pauluhn and Mohr, 1994; Pauluhn, 1995; Blaikie et al 1995).

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

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

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

Pg.14 - TDI may be found in SPF systems either as a minor component or as a residual constituent. For Example, TDI is declared in the MSDS of one manufacturer in California (UPI Inc., 2012)…Some SPF systems on the market today are SPF systems containing polyurethane based coatings, sealants, or adhesives which are likely to contain TDI. For this reason, TDI is included in this Priority Products listing.

<u>Comment:</u> The UPI MSDS cited in the Priority Products List is for a polyurethane construction coating, which is not an SPF application.

The UPI MSDS cited in the Priority Products List is for a polyurethane construction coating, which is not an SPF application. The product is a single-component, liquid-applied polyurethane waterproofing coating used as a base coat in most of UPI's polyurethane deck and roof coating systems. TDI is not used in SPF systems and therefore all references to TDI should be removed from the Priority Product Profile.

Pg. 14 Worker Exposures: Potential for exposure to isocyanates comes from inhalation of or dermal contact with the material in these ways (Petsonk et al., 2000; NIOSH 2006; U.S. EPA, 2013b, 2013c, and 2014; Rundman, 2013): Dust that may contain unreacted isocyanates, generated from cutting or trimming the foam as it hardens… Degradation products, including isocyanates, from heat-generating processes such as drilling, welding, soldering, grinding, sawing, or sanding on or near foam insulation… Isocyanates and other toxic chemicals release during fires (Blomqvist, 2005; Karlovich et ..al., 2011).

<u>Comment:</u> In a study conducted by the ACC Center for the Polyurethanes Industry, data on the potential for dust, MDI, and pMDI generation during the trimming of open-cell and closed-cell insulation foams was gathered. In all cases MDI and pMDI were not detected. In addition, the industry has published a guidance document and warning signs that describe fire protection measures to avoid heat-generating processes to prevent overheating and combustion of SPF. The Blomqvist 2005 reference simply mentions the possibility of isocyanate release during polyurethane combustion.

A study was initiated to evaluate the potential exposure of workers to inhalable and respirable particulates, as well as MDI and pMDI, during the post-application trimming and cutting of open cell and closed cell SPF insulation in interior applications. This study employed a written protocol under controlled laboratory conditions designed to simulate an extreme case trimming situation.

SPF insulation was applied to sections of timber drywall assemblies to simulate actual interior wall application. Extra spray was applied so that the resulting foam extended well past the studs to provide adequate foam to lengthen times for trimming and cutting in this study. Once the wall sections had cured for 1-2 hours, short-term (11-17 min) task personal exposure sampling and source air sampling was conducted during trimming and cutting. Various trimming tools, categorized as "low" or "high" dust potential, were used for both types of foam. In all cases MDI and pMDI were not detected. (M. Spence, C. Graham; Evaluation of Particulates Generated During Trimming and Cutting of Spray Polyurethane Foam Insulation, CPI Conference Paper,

2010 *available at*: http://polyurethane.americanchemistry.com/Resources-and-Document-Library/Evaluation-of-Particulates-Generated-During-Trimming-and-Cutting-of-Spray-Polyurethane-Foam-Insulat.pdf).

CPI has published a guidance document on SPF fire safety titled "Fire Safety Guidance: Working with Polyurethane Foam Products During New Construction, Retrofit and Repair" to specifically address fire protection of foams during heat generating processes (*Available at*: http://polyurethane.americanchemistry.com/Resources-and-Document-Library/11365.pdf) (ACC, 2011). SPFA has also published ANSI/OSHA compliant warning signs to be posted at all jobsites to warn other workers about potential fire hazards of exposed foam. Drilling, grinding, sanding and sawing operations are highly unlikely to generate enough heat to initiate any substantial isocyanate emissions.

The Blomqvist 2005 thesis paper (cited in the DTSC Priority Product Profile) focuses on measurement of standard combustion by-products from organic materials, such as CO, HCl, HCN, CO_2 and NO_x. Diisocyanates were only mentioned in passing and the thesis does not provide any quantitative isocyanate release data, nor does it specify the source polyurethane materials of concern for isocyanate release. Further, a paper measuring the toxic combustion by-products and oxygen depletion released from a variety of polyurethane products including foams shows that the release profile (LC50) from these materials is not significantly different than that of burning wood (Landry et al., 2007).

Finally, the reference to the Karlovich et al 2011 paper to support the statements regarding dust generation and the formation of degradation products from heat-generating processes is inappropriate. There is no mention of these items in the referenced document. We ask that this reference be removed from the Product Profile Document as it does not support the statements.

Pg. 15 - Long-time researchers of isocyanates and asthma have become concerned about the potential relationship between isocyanates in consumer products, including SPF, and the increasing prevalence of asthma in the general population, especially children, and point to the urgent need for further research (Krone and Klingner, 2005).

<u>Comment:</u> Exposure of adults and children to diisocyanates in everyday life from fully cured products, such as SPF, is not supported by the evidence. Diisocyanates are not released from SPF in normal and correct use. Thus, the emphasis on a unique health concern affecting children potentially exposed to diisocyanates is not supported by scientific evidence.

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

response are more active or efficient in children. That is, a comparison of age-dependent toxicities based on lung surface area to body mass is an inappropriate metric for diisocyanate toxicity. The chemical reactivity of diisocyanates results principally in portal-of-entry toxicity with no reproducible evidence of systemic adverse health effects. Thus, it is dose per unit area of exposed skin or lung epithelial surface that determines toxicity. Age-related pharmacodynamics that relate to the etiology of allergic dermatitis or asthma are not well understood for diisocyanates.

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

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

In conclusion, exposure of people and children to diisocyanates in everyday life from fully cured products, such as SPF is not credible, as diisocyanates would not be released from SPF in normal and correct use. Thus, the emphasis on a unique health concern affecting children potentially exposed to diisocyanates is not supported by scientific evidence. Notably, children live safer, healthier lives thanks in part to the development of many products and technologies made with diisocyanates chemistry that improve public health and safety.

Pg. 15 - Although there is much evidence relating adverse health effects on workers to diisocyanate exposures, the evidence of harm to the general public and consumers is more limited. However, extrapolation from what is known about occupational exposure risks to the less-protected settings in which wet SPF is used by independent contractors and DIYers indicates a high potential for adverse exposures to diisocyanates among the general population during the use of this product. A recent study found that rising use of isocyanate-based materials in consumer products is leading to an increased burden of disease, with an increase in nonoccupational exposure (Verschoor and Verschoor, 2014).

<u>Comment:</u> A review of the Verschoor and Verschoor paper reveals a number of inaccuracies and false assumptions. The use of this review article as a basis for determining health effects is flawed.

The Department is using a secondary reference instead of reading and referencing the primary references which would not lead to the same conclusions. The Verschoor and Verschoor (2014) paper is a review and personal opinion paper on exposure. No new or convincing data is presented. Most references are misquoted, taken out of context, or completely inaccurate. A comprehensive and detailed "Letter to Editor" will be offered to the journal. At the time of submission, ACC will share the individual details. In the meantime, it is highly recommended that the Department obtain the primary references and review the information to correct the Product Profile.

Pg. 16 - There are also anecdotal reports of strong odors and physiological reactions (headaches, dyspnea) following installation of insulation in various settings (Green Building Advisor, 2010).

<u>Comment:</u> This is an anecdotal report and not a peer-reviewed research paper, and provides no scientific evidence on isocyanate exposure to building occupants. Odors inside a building can come from many sources if minimum indoor ventilation rates are not achieved.

MDI is an odorless chemical and it is therefore highly likely that the odors cited in this article were from other sources. The presence of odors inside a building is very subjective, and is strongly dependent on an individual's olfactory sensitivities. Humans can detect odors of many chemical compounds at levels far below safe exposure limits. In terms of SPF application in buildings, ventilation of the spray zone for a few hours after spraying can eliminate these odors in most cases. In addition, the air sealing feature of SPF will dramatically reduce air leakage in a building to levels below the natural ventilation minimum of 0.35 ACH_n recommended by ASHRAE 62.1. Without minimum ventilation, emissions from many other sources can accumulate within the building. When SPF is installed, a common practice is to perform an air leakage test of the building after installation to determine if minimum ventilation rates are achieved or if additional mechanical ventilation is needed.

Pg. 16 - Incidental exposure to MDI and xylene caused asthma-like symptoms in 203 students in Taiwan, where students from two adjacent schools were exposed to MDI and xylene (Jan et al., 2008).

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

The Department assumes that purported asthma-like symptoms observed in school children were due to a MDI exposure (Jan et al., 2008). However, the reported symptoms (dizziness, nausea, sore throat, and breathing difficulties) are more likely attributable to xylene, a known CNS depressant and upper respiratory tract irritant that was used as a solvent for the applied MDI. This theory is based on the following: (a) air monitoring was not conducted for either volatile organic compounds or MDI, and (b) despite the claim by Jan and coworkers, an earlier work referenced by the authors did not detect MDI near polyurethane tracks up to a week after application. Examination of another reference (Chang et al., 1999) reveals no mention of MDI measurements. Further supporting an absence of an exposure to MDI is the determination that no MDA was detected in the hydrolyzed urine of school children purportedly exposed to MDI.

The sizeable difference in volatility between xylene and MDI, the high xylene content compared to MDI in the applied product (0.1% MDI in xylene), as well as the symptoms consistent with xylene or other solvent exposure, indicate that the symptoms observed were most likely due to the inhalation of xylene.

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

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

***Pg. 19-20 - Recent research has focused on the development of non-isocyanate chemistries especially for polyurethane adhesives, sealant and coatings, such as soy-based polyurethane (Javni et al., 2008), and linear or network non-isocyanate-based polyurethane (NIPU) produced by reaction of cyclocarbonate resins and amines (Figovsky and Shapovalov, 2006)…There exist very few isocyanate-free alternatives in the rigid spray foam market. The only reported commercialized product is an isocyanate-free expanding foam product for insulation applications utilizing a hybrid silane terminated polymer technology (Soudal,* **2010).**

<u>Comment:</u> There is currently no known substitute of the use of isocyanates to produce rigid SPF insulation and roofing that provides the qualities required for these applications.

There is currently no known substitute that would function as an appropriate alternative to the use of isocyanates to produce rigid SPF insulation and roofing that provides the qualities required for these applications. The unique qualities of SPF insulation and roofing include

consistently higher energy efficiency through thermal performance under a wide range of temperatures and low air permeability (air barrier material), low moisture transmission (vapor retarder material), low water absorption* (FEMA flood resistant material), improved physical strength and stiffness* (structural enhancement), adhesion to substrates and long-term durability. **Closed-cell SPF only.*

The technology described by Figovsky may have some applicability in the coatings area as curing at elevated temperatures can be more easily achieved. Its use in the rigid foam area appears extremely limited due to the reported difficulties in obtaining a fast curing system. Additionally, the technology described by Soudal is intended for one-component foam and does not meet the requirements for SPF.

Pg.18 - The ACGIH is proposing a TLV-TWA of 0.001ppm for TDI, and a 15-Minute STEL of 0.003 ppm, and lists the basis for the TLV as being "Asthma."

<u>Comment:</u> TDI is not used in SPF systems. Therefore, all references to the chemical as a component of SPF should be removed from the Priority Product Profile. Furthermore, based on the available information, the current ACGIH limits are sufficiently protective of workers. ACC does not believe that a reduction in the TLV-TWA or TLV-STEL is supported by the available science, or that such reductions will reduce the incidence of occupational asthma.

ACC has submitted extensive scientific information to ACGIH explaining the Panel's position that the proposed TLV values are not justified by the evidence and that the existing values are sufficiently protective of workers. The Panel does not believe a reduction in the TLV-TWA or TLV-STEL is supported by the science, or that such reductions would reduce the incidence of occupational asthma. The Panel's previous comments have discussed the following:

1) <u>No New Scientific Information.</u> The ACGIH Notice of Intended Changes (NIC) levels are not based on any new information that ACGIH did not have when it evaluated TLV levels for TDI in 2004. The draft documentation does not present any new scientific data that demonstrate a need to lower the TLVs.

2) <u>Unsupported Rationale</u>. The rationale for lowering the TLV-TWA reflects a belief that lowering the TLV the last time resulted in reduced incidence of occupational asthma, and a supposition that lowering the TLV again should lead to further reductions in occupational asthma. No empirical support for that first proposition is presented in the draft documentation. Nor is any scientific evidence presented to support the supposition that a further reduction in the TLV would lead to a further reduction in occupational asthma.

3) <u>Technical Feasibility of Monitoring at Lower Levels Using Direct Reading Instruments</u>. Direct reading instruments (DRIs) are commonly used to assess airborne concentrations of TDI because of their ability to provide a quick evaluation of the potential inhalation hazard in the work environment. The proposed TLV values push the limits of technology for monitoring compliance when using DRIs. For example, it may be possible to measure compliance with the proposed TLV-TWA (8-hour value) using passive

samplers, but it would not be possible to measure to the proposed TLV-STEL based on the current detection range of these devices.

In conclusion, ACC believes that based on available information, the current ACGIH limits are sufficiently protective of workers. ACC does not believe a reduction in the TLV-TWA or TLV-STEL is supported by available science, or that such reductions will reduce the incidence of occupational asthma.

Pg. 18 - In addition, ACGIH has published a "Biological Exposure Index" for TDI based upon toluene diamine in urine, collected at the end of the work shift.

<u>Comment:</u> TDI is not used in SPF systems. Therefore, all references to the chemical as a component of SPF should be removed from the Priority Product Profile. Furthermore, the ACGIH rationale for the Biological Exposure Index (BEI) for TDI is scientifically flawed and should instead address the importance of using a specific biomarker of TDI exposure.

ACC has submitted extensive comments questioning the scientific validity of the development of a Biological Exposure Index for TDI based upon toluene diamine in urine. Previous comments have discussed the following:

1) <u>TDA is not an Expected Metabolite of TDI in Humans</u>
   Under normal physiologic exposure conditions, the formation of free TDA from TDI has not been demonstrated *in vivo*. The text in the draft documentation of the BEI for TDI that refers to the presence of free TDA in the metabolic scheme of TDI should be revised to accurately reflect the current understanding of TDI metabolic pathways.

2) <u>Non-Specificity of the Proposed Biomonitoring Method</u>
   The inability to specifically assess TDI exposure and to differentiate TDI from TDA exposures is considered a limitation of this method. This limitation downgrades the use of this biomonitoring method as a screening or surveillance tool and does not permit a more definitive and quantitative assessment of exposure to TDI.

3) <u>Specific Biomarkers of TDI Exposure are Available</u>
   A TDI-specific biomonitoring method such as that based on albumin conjugates are available and should be considered rather than the non-specific urine hydrolysis method.

4) <u>Description of the Recommended Analytical Method Should be Expanded</u>
   Additional details of the proposed analytical method should be provided along with validation of the procedure before it is adopted for use as a biomonitoring method to screen TDI workers for potential exposure.

5) <u>Non-Occupational Exposure to TDI is Very Limited</u>
   TDI-based products should not be listed as sources of non-occupational exposure. Further, the BEI Documentation inaccurately mentions several product types that may

represent sources of non-occupational exposure to TDI. These product types (e.g., SPF, one-component foams) contain MDI, not TDI, therefore do not present opportunities for non-occupational exposure to TDI.

6) References to Urinary TDA in the Documentation Require Qualification
To prevent a misinterpretation of the text in BEI documentation, we strongly recommend that each reference to "TDA in urine" or "plasma TDA" or "TDA elimination in urine" or similar statements be qualified to indicate that the urine was hydrolyzed prior to measurement of TDA levels. This is to preclude a reader from mistakenly assuming that such statements indicate the presence of free TDA in workers.

7) Basis of a Proposed BEI for TDI Should be the Current TLV
Any proposed BEI for TDI should be based on the current 8-hour TWA of 5 ppb and not in anticipation of a proposed change to the TLV to 1 ppb.

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Appendix 1

Are Diisocyanate Occupational Asthma Cases Declining?
Poster Presented at the Isocyanates and Health Conference
Potomac, Maryland, April 3-4, 2013

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Are Diisocyanate Occupational Asthma Cases Declining?

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Study Objective

To review recent publications and Surveillance databases in order to evaluate trends of diisocyanate-related occupational asthma (OA).

BACKGROUND

Diisocyanates are often cited as a leading cause of occupational asthma. We reviewed trends of diisocyanate-related OA in order to evaluate the effect of compliance with current occupational exposure limits aimed at preventing new cases.

METHODS

A literature search was done on recent publications. Information was gathered from national or state/province-based registries, surveillance schemes and compensation statistics of various metrics for rates of diisocyanate-related occupational asthma. European manufacturer data on occupational asthma incidence (unpublished data) was collected. Data was reviewed to assess possible trends.

RESULTS

USA, Center for Disease Control (CDC) Work-Related Lung Disease Surveillance System (eWoRLD):

The categories for Diisocyanates n.o.s. (221.00), TDI (221.01), MDI, (221.02), and HDI (221.04) were included for the years 1993-1999, 1993-2002, and 1993-2006. Unfortunately these numbers include work-aggravated asthma cases, reactive airways dysfunction syndrome cases, and confirmed but unclassified cases which may not be diisocyanate asthma.

An average of 30.7 cases per year have been reported during 1993-1999, which dropped to 21.33 cases per year during 2000-2002, and to 20.75 cases per year during 2003-2006.

Years	Number of cases	Number of new cases	New Cases per year
1993-1999	215		30.7
1993-2002	279	64	21.33
1993-2006	362	83	20.75

Michigan, USA:

MICHIGAN'S PROJECT SENSOR publishes annual reports on work-related illness and specifically, work-related asthma (WRA) to isocyanates. Asthma rates of Diisocyanates have fallen from 22.9 cases per year in 1988-1997 to a recent 6.4 cases per year in 2005-2010.

(http://www.oem.msu.edu/AnnualReports.aspx)

Years	Number of cases	% of cases	Number of new cases	New Cases per year
1988 - 1997	229	19.4		22.9
1988 - 2000	295	18	66	22.0
1988 - 2005	351	14.6	56	11.2
1988 - 2010	383	12.7	32	6.4

Ontario, Canada:

Annual rates of successful isocyanate-related worker compensation claims for occupational asthma have been recorded in the Canadian Province of Ontario. A recent publication reports a reduced annual rate of successful isocyanate-related worker compensation claims comparing **30.5 occupational asthma claims/year** during 1980-1993 with **7.4 claims/year** during the period 1998-2002 (Buyantseva *et al*., 2011).

EU production sites for TDI:

No asthma cases were reported and only one case of other respiratory disease occurred during 2000-2005 in all TDI production plants (III, Unpublished data).

United Kingdom:

Data from the period 1989-1991 showed the proportion of occupational asthma ascribed to isocyanates as **22%** (McDonald *et al*, 2000), while during the period 1992 – 2001 the annual rate attributed to diisocyanates was consistent at about **14%** of all occupational asthma, or an annual average of **84 cases** (McDonald et al 2005). Data for 2008-2010 reports a decline to an average of **44 cases** per year (UK HSE 2011).

Netherlands:

For the years 2009-2011 isocyanate-related cases were reported as **none to 4** (Nederlands Centrum voor Beroepsziekten, 2012).

Switzerland:

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

France:

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

Years	avg #cases/year	% of all WRA
2001-2003	49	12.1
2004-2006	38.6	12.3
2007-2009	12.3	4.8

Germany:

Total Diisocyanate asthma cases recorded as 'new pension because of recognized occupational disease' show a decline over the last 16 years (DGUV).

Years	Average/year
1995 - 1999	47
2000 – 2004	26.6
2005 – 2010	17.3

CONCLUSIONS

Metrics on diisocyanate-related asthma rates indicate a significant reduction in reported cases. The data variability can be accounted for by the difference in source and method of diagnosis, which varies from patient's association of symptoms with work and a physician diagnosis of asthma (UK) to specific challenge testing (Canada and Germany). We emphasize the importance of exposure control and medical surveillance which various authors advocate as strong methods of prevention.

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Appendix 2

III Scientific Office

Critique of Jan et al. (2008)

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

Summary and Conclusion

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

Critique Details

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

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

- **Attribution of noted effects (CNS) to MDI** - Jan et al reports on acute respiratory symptoms following exposure to MDI and xylene.

They distinguish between immunologic and irritant-induced asthma or reactive airway dysfunction syndrome (RADS) and provide two references of previously reported MDI – induced RADS. Only one of the two actually involved MDI (Leroyer et al 1998) and interestingly enough this case also involved MDI mixed with a solvent. The exposure in the Jan paper was described to the raw material and not to MDI. The acute symptoms consisted of dizziness, nausea, sore throat, and breathing irregularities, symptoms associated with solvent exposure and specifically xylene, which is well known to cause acute to chronic CNS encephalopathy. MDI on the other hand, has not been associated with CNS symptoms, except in the presence of other confounders such as when mixed with solvents and other chemicals (Herbert et al 1995, Longley 1964), litigation cases (Reidy 1994) and a detailed review found no evidence of CNS effects of MDI exposure (Carson et al 2011). In conclusion, we do not believe that the health effects reported by Jan et al, can be linked to MDI exposure. In addition, local newspaper reports of the incident attributed the children's symptoms to xylene (per communication of Alex Xu, BASF via William Robert, BASF)

- **Misstatements concerning MDI concentrations** – in the abstract, the authors state, "In a simulation, we found the raw material used for tract (sic) surfacing, primarily MDI dissolved in xylene, to be present at a concentration (870 ppm w/w) more than 8000-fold the level defined as safe for a working environment". In the results section, the authors explain, "The raw material used for track surfacing was found to be primarily MDI dissolved in xylene at a concentration of 870 ppm w/w, by use of the reference Occupational Safety and Health Administration analytical method 42 [6], more than 8000-fold the recommended safe minimum inhalation concentration for a working environment [7]". It appears that the authors have a poor understanding of the application of OSHA occupational exposure limits (OELs). The OEL referenced is the NIOSH REL – 0.005 ppm (8-h TWA), 0.02 ppm (Ceiling) in air on a molar volume (i.e., v/v) basis. From the authors statement, I can only conclude that they somehow applied the OSHA Method 42 (1,2-pyridyl piperazine derivatization air monitoring filter method) to assay the composition of the bulk liquid solution (as further indicated by the weight basis designation (i.e., w/w), as would be typical for reporting liquid solution compositions). They apparently then proceeded to compare the liquid concentration with the air concentration somehow, although it is unclear how they arrived at the factor of 8000: 870 ppm / 0.02 ppm = 4100; 820 ppm / 0.005 ppm = 164,000; 820 ppm / 8000 = 0.1025 ppm.

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

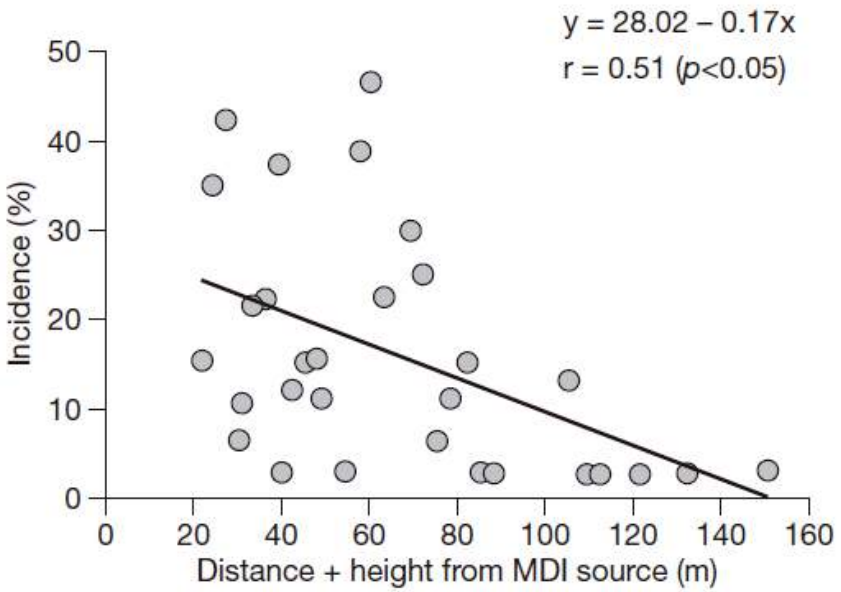

Fig. 2. Linear relationship between the incidence of affected students in various school classrooms and distance/height combinations from the suspected methylene diphenyl diisocyanate (MDI) emission source.

M Spence
M Collins
16 March 2012

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Appendix B

ACC NEP for Isocyanates Fact Sheet, Dated June 2013

OSHA's New National Emphasis Program for Isocyanates

American Chemistry Council
June 2013

Information about OSHA's New National Emphasis Program for Isocyanates[1]

The Occupational Safety and Health Administration (OSHA) National Emphasis Program (NEP) for isocyanates was developed to focus OSHA resources on occupational exposure to isocyanates. The Isocyanates NEP will combine enforcement and outreach efforts to raise awareness of employers, workers, and safety and health professionals of the health effects associated with occupational exposure to isocyanates.

Which industries are subject to inspection under the Isocyanates NEP?

OSHA stated that inspections under this NEP will target all workplaces under the jurisdiction of Federal OSHA, including general industry, construction and maritime industries where exposures to isocyanates are known or are likely to occur. Establishments with fewer than 10 workers will be included in this NEP. A list of relevant industries (by Standard Industrial Classification (SIC)/North American Industry Classification System (NAICS) codes) where isocyanates are to be used is in Appendix A of the NEP. Among the relevant industries are automotive, casting, building and construction, electricity and electronics, mechanical engineering, paints, plastics, printing, timber and furniture, textile, medical care, mining, and food industry.

What is OSHA's goal for the Isocyanates NEP?

According to OSHA, the goal of this NEP is to reduce employee exposure to isocyanates that potentially cause work-related asthma, sensitization (respiratory, skin) and other occupational health effects. OSHA plans to accomplish this by a combined effort of inspection targeting, outreach to employers, and compliance assistance.

What chemicals are covered by the Isocyanates NEP?

The NEP covers all isocyanates including methylene diphenyl diisocyanate (MDI), toluene diisocyanate (TDI), hexamethylene diisocyanate (HDI), methylene bis-cyclohexylisocyanate (HMDI) (hydrogenated MDI), isophorone diisocyanate (IPDI), naphthalene diisocyanate (NDI), HDI biuret, HDI isocyanurate, and methyl isocyanate (MIC).

What is the expiration date for the Isocyanates NEP?

The Isocyanates NEP became effective on June 20, 2013. The Isocyanates NEP will expire three (3) years from the effective date in 2016 and supersedes regional and local emphasis programs specifically targeting occupational exposure to isocyanates.

What are the anticipated inspection cycles?

OSHA Area Offices will create inspection cycles of five (5) or more establishments. Each OSHA Area Office is to conduct at least three (3) inspections per year. Subsequent cycles will be created in the same manner until the expiration of this NEP or until all establishments on the list have been assigned to a cycle.

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[1] *This information should not be viewed as the American Chemistry Council or industry's interpretation of federal statutory or regulatory requirements. If you need assistance with any interpretations, you should contact the agency involved or your own legal counsel.*

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What will OSHA inspect?

OSHA will inspect the employer's 1) injury and illness records to determine if injuries and illnesses related to isocyanate exposures have been recorded, including any work-related cases of asthma, 2) controls (engineering controls, administrative and work practice controls, and personal protective equipment (PPE)) where potential exposures to isocyanates are present, 3) hazard communication program, 4) methods for ensuring adequate housekeeping, and 5) compliance where chemical components of an isocyanate process or operation contain flammable or combustible materials.

Can OSHA expand the scope of the inspection?

The NEP states that an OSHA compliance officer may expand the scope of the inspection beyond the isocyanate-related work operations or activities if other workplace hazards or violations are observed and/or brought to their attention.

What happens when OSHA receives a complaint?

Complaints and referrals alleging worker exposures to isocyanates or involving workers with occupational asthma from isocyanates exposure or symptoms of exposure to isocyanates will be treated as having priority and handled by an inspection.

Are you exempt from inspections if you participate in an OSHA cooperative program?

Employers participating in cooperative programs may be exempt from programmed inspections, but refer to the NEP for more information. Examples include OSHA's Voluntary Protection Program (VPP) and the Safety and Health Achievement Recognition Program (SHARP). Establishments engaged in OSHA Strategic Partnerships (OSP) may also be exempt from programmed inspection or may qualify for a focused inspection (or limited inspection), the scope of which should be specified in the partnership agreement.

What is ACC's response to the Isocyanates NEP?

The isocyanates and polyurethanes industries are strongly committed to supporting the continued safe and responsible use of their products. These industries undertake extensive programs to educate and provide information about safety precautions to protect workers and consumer health and to provide information to help users of isocyanates comply with all regulations. Our organizations work with the value chains and provide extensive resources, including training opportunities, guidance documents and videos, and professional development courses for example, that can help facilities comply with OSHA requirements. We also partnered with OSHA in the past on worker safety efforts. The industry will continue to lead worker safety and product stewardship efforts and coordinate with OSHA on worker safety initiatives.

Where do I get additional information?

OSHA's NEP on isocyanates is available at http://www.osha.gov/OshDoc/Directive_pdf/CPL_03-00-017.pdf. For more information, contact Sahar Osman-Sypher, Director of the Diisocyanates and Aliphatic Diisocyanates Panels at ACC (Sahar_Osman-Sypher@americanchemistry.com, 202-249-6721), or Lee Salamone, Senior Director of the Center for the Polyurethanes Industry at ACC (Lee_Salamone@americanchemistry.com, 202-249-6604).

ACC Diisocyanates Panel: www.americanchemistry.com/dii
ACC Aliphatic Diisocyanates Panel: www.americanchemistry.com/adi
ACC Center for the Polyurethanes Industry: www.polyurethane.org

Appendix C

Summary of Industry IH Studies on MDI Exposure for Two-Component Low-Pressure SPF and Insulating Foam Sealants
-AND-
Residential Home Re-Occupancy and Ventilation after Crawl Space Sprayed with LP SPF, Presented at 2013 CPI Technical Conference

Summary of Industry Industrial Hygiene Studies on MDI Exposure during Use of 2-Component Low-Pressure Spray Polyurethane Foam Products and Insulating Foam Sealants

Attached is a compilation of industrial hygiene studies representing 58 measurements of applicator personal exposure to methylene diphenyl diisocyanate (MDI) and 92 area measurements of MDI air concentration taken during application of various insulating foam sealants and 2-component low-pressure spray polyurethane foam (LP SPF) products (Appendix A). These studies, which were conducted as part of the product stewardship programs of the companies that contributed them, use sampling techniques and analysis methods which are valid and typical for industrial hygiene monitoring of exposures to MDI. They are presented because their results give a general sense of exposure levels that can be anticipated during use of LP SPF products.

Because these studies are an aggregation of prior research with varied methodologies by the companies who provided this exposure data, they do not, for the most part, rise to the level of rigor and completeness that might be expected of a protocol-based research study designed to address all areas of concern. In addition, several contain some measurements that do not relate directly to product use (e.g., personal exposures of production line operators). The summarized results of the majority of these studies, along with an overview of the types and characteristics of LP SPF products, was presented and discussed by the Center for the Polyurethanes Industry of the American Chemistry Council during a webinar on December 1, 2009; the slides from that webinar are attached (Appendix B). Since that time, several additional industry studies have been contributed and are included in this summary.

Exposure Guidelines

The relevant exposure guidelines for MDI are:

- The OSHA PEL (Ceiling is equal to 200 µg/m3. According to 20 CFR 1910.1000, the PEL-C should not be exceeded during any part of the workshift. Concentrations measured during instantaneous (or short duration when instantaneous sampling is not feasible) are compared to the ceiling.
- The NIOSH REL (Ceiling) is equal to 200 µg/m^3 as a 10-minute time-weighted average (TWA). The measured average concentration over a 10-minute period is compared to the NIOSH REL (Ceiling), 10-minute.The ACGIH TLV® is equal to 50 µg/m3 as an 8-hour TWA. The measured average concentration over a worker's standard 8-hour shift is compared to the ACGIH TLV®.
- The NIOSH REL is 50 µg/m3 as a 10-hour TWA in a 40-hour workweek. The measured average concentration over a worker's standard 10-hour shift is compared to the NIOSH REL.

2-Component LP SPF Exposures

Two-component LP SPF products are primarily used as sprayed thermal insulation.

Of 31 personal task samples (approximately 15 minutes in duration) of application exposure during 2-component LP SPF application, the mean concentration of MDI measured was 23 µg/m^3 (range: 1.3-89 µg/m^3).

- All measured concentrations during 2-component LP SPF product exposures were well below the OSHA PEL (NIOSH REL)of 200 µg/m^3 (ceiling)

This contrasts markedly with the situation for similar 2-component ***high pressure*** SPF products (HP-SPF) which are used for commercially-applied sprayed insulation. A separate summary and review of MDI exposures during HP-SPF application has been conducted (Appendix C). That review showed that the mean of over 240 personal-task and TWA_8 samples representing applicator MDI exposures during application of various HP-SPF products was 577 µg/m^3 (range: 5-2100 µg/m^3).

Insulating Foam Sealant Exposures

Insulating foam sealant products are exclusively low-pressure, and are used as insulating foam sealants and adhesives. While technically SPF products, their application form is not really a "spray" – "bead" or "stream" is a better description of the application mode.

MDI was not detected in 13 samples in which applicators were monitored for MDI during application of insulating foam sealant products. The mean of the sample detection limits was 5 µg/m^3 (range: 2.5-16 µg/m^3).

Contrasts between High Pressure and Low Pressure 2-component SPF systems

While the chemistry and composition of high- and low-pressure 2-component SPF systems are very similar, there are several differences in characteristics that have significant impact on the potential for applicator inhalation exposure during use. The high-pressure SPF systems have operating pressures over 1000 lbs/in^2 and are machine-heated to delivery temperatures of 120-150°F, while the low-pressure have operating pressures of <250 lbs/in^2 and are unheated. High-pressure systems have delivery rates of up to 30 lbs/min while that for low-pressure systems is 5-7 lbs/min. The equipment used for mixing and spraying the two types of systems differs greatly as well. High-pressure systems use impingement mixing in a spray gun, while low-pressure systems use a nozzle with a static mixer to produce the spray. As a result of these differences, use of high-pressure 2-component SPF systems would be expected to produce higher potential for applicator exposure than use of low-pressure 2-component SPF systems.

Contrasts between 2-component Low-Pressure SPF systems and Insulating Foam Sealants

There are several differences between the 2-component low-pressure SPF systems and insulating foam sealant products that result in lower expected applicator inhalation exposures for insulating foam sealants.

- The most significant difference is the fact that insulating foam sealants are exclusively applied as a bead or stream rather than a spray. This form of application offers no practical opportunity for aerosolization of the product, leaving vaporization as the only route for producing air concentrations. The lack of aerosolization with insulating foam sealants also contributes to a reduced potential for dermal exposure since droplet deposition on skin or surfaces is not a factor. This is true even though the insulating foam sealant formulations have an excess of MDI (~15%) and slower cure times (~20 min versus <1 min) compared to 2-component low-pressure SPF.

- Another significant difference is that the insulating foam sealant systems utilize a prepolymer that is 'pre-reacted' within the container prior to application. This factor reduces the amount of MDI available during application of the low pressure bead or stream.

APPENDIX A

Clayton Studies

JOHN A. JURGIEL & ASSOCIATES, INC.

Industrial Hygiene & Safety Consultants *Since 1978*

April 22, 2009

Mr. Jay Zhang
Technical Manager
Clayton Corporation
866 Horan Drive
Fenton, MO 63026-2416

Re: Industrial Hygiene Sampling for MDI
April 15, 2009

Dear Mr. Zhang:

The attached report contains a summary table of the methylene bisphenyl isocyanate (MDI) sampling results conducted at the Fenton facility on April 15, 2009. A total of nine air samples were collected in conjunction with the three tests for different urethane foam products. A combination of personal and area samples were collected, four personal and five area.

All nine sample results were non-detected for airborne vapors of MDI, that is less than the analytical detection levels. The analytical detection level is dependent on the sample volume, which in turn is dependent on the sampling period. The specific detection limit for each sample is listed in the parentheses.

The specific detection limit was less than the OSHA PEL for MDI of 0.02 parts per million (ppm) and the ACGIH TLV of 0.005 ppm.

Separate reports for each test have been prepared. Please contact us if you have any questions.

Very truly yours,

John A. Jurgiel, CIH
President

JAJ/jah

1810 Craig Road , Suite 207 St. Louis, Missouri 63146 Phone: 314-878-8666 Fax: 314-878-0297

TABLE 1
Clayton Corporation
Summary Table of MDI Sampling Results
April 15, 2009

Sample Number	Location	Result (ppm)
C-1	Touch n' Foam - No Warp Window and Door Sealant Area 3 feet from Spraying Area	ND(0.00065)
C-2	Touch n' Foam - No Warp Window and Door Sealant Area 3 feet from Spraying area	ND(0.00016)
C-3	Touch n' Foam - No Warp Window and Door Sealant Area 3 feet from Spraying Area	ND(0.000081)
C-4	Touch n' Foam - No Warp Window and Door Sealant Personal Clyde Smothers	ND(0.00065)
C-5	Touch n' Foam - No Warp Window and Door Sealant Personal Clyde Smothers / Jeff Harris	ND(0.00016)
C-6	Touch n Foam Home Seal Minimum Expanding Sealant Area 3 feet from Spraying Area	ND(0.00065)
C-7	Touch n Foam Home Seal Minimum Expanding Sealant Personal Clyde Smothers	ND(0.00065)
C-8	Touch n Seal, Fire Break, Flame Resistant Sealant Area 3 feet from Spraying Area	ND(0.00065)
C-9	Touch n Seal, Fire Break, Flame Resistant Sealant Personal Clyde Smothers	ND(0.00065)
	OSHA PEL (ceiling level)	**0.02 ppm**
	ACGIH TLV (8-hr. TWA)	**0.005 ppm**

Notes:

1. Test runs were 15 minutes of continuous foam spraying.
2. None Detected (ND) at the analytical detection limit indicated in parentheses.

JOHN A. JURGIEL & ASSOCIATES, INC.

1810 Craig Road , Suite 207 St. Louis, Missouri 63146 Phone: 314-878-8666 Fax: 314-878-0297

JOHN A. JURGIEL & ASSOCIATES, INC.

Industrial Hygiene & Safety Consultants *Since 1978*

November 13, 2008

Mr. Jay Zhang
Technical Manager
Clayton Corporation
866 Horan Drive
Fenton, MO 63026-2416

Re: Industrial Hygiene Sampling
Test 2: Touch n' Seal Foam Kit and Touch N Foam Pro System 110/200/600
Large Room
November 3, 2008

Dear Mr. Zhang:

This letter and attached table will serve as our report of sampling for Test 2 conducted for airborne concentrations of methylene bisphenyl isocyanate (MDI) during spray application test runs for polyurethane formulations on November 3, 2008.

Sampling was conducted for 15 minute periods during which the foam was being sprayed continuously. A personal sample in the breathing zone of the sprayer and an area sample (5 feet behind the sprayer) were collected.

Sampling Methods
Samples were collected using SKC air sampling pumps calibrated to a flowrate of 1.0 liters per minute and 1-(2-pyridyl) piperazine treated glass fiber filters in open-face configuration. Samples for MDI were analyzed using high pressure liquid chromatography following the OSHA 42 protocol at the Bureau Veritas Laboratory in Lake Zurich, Illinois, an AIHA accredited laboratory. Sample results are summarized in Table 1.

Results and Discussion
This test was conducted in a large room with no exhaust ventilation. Sample results were less than the OSHA PEL of 0.02 ppm and ACGIH TLV of 0.005 ppm.

Please contact us if you have any questions.

Sincerely,

John A. Jurgiel, CIH
President

JAJ/jah
Enclosure

1810 Craig Road , Suite 207 St. Louis, Missouri 63146 Phone: 314-878-8666 Fax: 314-878-0297

TABLE 1
Clayton Corporation
Test 2: Air Sampling Results
Touch n' Seal Foam Kit and Touch N Foam Pro System 110/200/600
November 3, 2008

Sample Number	Time (min)	Name/Location	MDI (ppm)
C-3	15	Clyde Smothers, Sprayer	0.00094
C-4	15	Area, 5 ft. behind Sprayer	ND(0.00065)
		OSHA PEL (ceiling level)	**0.02 ppm**
		ACGIH TLV (8-hr. TWA)	**0.005 ppm**

Note:

1. None Detected (ND) at the analytical detection limit indicated in parentheses.

JOHN A. JURGIEL & ASSOCIATES, INC.

Industrial Hygiene & Safety Consultants *Since 1978*

November 13, 2008

Mr. Jay Zhang
Technical Manager
Clayton Corporation
866 Horan Drive
Fenton, MO 63026-2416

Re: Industrial Hygiene Sampling
Test 4: Touch n' Seal Foam Kit, 300 FR/1000 FR
November 3, 2008

Dear Mr. Zhang:

This letter and attached table will serve as our report of sampling for Test 4 conducted for airborne concentrations of methylene bisphenyl isocyanate (MDI) during spray application test runs for polyurethane formulations on November 3, 2008.

Sampling was conducted for 15 minute periods during which the foam was being sprayed continuously. A personal sample in the breathing zone of the sprayer and an area sample (5 feet behind the sprayer) were collected.

Sampling Methods

Samples were collected using SKC air sampling pumps calibrated to a flowrate of 1.0 liters per minute and 1-(2-pyridyl) piperazine treated glass fiber filters in open-face configuration. Samples for MDI were analyzed using high pressure liquid chromatography following the OSHA 42 protocol at the Bureau Veritas Laboratory in Lake Zurich, Illinois, an AIHA accredited laboratory. Sample results are summarized in Table 1.

Results and Discussion

This test was conducted in a large room with no exhaust ventilation. Sample results were less than the OSHA PEL of 0.02 ppm and ACGIH TLV of 0.005 ppm.

Please contact us if you have any questions.

Sincerely,

John A. Jurgiel, CIH
President

JAJ/jah
Enclosure

1810 Craig Road , Suite 207 St. Louis, Missouri 63146 Phone: 314-878-8666 Fax: 314-878-0297

TABLE 1
Clayton Corporation
Test 4: Air Sampling Results
Touch n' Seal Foam Kit, 300 FR/1000 FR
November 3, 2008

Sample Number	Time (min)	Name/Location	MDI (ppm)
C-7	15	Clyde Smothers, Sprayer	0.00013
C-8	15	Area, 5 ft. behind Sprayer	ND(0.00065)
		OSHA PEL (ceiling level)	**0.02 ppm**
		ACGIH TLV (8-hr. TWA)	**0.005 ppm**

Note:

1. None Detected (ND) at the analytical detection limit indicated in parentheses.

JOHN A. JURGIEL & ASSOCIATES, INC.

Industrial Hygiene & Safety Consultants *Since 1978*

November 13, 2008

Mr. Jay Zhang
Technical Manager
Clayton Corporation
866 Horan Drive
Fenton, MO 63026-2416

Re: Industrial Hygiene Sampling
Test 6: Touch n' Seal Foam Kit, Class 1 Flame Retardant
Refillable Systems, RF-17FR, RF-60FR, RF-120FR
November 3, 2008

Dear Mr. Zhang:

This letter and attached table will serve as our report of sampling for Test 6 conducted for airborne concentrations of methylene bisphenyl isocyanate (MDI) during spray application test runs for polyurethane formulations on November 3, 2008.

Sampling was conducted for 15 minute periods during which the foam was being sprayed continuously. A personal sample in the breathing zone of the sprayer and an area sample (5 feet behind the sprayer) were collected.

Sampling Methods

Samples were collected using SKC air sampling pumps calibrated to a flowrate of 1.0 liters per minute and 1-(2-pyridyl) piperazine treated glass fiber filters in open-face configuration. Samples for MDI were analyzed using high pressure liquid chromatography following the OSHA 42 protocol at the Bureau Veritas Laboratory in Lake Zurich, Illinois, an AIHA accredited laboratory. Sample results are summarized in Table 1.

Results and Discussion

This test was conducted in a large room with no exhaust ventilation. Sample results were less than the OSHA PEL of 0.02 ppm and ACGIH TLV of 0.005 ppm.

Please contact us if you have any questions.

Sincerely,

John A. Jurgiel, CIH
President

JAJ/jah
Enclosure

1810 Craig Road , Suite 207 St. Louis, Missouri 63146 Phone: 314-878-8666 Fax: 314-878-0297

TABLE 1
Clayton Corporation
Test 6: Air Sampling Results
Test 6: Touch n' Seal Foam Kit, Class 1 Flame Retardant
Refillable Systems, RF-17FR, RF-60FR, RF-120FR
November 3, 2008

Sample Number	Time (min)	Name/Location	MDI (ppm)
C-11	15	Clyde Smothers, Sprayer	0.00057
C-12	15	Area, 5 ft. behind Sprayer	0.001 ppm
		OSHA PEL (ceiling level)	**0.02 ppm**
		ACGIH TLV (8-hr. TWA)	**0.005 ppm**

Note:

1. None Detected (ND) at the analytical detection limit indicated in parentheses.

Dow Studies

2004 IH Study of OCF Adhesive

Study was done by a major isocyanate and OCF supplier at their facility

- Evaluated product contained ~ 15% PMDI supplied in a cylinder under 230-250 psi pressure
  - Note: Reflects 'worst case' scenario for consumer aerosol cans

- 3 scenarios were evaluated:
  - Sprayed two 23 lb cylinders into a 3'x4'x3' box with filter collection devices at edges. Over a 24 min collection period, found 8.7 and 5.1 ppb MDI respectively.
  - Sprayed continuously a 9'x8' sheet on the ground for 18 minutes. Filters located 18" above the ground inside a hood at the start of spray pattern and outside the hood, at the end of spray. The hood was not operational. A personal monitor was attached to the applicator. Area samples found 4.4 ppb inside the hood and 0.75 ppb outside the hood. Personal monitor found no detectable amounts; detection limit being 0.5 ppb.
  - Sprayed 3 times the normal amount of adhesive on a sheet for 11 minutes. Personal monitors on the applicator and an assistant whose filter was 18" off the ground found no detectable amounts; detection limit of 0.8 ppb.

- All personal monitoring results were below OSHA PEL of 20 ppb, ceiling and the ACGIH 8-hr TLV / TWA of 5 ppb.

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2004 IH Study of OCF Adhesive

Sample ID and description	Duration (minutes)	Analytical results over time sampled (ppb)
Scenario 1: Area #1 box spray, upwind	24	8.7
Scenario 1: Area #2 box spray, downwind	24	5.1
Scenario 2: Area #5 plastic sheet, outside of hood, 18" off ground	18	0.75
Scenario 2: Area #6 plastic sheet, inside of hood, 18" off ground	18	4.4
Scenario 2: Personal #4 applicator applying to sheet	18	ND* (0.5)
Scenario 3: Personal #7 applicator in work pattern	11	ND* (0.8)
Scenario 3: Personal # 3 assistant to #7, 18" off ground	11	ND* (0.8)

OSHA PEL = 20 ppb, ceiling
ACGIH TLV = 5 ppb 8 hr TWA
*ND = not detected at conc indicated

Confidential - Do Not Share Without Permission

EXPOSURE ASSESSMENT REPORT *Thermoset Systems*	INDUSTRIAL HYGIENE REPORT NUMBER:
AUTHOR:	REPORT DATE: November, 24, 2004
REVIEWER:	EXPIRATION/RETENTION: 75 years

Title **Personal and Area Monitoring for Airborne Concentrations of Methylene Bisphenyl Diisocyanate (MDI) During Simulated Applications of INSTA-STIK™ Polyurethane Roof Adhesive at October 22, 2004**

Abstract Short-term personal and area monitoring for MDI was conducted at on October 22, 2004. The objectives of the air monitoring were to measure airborne concentrations of MDI and evaluate employees' potential exposures to MDI during simulated applications of INSTA-STIK Polyurethane Roof Adhesive.

Three different application scenarios were monitored for airborne concentrations of MDI:

1. Spraying a stream of adhesive into a 3'x4'x3' container located partially inside of a walk-in fume hood. The results of two area air samples collected at the edge of the container were 8.7 and 5.1 ppb with an arithmetic mean of 6.9 ppb.

2. Spraying a stream of adhesive onto, and completely covering, a small (8'x9') plastic sheet. The sheet was partially enclosed by the walls of a walk-in fume hood; however, the fume hood was not operating during sampling. The results of two area air samples collected approximately 18" above the floor were 0.75 and 4.4 ppb with an arithmetic mean of 2.6 ppb. A personal exposure measurement for the applicator was less than the detection limit of 0.5 ppb.

3. Spraying a stream of adhesive onto a large (8'x30') plastic sheet using a spray pattern similar to that used when installing roofing panels; however, 3x the typical amount of adhesive applied was used. The results of personal exposure measurements for the applicator and assistant were both less than the detection limit of 0.8 ppb.

All personal exposure monitoring results were below the applicable exposure limits of both the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 20 ppb as a ceiling limit, and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 5 ppb as an 8-hr Time Weighted Average (TWA). OSHA and ACGIH exposure limits are applicable only to personal exposures (not area measurements).

Area monitoring results cannot be construed as representing potential personal exposures.

Distribution Full Report:

Date Printed: 11/29/04

Title

Personal and Area Monitoring for Airborne Concentrations of Methylene Bisphenyl Diisocyanate (MDI) During Simulated Applications of INSTA-STIK™ Polyurethane Roof Adhesive at the
October 22, 2004

Author Signature **Reviewer Signature**

Introduction

The objectives of the air monitoring were to measure airborne concentrations of MDI and evaluate employees' potential exposures to MDI during simulated applications of INSTA-STIK Polyurethane Roof Adhesive.

Background

INSTA-STIK™ is a polyurethane based material that is used as an adhesive in the installation of roofing panels. It is a one component foam contained in a pressurized cylinder. The foam is transferred from the cylinder through a hose and valve to a wand which allows the foam to be dispensed within inches of where it is to be applied. No previous air monitoring has been done at for MDI during simulated or actual application of INSTA-STIK™ Polyurethane Roof Adhesive.

Discussion

Three different application scenarios were selected to provide some variation in application conditions.

In the first scenario, the contents of two 23 lb tanks of foam were sprayed (using a wand) into a cardboard container (3'x4'x3'deep) which was partially located inside of a walk-in fume hood. Area air samples were taken at two edges of the top of the container.

The second scenario involved application of the foam onto a 9'x8' plastic sheet spread on the floor. The sheet was partially enclosed by the walls of a fume hood; however, the fume hood was not operating during sampling. Using a wand, the applicator applied the foam by running a continuous bead back and forth until the entire plastic sheet was covered. Two area air samplers were located approximately 18" from the floor, diagonal to each other near the edge of the plastic sheet. One sampler was within the walls of the hood; the other was outside of the hood. A personal sampler was worn by the applicator during this process.

The third scenario involved application of the foam onto a 8'x30' plastic sheet spread on the floor. Using a wand, the applicator applied the foam by running a bead in an elongated "S" pattern onto the plastic sheet. The lines of the bead were separated by approximately 1' to simulate typical spray patterns when installing roofing panels; however, 3x the typical amount of adhesive applied was used. One personal sampler was worn by the adhesive applicator during this process. A second "personal" sample was worn by an assistant who followed the applicator during spraying. The sampler on the assistant was worn approximately 18" from the floor, to simulate breathing zone measurements for an employee applying roofing panels. Application of the roofing panels is typically done with the employee crouching close to the roof so 18" was selected as an approximate breathing zone height.

Results and Conclusions

The results of seven air samples collected for MDI are fully described in Table 1.

In summary:

- The results of two area air samples collected at the edge of the container during scenario 1 were 8.7 and 5.1 ppb with an arithmetic mean of 6.9 ppb.
- The results of two area air samples collected approximately 18" above the floor during scenario 2 (8'x9' plastic sheet) were 0.75 and 4.4 ppb with an arithmetic mean of 2.6 ppb. A personal exposure measurement for the applicator was less than the detection limit of 0.5 ppb.
- The results of personal exposure measurements for the applicator and assistant were both less than the detection limit of 0.8 ppb during scenario 3 (8'x30' plastic sheet).

All personal exposure monitoring results were below the applicable exposure limits of both the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 20 ppb as a ceiling limit, and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) of 5 ppb as an 8-hr Time Weighted Average (TWA). OSHA and ACGIH exposure limits are applicable only to personal exposures (not area measurements).

Area monitoring results cannot be construed as representing potential personal exposures.

Sampling Method

Method 333 was used and samples were analyzed by the IH Expertise Center lab.

Table 1: **Personal and Area Monitoring for Airborne Concentrations of Methylene Bisphenyl Diisocyanate (MDI) During Simulated Applications of INSTA-STIK™ Polyurethane Roof Adhesive at the , October 22, 2004**

Sample Description	Sample Type	Sample Number	Sample Duration (min.)	MDI Concentration for Time Sampled (ppb)
Scenario 1: Spraying a stream of adhesive into a 3'x4'x3' container located inside of a fume hood. Sample was taken on the "*upwind*" side of the container.	Area	1	24	8.7
Scenario 1: Spraying a stream of adhesive into a 3'x4'x3' container located inside of a fume hood. Sample was taken on the "*downwind*" side of the container.	Area	2	24	5.1
Scenario 2: Spraying a stream of adhesive onto an 8'x9' plastic sheet on the floor. The sheet was partially enclosed by the walls of a fume hood; however, the fume hood was not operating during sampling. Sample was taken at the corner (18" above the floor) of the plastic sheet, outside of the fume hood, where the spray pattern *ended*.	Area	5	18	0.75
Scenario 2: Spraying a stream of adhesive onto an 8'x9' plastic sheet on the floor. The sheet was partially enclosed by the walls of a fume hood; however, the fume hood was not operating during sampling. Sample was taken at the corner (18" above the floor) of the plastic sheet, inside the fume hood walls, where the spray pattern *began*.	Area	6	18	4.4
Scenario 2: Sampler was worn by an employee who applied the adhesive to the 8'x9' plastic sheet.	Personal	4	18	ND*(0.5)
Scenario 3: Employee sprayed a stream of adhesive onto an 8'x30' plastic sheet on the floor. Spray pattern was similar to that used when installing roofing panels; however, 3x the typical amount of adhesive applied was used.	Personal	7	11	ND (0.8)
Scenario 3: Employee walked behind the applicator who sprayed a stream of adhesive onto an 8'x30' plastic sheet on the floor. Spray pattern was similar to that used when installing roofing panels; however, 3x the typical amount of adhesive applied was used. This sample was taken 18" above the floor to evaluate potential exposure for the employee who would crouch while installing roofing panels.	Personal	3	11	ND (0.8)

OSHA PEL: 20 ppb Ceiling
ACGIH TLV: 5 ppb 8 hr TWA
*ND = Not Detected at the concentration in parentheses

Date Printed: 11/29/04

1998 IH Study of One Component Foam (OCF)

Study was conducted by a major isocyanate supplier at their facility

- Six various OCF formulations were surveyed using GMD/Bacharach AUTOSTEP+ Iso monitor to identify the formulation with the highest reading.
  - None of the samples registered a positive reading
- Selected a product with the highest iso content (~ 15%) based on known formulation and an OCF adhesive supplied in a cylinder under 230-250 psi pressure.
  - Note: This adhesive represents the "worst case scenario" for one component foams. Consumer products are usually aerosol cans at 75-100 psi pressure and 7-10% PMDI as filled. Consumer cans dispense 20 oz in about 2.5 – 3 minutes.
- Seven personal and 14 area samples were taken using filters impregnated with 1,(2-methoxy phenyl) piperazine and diethylphthalate. Monitors attached to workers in the breathing zone and at sides of cardboard box into which the foam was applied. Filters were 6 in. from spray nozzle.
  - All 7 personal samples were below the detection limit and below OSHA PEL of 0.20 mg/M3 and the ACGIH 8-hr TLV of 0.51 mg/M3.
  - All 14 area samples were below the detection limit and the OSHA PEL of 0.20 mg/M3

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1998 IH Study of OCF (filters)

Sample ID /date	Duration (minutes)	Volume (liters)	Analytical result (ug)	Sample Result (mg//M3)	TWA (est avg using 480 min shift) (mg/M3)	Comments
Personal # 415 (avg of 4) 10/29/98	15.5	16.2	<0.1 (all readings)	<0.006	<0.0008	spraying foam on plastic near waist level
Personal #325 (avg of 3) 10/30/98	15	16.1	<0.1 (all readings)	<0.006	<0.0008	spraying foam on plastic near waist level
Area # 449 (avg of 4) 10/29/98	15.5	16.3	<0.1 (all readings)	<0.006	NA	right side of board; 6" from foam; rear
Area # 450 (avg of 4) 10/29/98	15.5	16.6	<0.1 (all readings)	<0.006	NA	left side of board; 6" from foam; rear
Area # 436 (avg of 3) 10/30/98	15	15.5	<0.1 (all readings)	<0.006	NA	right side of board; 6" from foam; rear
Area # 380 (avg of 3) 10/30/99	15	16.2	<0.1 (all readings)	<0.006	NA	left side of board; 6" from foam; rear

Limit of Quantification = 0.1 ug

OSHA PEL = 0.20 mg/M3 ceiling

ACGIH 8-hr TLV/TWA = 0.051 mg/M3

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Description of Survey Methods	5

ATTACHMENTS

Table I	Summary of Personal Sampling Results - MDI
Table II	Summary of Area Sampling Results - MDI
Attachment	

NOTICE TO ICI PERSONNEL
This report contains customer process information.
DO NOT DISTRIBUTE OR DUPLICATE

INDUSTRIAL HYGIENE SURVEY
OCTOBER 29-30, 1998

EXECUTIVE SUMMARY

Seven personal samples were taken for MDI. All results were well below the OSHA Permissible Exposure Limit (PEL) of 0.20 mg/M^3 ceiling and the recommended ACGIH Threshold Limit Value (TLV) 8-hour Time Weighted Average (TWA) of 0.051 mg/M^3. See Table I.

Fourteen short-term area samples were taken in the spray hood.. Results for all these samples were well below the OSHA Permissible Exposure Limit (PEL) of 0.20 mg/M^3 ceiling. See Table II.

Based on the monitoring results, a health hazard due to inhalation of MDI vapors/aerosols did not exist on the days of the survey.

Note: The data obtained during this survey is required to be readily accessible to your employees, their agents and government agencies under OSHA's Access to Employee Exposure and Medical Records Standard (29CFR 1910.20). In addition, this survey should be stored in a secure area at for a period of thirty (30) years.

INDUSTRIAL HYGIENE SURVEY
OCTOBER 29-30, 1998

FULL REPORT

At the request of , testing was performed at the West Deptford site of ICI Polyurethanes to evaluate potential exposure to MDI of workers using prepackaged single component MDI based foam insulation contained in an aerosol type can..

Both personal and area samples were taken to evaluate worker exposure to MDI (CAS# 101-68-8) during spray foam operations.

DISCUSSION OF FINDINGS

Seven personal samples were taken while a employee sprayed a prepackaged single component formulation of MDI-based foam insulation from an aerosol type can. MDI was not detected above the analytical methods Limit of Quantification (LOQ) of 0.1 µg. All results have been reported as < 0.006 mg/M^3. Results for the calculated Time Weighted Averages (TWA) have been reported as ≤ 0.0008 mg/M^3. These results are well below the OSHA Permissible Exposure Limit (PEL) of 0.2 mg/M^3 (ceiling) and the American Conference of Governmental Industrial Hygienists Threshold Limit Value (TLV) 8-hr TWA (TLV/TWA) of 0.051mg/M^3. See Table I.

Fourteen short-term area samples were taken in the vicinity of the spray operations. MDI was not detected above the analytical methods LOQ of 0.1 µg. All results for these samples have been reported as < 0.006 mg/M^3.

Screening tests were performed with a GMD/Bacharach Autostep+ Isocyanate direct reading monitor. These tests were performed during short term spraying of different formulations to determine which one would likely produce the highest airborne concentrations of MDI. Whichever formulation produced the highest concentrations would be used to do the in-depth sampling described above. MDI was not detected with the Autostep+ during the spraying of any of the formulations that were available. The formulation used during the in-depth testing was selected based on the knowledge of the chemistry of the formulations that were available.

EXPOSURE EVALUATION CRITERIA

The exposure limits for the chemical of interest in this survey are as follows:

Substance	OSHA PEL	ACGIH Recommended Value
MDI	0.2 mg/M^3 ceiling	0.051 mg/M^3 8-hr TLV/TWA

The Occupational Health and Safety Act (OSHA) became effective in 1971 and the Permissible Exposure Limits (PEL's) were published in Title 29 of the Code of Federal Regulations (CFR), Part 1910, Subpart Z. The law requires compliance with these regulations.

The American Conference of Governmental Industrial Hygienists (ACGIH) have issued other exposure criteria called Threshold Limit Values (TLV's). These values are not law but are recommended guidelines. The ACGIH is a recognized advisory group of governmental occupational health professionals.

Most exposure criteria represent time-weighted average (8-hr TWA or 8-hr TLV/TWA) concentrations to which it is believed most members of a working population can be repeatedly exposed, during an 8-hr day, 40-hour week, for a working lifetime, without any adverse effect. Time-Weighted averaging permits excursions above the exposure limits, provided they are compensated by equivalent excursions below the limits during the workday.

A ceiling limit is a concentration that should not be exceeded at any time during the workday.

PROCESS DESCRIPTION

Sampling was performed in the machine hall of Building 2 at ICI Polyurethanes West Deptford Regional Development Center. shipped various formulations of different types of spray foam insulation to ICI. The formulations initially tested were:

- Insta-seal ,750 ml, 935 metal gun system (CCMC# 09431-R)
- Insta-seal 3X, 24 oz cans (IS2412-12)
- Great Stuff, 12 oz cans (MS121201)
- Great Stuff Pro, 12 oz. cans (MSP121201)
- Insta-pro, 24 oz. cans (PF241209)
- Insta-seal, 16 lb. canister (35FK128)

All spraying was performed in the large walk-in spray booth located in the machine hall. The exhaust of the spray booth remained off during the testing. A large surface (cut open cardboard boxes laying flat) area was set-up in the spray booth. A screening test was performed on each formulation to determine which one would likely produce the highest airborne concentrations of MDI. This test consisted of spraying each formulation for 4 minutes on to a large surface area. A GMD/Bacharach Autostep+ Isocyanate direct reading monitor was used during this spray period to determine airborne concentrations of MDI. Based on the results of this screening test, whichever formulation produced the highest airborne concentrations of MDI would be used to do the in-depth testing. MDI

TOTAL P.08

was not detected with the Autostep+ during the spraying of any of the formulations that were available. Therefore, the Insta-seal (16 lb. canister), was selected based on the higher NCO content of the formulation.

DESCRIPTION OF SURVEY METHODS

All air sampling was conducted using SKC 224-PCXR7/8 air sampling pumps. Calibration was performed before and after using a Mini Buck primary flow meter. The first three digits of the sample ID number in Table I identify the specific pump used to collect each sample. The relevant calibration data are not included with this report but are available upon request.

A. Personal Air Samples

A 13 mm glass fiber filter impregnated with 2 mg of 1,(2-methoxy phenyl) piperazine (1-2 MP) and 2% diethylphthalate (DEP), was placed in the worker's breathing zone. This device was connected via clear plastic tubing to an air pump attached to the worker's waist. Operation of the pump caused ambient air to be drawn through the collection device. The pumps were checked several times during the sampling period to ensure that they remained operational and the filters were properly positioned.

At the completion of the sampling period, the 13 mm filters were removed from their holders, put into glass vials with derivitization solution and forwarded to the ICI Polyurethanes' Industrial Hygiene Analytical Laboratory, an AIHA accredited lab located in West Deptford, NJ for analysis by high performance liquid chromatography (HPLC) using method I1024G, Revision 1.9.

B. Short-Term Area Samples

Area samples were taken in the same manner as personal samples except that the samples were placed in stationary locations around the cardboard box top.

TABLE I

INDUSTRIAL HYGIENE SURVEY
OCTOBER 29-30, 1998
PERSONAL AIR SAMPLING RESULTS – MDI

Name/Job Title	Sample ID	Duration (minutes)	Volume (Liters)	Analytical Result (µg)	Sample Result (mg/M^3)	TWA[1] (mg/M^3)	Comments
10-29-98							
Sr. Development Chemist	415-1	16	16.8	< 0.1	< 0.006	< 0.0008	Spraying foam on plastic near waist level.
	415-2	15	15.7	< 0.1	< 0.006		
	415-3	15	15.7	< 0.1	< 0.006		
	415-4	16	16.8	< 0.1	< 0.006		
10-30-98							
Sr. Development Chemist	325-1	15	16.1	< 0.1	< 0.006	< 0.0006	Spraying foam on plastic near waist level.
	325-2	15	16.1	< 0.1	< 0.006		
	325-3	15	16.1	<0.1	< 0.006		

0.1 µg = Limit of Quantification
ACGIH 8-hr TLV/TWA = 0.051 mg/M^3
OSHA PEL = 0.20 mg/M^3 ceiling
< = Less Than

1. TWA results represent the average exposure for a 480 minute workshift. Airborne level of MDI for the unsampled periods of the shift are assumed to be zero. TWA was calculated as follows: {(< 0.006 mg/M^3)(16 min) + (< 0.006 mg/M^3)(15 min) + (< 0.006 mg/M^3)(15 min) + (< 0.006 mg/M^3)(15 min) + (< 0.006 mg/M^3)(16 min) + (0)(418 min)}/ 480 min.

TABLE II

INDUSTRIAL HYGIENE SURVEY
OCTOBER 29, 1998
AREA AIR SAMPLING RESULTS – MDI

Area	Sample ID	Duration (minutes)	Volume (Liters)	Analytical Result (µg)	Sample Result (mg/M^3)	TWA[1] (mg/M^3)	Comments
Spray Booth	449-1	16	16.8	< 0.1	< 0.006	----------	Right side of board, 6" from foam, rear
	449-2	15	15.8	< 0.1	< 0.006		
	449-3	15	15.8	< 0.1	< 0.006		
	449-4	16	16.8	< 0.1	< 0.006		
Spray Booth	450-1	16	17.1	< 0.1	< 0.006	----------	Left side of board, 6" from foam, rear
	450-2	15	16.1	< 0.1	< 0.006		
	450-3	15	16.1	< 0.1	< 0.006		
	450-4	16	17.1	< 0.1	< 0.006		

0.1 µg = Limit of Quantification
ACGIH 8-hr TLV/TWA = 0.051 mg/M^3
OSHA PEL = 0.20 mg/M^3 ceiling
< = Less Than

TABLE II cont.

INDUSTRIAL HYGIENE SURVEY
OCTOBER 30, 1998
AREA AIR SAMPLING RESULTS – MDI

Area	Sample ID	Duration (minutes)	Volume (Liters)	Analytical Result (µg)	Sample Result (mg/M^3)	TWA[1] (mg/M^3)	Comments
Spray Booth	436-1	15	15.5	< 0.1	< 0.006	--------	Right side of board, 6" from foam, rear
	436-2	15	15.5	< 0.1	< 0.006		
	436-3	15	15.5	< 0.1	< 0.006		
Spray Booth	380-1	15	16.2	< 0.1	< 0.006	--------	Left side of board, 6" from foam, rear
	380-2	15	16.2	< 0.1	< 0.006		
	380-3	15	16.2	< 0.1	< 0.006		

0.1 µg = Limit of Quantification
ACGIH 8-hr TLV/TWA = 0.051 mg/M^3
OSHA PEL = 0.20 mg/M^3 ceiling
< = Less Than

TOTAL P.04

Fomo Studies

Bayer MaterialScience

March 9, 2010

Ms. Robin Hunt
Fomo Products, Inc.
2775 Barber Road
Norton, Ohio 44203

Dear Robin:

Please find enclosed the report of the industrial hygiene evaluation conducted by Bayer MaterialScience on February 4, 2010 at your facility in Norton, OH. The airborne levels of 2,4- and 4,4-diphenylmethane diisocyanate (MDI) were measured during the production of one component polyurethane foam, as well as during the test application of one and two-component low pressure polyurethane foam systems.

It was a pleasure being of service to you, and I'd like to express my appreciation for the cooperation that I received from your personnel. Please feel free to contact me if you have any questions.

Sincerely,

Brian F. Karlovich, CIH, CSP
Manager, Industrial Hygiene Customer Services
Product Safety & Regulatory Affairs Department
(412) 777-4808
FAX (412) 777-7484

cc: N.Goshen
J. Chapman/DOC

Enclosure

Bayer MaterialScience

An Evaluation of Airborne Methylene Diphenyl Diisocyanate (MDI)

at

Fomo Products, Inc.
Norton, OH

Conducted and Reported by:
B.F. Karlovich, Manager - Industrial Hygiene Customer Services, Product Safety & Regulatory Affairs

Date of Evaluation: February 4, 2010
Date of Report: March 9, 2010

The testing and evaluation described in this report have been conducted as a customer service at no additional charge to the Customer. As such, any information contained in this Report has been obtained in accordance with industry standards and is, to the best of our knowledge, true and accurate, and is based only upon the conditions observed at the time of the evaluation. The test results, recommendations and/or suggestions contained in this Report are made only as a courtesy as part of our customer service and Bayer makes no warranty, either expressed or implied, with respect to any such test results, recommendations and/or suggestions.

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SUMMARY

On February 4, 2010 air sampling for methylene diphenyl diisocyanate (MDI) was conducted during the production of one component polyurethane foam products, as well as during the test application of both one and two component polyurethane foam products at Fomo Products, Inc., Norton, Ohio. Both personal and area samples were collected. Sample results are summarized in Table 1.

Personal Samples

Airborne MDI was detected in the two samples collected in the breathing zone of the aerosol line operator. The airborne concentrations were 15 and 2.7 ug/m^3, with a corresponding sampling period TWA concentration of 8.8 ug/m^3. This value does not exceed the ACGIH 8-hr. TLV-TWA of 51 ug/m^3.

Airborne MDI was not detected at or above the analytical quantitation limit in three short-term air samples collected in the breathing zones of 1) the technical training representative during the application of the E84 Class I Refillable System in the Training Lab hood, using the "10, 10, 10" rule, 2) the product manager during the application of a two component 205 Disposable Kit in the Spray Lab hood, using the "10, 10, 10" rule, and 3) the product manager during the application of one component HandiFoam in the Humidity Chamber. Therefore, the OSHA PEL-C of 200 ug/m^3 was not exceeded.

Airborne MDI was identified at a level of 89 ug/m^3 in the one short-term air sample collected in the breathing zone of the product manager during the continuous application of the 205 Disposable Kit in the Training Lab hood. However, the OSHA PEL-C of 200 ug/m^3 was not exceeded. Because the employee wore an air purifying respirator during this activity, the airborne concentration to which the employee was potentially exposed was likely less than the measured concentration. It is of note that the local exhaust ventilation hood was purposely not operated during this activity.

Area Samples

Airborne MDI was identified at 3.0 and 1.1 ug/m^3 in the two samples collected near the dispensing heads of the aerosol filling station.

Airborne MDI was not identified at or above the analytical quantitation limit in the two area samples collected at a distance of 10 feet from spraying activities, or in the two area samples collected beginning one hour following spraying activities in the Training Lab.

Recommendations based on results and observations at the time of the evaluation appear on Page 7.

I. INTRODUCTION

At the request of Fomo Products, Inc., the Bayer MaterialScience (BMS) Product Safety & Regulatory Affairs Department sampled for potential airborne MDI during the manufacture of one and two component low pressure polyurethane foam systems, as well as the test application of these systems. BMS supplies Fomo with Mondur MR Light, which contains approximately equal amounts of monomeric MDI and polymeric MDI.

II. PROCESS OBSERVATIONS

The Norton facility blends and packages various-sized one and two-component low pressure polyurethane foam systems. The one component systems dispense somewhat like a caulking, whereas the two-component systems are spray applied. The aerosol filling operation was evaluated during this investigation. In addition, air sampling was conducted during the test application of some of Fomo's one and two-component low pressure polyurethane foam systems.

The aerosol line is highly automated and is located in a large production area (greater than 10,000 square feet with ceilings of approximately 15 feet). Two lines, 1 and 2, are immediately adjacent to and run parallel with one another. For each line, a conveyor first delivers empty metal cans (typically 12 or 24 ounce) to the aerosol filling station, where two heads dispense MDI under low pressure into the tops of two cans for a period of about 1 to 2 seconds. Following this, the cans proceed a short distance down the line, and two additional heads dispense polyol blend into the tops of the cans, also for a period of about 1 to 2 seconds. Heads that dispense other additives are also present and are used for certain products. Following the addition of product, valves are then automatically added to the tops of the cans. The cans then proceed to the "Gas House" where propellant is injected. Following the Gas House, the conveyor delivers the cans to a station where collars are added (for products that use a gun attachment), and then to the shaker (10 to 15 shakes per can). The cans are then submerged in a "hot bath" to increase the temperature to about 120 degrees Fahrenheit, and then proceed through a cold bath. The cans then move to the "Blower House" to be dried with fast moving air. The cans then proceed along to the labeler, capper, and adapter placer, before being fitted with an outer thin plastic sleeve, which is then heated via heat gun, and then followed up by a heat tunnel. The cans are then boxed up manually. From here, the boxes of cans proceed to the palletizer. The pallet with boxes of product is then shrink wrapped, at which point it is ready for shipment. On the day of the evaluation, the products produced included 24-ounce Window and Door, 12-ounce Straw Foam, and 12-ounce Window and Door. Approximately 14,000 cans were produced in total.

The aerosol filling station is equipped with a canopy hood; the dimensions of the hood face are approximately 4 feet by 4 feet. The face of the hood is located about 6 feet above the floor. Smoke gun testing indicated that air was moving slowing into the hood.

Fomo has implemented a "10, 10, 10" policy where two component spray polyurethane foam systems are being demonstrated for customers, or where customers are being trained. The policy is reportedly used at both the Fomo facility as well as at customer locations. The policy is as

follows. Spraying is permitted for no more than 10 seconds at a time; observers must be at least 10 feet away from the applicator; and there is a minimum 10-minute waiting period between spraying events.

On the day of the evaluation, test application of various Fomo products were conducted in the Training Lab, Spray Lab, and Humidity Chamber. The Training Lab is approximately 24 feet by 19 feet by 12 feet high. Two supply air diffusers are located in the ceiling. A local exhaust ventilation hood with the dimensions of approximately 6 feet wide, by 3 feet deep, by 6 feet high is located in the far corner of the room. Two component foam kits are applied into simulated wall cavities or onto other substrates in the hood. The hood is reportedly operated during spraying; however, Fomo chose to not operate the hood on the day of the evaluation in order to represent worst case conditions.

The room that houses the Spray Lab is approximately 45 feet by 20 feet by 18 feet high. One supply air diffuser was observed in overhead ductwork. A local exhaust ventilation hood with the dimensions of approximately 10 feet wide by 5 feet deep is present in the Spray Lab. Similar to the hood in the Training Lab, two component foam kits are applied into simulated wall cavities or onto other substrates in the hood. The hood is reportedly operated during spraying; however, similar to the Training Lab hood, Fomo chose to not operate the hood on the day of the evaluation in order to represent worst case conditions.

The Humidity Chamber is approximately 8 feet by 16 feet by 8 feet high. One supply air diffuser was observed in the ceiling. The room is reportedly kept at a relative humidity of approximately 50 percent for the purpose of testing single-component foam products.

Three employees were monitored during this investigation, an aerosol line operator, a technical training representative, and a product manager. The aerosol line operator worked at both Lines 1 and 2. His primary tasks were to restock the conveyor lines with empty cans and valves, and to weigh the aerosol cans at different stages of the process for quality control purposes. He wore boots, pants, a short sleeved work shirt, safety glasses with side shields, disposable latex gloves, and earplugs.

The technical training representative demonstrated the "10, 10, 10" rule in the hood of the Training Lab. He applied a two component "E84 Class I Refillable System" to a cardboard-lined, simulated wall assembly (2" by 4" framing) in the hood. The E84 Class I Refillable System was equipped with a 10-inch HandiGun with a disposable tip and a Magnum hose heater (80 degrees F). Dynamic pressure at the gun was reported to be approximately 75 pounds per square inch. The product was applied for 10 seconds, and then applied for another 10 seconds 10 minutes later. The total length of the activity was 15 minutes. When not spraying, the employee stood at approximately the same location as when spraying. As previously stated, the ventilation hood was not operated. The door to the Training Lab was closed during the sampling period. The employee wore boots, jeans, a short sleeved shirt, safety glasses with side shields, Duraskin disposable nitrile gloves, and disposable plastic sleeves to cover the forearms.

The product manager conducted three separate tasks. The first task was the application of a two component "205 Disposable Kit" into cardboard boxes on the floor in the hood in the Training Lab. One entire kit was dispensed over a period of approximately 15 minutes. The ventilation hood was not operated, and the door to the room was closed. The product manager wore shoes, pants, fabric lab coat, half mask air purifying respirator with organic vapor cartridges, disposable nitrile gloves, and safety glasses with side shields during this activity.

The product manager's second task was to apply a one component "HandiFoam" with attached straw dispenser to plastic covered cardboard sheets in the Humidity Chamber. The cardboard sheets were located on a desktop about 3 feet above the floor. The foam was nearly continuously applied in a bead width of about 3/8-inch. Approximately one and one half cans were used over a 15-minute period. The door was closed during this activity. The employee wore shoes, pants, fabric lab coat, High Five disposable latex gloves, and safety glasses with side shields during this activity.

The product manager's third task was to demonstrate the "10, 10, 10" rule in the hood of the Spray Lab. She applied the two component "205 Disposable Kit" to a piece of cardboard on the back wall of the hood at a height of about 3 to 4 feet above the floor. The product was applied for 10 seconds, and then applied for another 10 seconds 10 minutes later. The total length of the activity was 15 minutes. When not spraying, she stood at approximately the same location as during spraying. As previously stated, the ventilation hood was not operated. She wore shoes, pants, fabric lab coat, Duraskin disposable latex gloves, and safety glasses with side shields during this activity.

III. CRITERIA

MDI

The American Conference of Governmental Industrial Hygienists (ACGIH) has adopted a Threshold Limit Value - Time Weighted Average (TLV-TWA) for 4,4'-methylene bisphenyl isocyanate (MDI) of 0.005 parts per million (ppm) (i.e., 5 parts per billion, ppb) or 51 micrograms per cubic meter of air (ug/m^3). This is an airborne concentration for a normal 8-hour workday and a 40-hour workweek and represents conditions under which nearly all workers can be exposed without adverse effect. In addition, the federal Occupational Safety and Health Administration (OSHA) has established a Permissible Exposure Limit (PEL) for 4,4'-MDI of 0.02 ppm or 200 ug/m^3 as a Ceiling (C) limit. The Ceiling limit is a concentration that should not be exceeded during any part of the day.

At present, neither an ACGIH TLV nor a federal OSHA PEL has been established for 2,4'-MDI or polymeric MDI. However, Bayer MaterialScience recommends that the exposure limits for 4,4'-MDI be used for the 2,4'- MDI isomer.

The United States Environmental Protection Agency (EPA) has established a Reference Concentration (RfC) for 4,4'-MDI of 0.06 ppb (0.6 ug/m^3). The RfC is for chronic inhalation

exposure, and represents the airborne exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

IV. SAMPLING AND ANALYTICAL TECHNIQUES

Where spraying activities were conducted, samples of airborne MDI were collected using glass impingers containing 15 milliliters of a solution of toluene and 1-(2-pyridyl)piperazine, backed up by coated 13mm glass fiber filters mounted in Swinnex holders, and connected to A.P. Buck Basic 5 air sampling pumps. The impinger/filter sampling trains were either attached to the workers' lapels (i.e., personal samples) or placed in the surrounding work area (i.e., area samples). All pumps were calibrated before sample collection to a sampling rate of approximately 1 Lpm using a Bios DryCal® DC-Lite Primary Air Flow Meter. The sampling rate was reconfirmed after the sampling event, with the average value used in the sample volume calculation. Prior to mounting the filter to the Swinnex holder, each filter was coated with 2 mg of 1-(2-pyridyl)piperazine and diethyl phthalate. Immediately upon completion of sampling, the impinger solution was transferred to sample bottles, and the filters were removed from the Swinnex holders and desorbed in 2 ml of acetonitrile/dimethyl sulfoxide (90:10 v/v) solution. When airborne MDI is drawn through the impinger solution (and treated filter) it is converted to a stable urea derivative, which is quantitatively analyzed by HPLC using Bayer MaterialScience Method 1.20.0. The 13mm filters were analyzed according to Bayer MaterialScience Method 1.7.7.

Where spraying activities were not conducted, samples of airborne MDI were collected using 1-(2-pyridyl)piperazine and diethyl phthalate-coated 13mm glass fiber filters mounted in Swinnex holders, and connected to SKC Airchek 52 air sampling pumps. The filters were either attached to the workers' lapels (i.e., personal samples) or placed in the surrounding work area (i.e., area samples). The 13mm filters were analyzed according to Bayer MaterialScience Method 1.7.7.

All samples collected were analyzed at the Bayer MaterialScience Industrial Hygiene Laboratory, which is accredited by the AIHA.

Airflow

Air movement in the aerosol filling station area was assessed with a TelTru™ Borozin A.C. Gun (i.e., smoke gun) that uses 100% Air Test Grade Zinc Stearate as the testing powder.

V. RESULTS AND DISCUSSION

The analytical results are presented in Table 1. Note that the reported MDI values for the samples collected during/following spraying activities represent MDI found in the impinger solution only, as MDI was not identified in any of the back-up 13mm filters.

Personal Samples

Airborne MDI was detected in the two samples collected in the breathing zone of the aerosol line operator. The airborne concentrations were 15 and 2.7 ug/m^3, with a corresponding TWA concentration of 8.8 ug/m^3. This value does not exceed the ACGIH 8-hr TLV-TWA of 51 ug/m^3.

Airborne MDI was not detected at or above the analytical quantitation limit in the one short-term sample collected in the breathing zone of the technical training representative during the application of the E84 Class I Refillable System in the Training Lab hood, using the "10, 10, 10" rule. Therefore, the OSHA PEL-C of 200 ug/m^3 was not exceeded.

Airborne MDI was not detected at or above the analytical quantitation limit in the one short-term sample collected in the breathing zone of the product manager during the application of the two component 205 Disposable Kit in the Spray Lab hood, using the "10, 10, 10" rule. Similarly, airborne MDI was also not detected at or above the analytical quantitation limit in the short-term sample collected during the application of the one component HandiFoam in the Humidity Chamber. Therefore, the OSHA PEL-C of 200 ug/m^3 was not exceeded for either of these samples.

Airborne MDI was identified at a level of 89 ug/m^3 in the one short-term sample collected in the breathing zone of the product manager during the application of the two component 205 Disposable Kit in the Training Lab hood. However, the OSHA PEL-C of 200 ug/m^3 was not exceeded. Because the employee wore a half mask air purifying respirator during this activity, the airborne concentration to which the employee was potentially exposed was likely less than the measured concentration.

Area Samples

Airborne MDI was identified at 3.0 and 1.1 ug/m^3 in the two samples collected near the dispensing heads of the aerosol filling station.

Airborne MDI was not identified at or above the analytical quantitation limit in the two area samples collected at a distance of 10 feet from spraying activities, one for the E84 Class I Refillable System, and one for the 205 Disposable Kit. Airborne MDI was also not identified in the two area samples collected beginning one hour following continuous 205 Disposable Kit spraying activities in the Training Lab.

TABLE 1
AIRBORNE METHYLENE DIPHENYL DIISOCYANATE (MDI) CONCENTRATIONS
Personal & Area Samples – Fomo Products, Inc.
Norton, Ohio – February 4, 2010

Sample Number	Name/ Job Description/Location	Sampling Period	Sample Volume (liters)	2,4'-MDI (ug/m^3)	4,4'-MDI (ug/m^3)	Total MDI (ug/m^3)	TWA[1] (ug/m^3)
PERSONAL SAMPLES – LONG TERM							
006-1	Aaron Runyon, Aerosol Line Operator	7:04-11:08	251.3	1.51	13.1	15	8.8
006-2		11:08-15:03	242.1	ND[2]	2.73	2.7	
PERSONAL SAMPLES – SHORT TERM							
308-1	Derrick Hyde, Technical Training Representative, Applies *E84 Class I Refillable System* in Training Lab Hood ("10, 10, 10")	8:18-8:33	15.7	ND	ND	ND	--
308-2	Sandy Gump[3], Product Manager, Applies *205 Disposable Kit* in Training Lab Hood	8:50-9:05	15.3	17.0	71.9	89	30
308-4	Sandy Gump, Product Manager, Applies *205 Disposable Kit* in Spray Lab Hood ("10, 10, 10")	10:41-10:56	15.5	ND	ND	ND	
442-1	Sandy Gump, Product Manager, Applies One Component *HandiFoam* in Humidity Chamber	9:15-9:30	15.4	ND	ND	ND	
AREA SAMPLES							
900-1	Aerosol Filling Station, Between Lines 1 and 2, immediately upline of dispensing heads, about 5 feet above floor	7:00-11:09	264.7	0.60	2.46	3.0	--
900-2		11:09-15:03	248.7	0.40	0.68	1.1	--
531-1	On cart, 10 feet from Training Lab hood, 3 feet above floor, during *E84 Class I Refillable System* application ("10, 10, 10")	8:18-8:33	15.3	ND	ND	ND	--
308-3	On cart, 10 feet from Training Lab hood, 3 feet above floor, one hour following end of 15-minute application of *205 Disposable Kit*	10:05-10:20	15.8	ND	ND	ND	--
531-2	On cart, 10 feet from Training Lab hood, 3 feet above floor, started at one hour following end of 15-minute application of *205 Disposable Kit*	10:05-13:05	178.2	ND (<0.56 ug/m^3)	ND (<0.56 ug/m^3)	ND	--
309-1	On desk top, 10 feet from Spray Lab hood, 3 feet above floor, during application of *205 Disposable Kit* ("10, 10, 10")	10:41-10:56	15.5	ND	ND	ND	--

1. Time Weighted Average (TWA) based on the combined samples.
2. ND (Non-detectable) – concentration was less than the analytical Limit of Quantitation (LOQ) of 0.1 µg/sample. For samples that were 15 minutes in duration, the corresponding total MDI concentration is of approximately <13 ug/m^3.
3. Employee wore a half mask air purifying respirator during this activity. Therefore, the airborne concentration to which the employee was potentially exposed was likely less than the concentration shown.

HUNTSMAN
Polyurethanes

June 3, 2005

Mr. Timothy J. Eberling
Safety and Regulatory Manager
Fomo Products, Inc.
2775 Barber Road
Norton, Ohio 44203

Dear Tim:

Attached is the report of the air monitoring performed for MDI during the spray application of polyurethane foam onto the walls of a house under construction in Hudson, Ohio on May 12, 2005. Personal monitoring results for the sprayer and helper ranged from less than, <0.006-0.082 mg/m^3. These results are below the OSHA Permissible Exposure Limit (PEL) of 0.2 mg/m^3.

Most of the area samples taken were below the reporting limit and less than <0.0041mg/m^3. One area sample was barely detectable, # 486-2, and was 0.0041 mg/m^3.

If after reviewing the report you have any questions, please call me at (856) 423-8412.

Sincerely,

Bill Karoly

Bill Karoly
Industrial Hygiene Consultant

CC: Monica Ntiru

RECEIVED 06-14-05

HUNTSMAN POLYURETHANES
286 Mantua Grove Road • West Deptford, New Jersey 08066-1732 USA • 856-423-8300 • 800-257-5547 • Fax 856-423-8501

An international business unit of Huntsman International LLC

SUMMARY

A two component system (Handi-Foam magnum system 27 E 84 class 1) was used to spray polyurethane foam insulation in between the studs of the outside walls on a home under construction in Husdon, Ohio on May 12, 2005. Spray foaming began around 10:45 am (temperature/relative humidity were 54°F/44%) and ended around 12:43 pm. The temperature and relative humidity at 1:20 pm were 60°Fand 52%. All the windows were installed – there was no protective covering on any of them. General ventilation came from the front entrance to the house and the garage since the doors were not installed.

A "low pressure" spray system was used to apply the polyurethane foam insulation. No visible overspray was noted during the application process.

RESULTS

Personal Samples:

Six short-term personal samples were taken on the sprayer to evaluate airborne concentrations of MDI during the spray application of polyurethane foam insulation to the walls of the house. Sampling results ranged from 0.016 – 0.082 mg/m^3 (1.6-8.2 ppb). When the sampling results are averaged over the total spraying duration of 118 minutes, the time-weighted average (TWA) concentrations is 0.047 mg/m^3 (4.7 ppb).

Six short-term personal samples were also taken on a Fomo employee who was helping the sprayer. He stayed anywhere from several feet (for short time periods) to 10 feet or more behind and to the side of the sprayer, occasionally checking the cured/partially cured foam in the same and adjacent rooms. His results ranged from <0.006 – 0.036 mg/m^3 (<0.6-3.6 ppb). When averaged over the total sampling duration of 115 minutes, the TWA concentration is ≤0.018 mg/m^3 (≤1.8 ppb).

The sampling results for both the sprayer and helper were below the OSHA Permissible Exposure Limit (PEL) of 0.2 mg/m^3 and the ACGIH Threshold Limit Value (TLV) of 0.051 mg/m^3, 8-hour TWA. If one were to extrapolate the 118-minute TWA exposure of the sprayer and the 115 TWA exposure of the helper, without regard to the use of respirators, to 8-hours for compliance purposes, the respective 8-hour TWAs would be 0.011 mg/m^3 for the sprayer and ≤0.0.004 mg/m^3 for the helper.

Personal protective equipment worn by the sprayer included, Tyvek coveralls, nitrile gloves and a 3M model GVP1 powered air-purifying respirator equipped with a combination HEPA/organic vapor (OVA) cartridge and a Tyvek snap cap hood. One Fomo employee substituted as the sprayer's helper. He wore casual work clothes and a half-mask air-purifying respirator with combination HEPA/OVA cartridges when in the same room with or in close proximity to the sprayer.

Area Samples:

The duration of the area samples ranged from 20 – 40 minutes. MDI was barely detected in only one sample (# 486-2), and not detected in all other area samples. All but one of the samples were taken while spray foam was being applied. The area samples were located at varying distances (approximately 15-30 feet) from the sprayer. One sample, # 489-3, was started 4 minutes prior to spray completion of the last room and continued for 19 minutes after spray completion. MDI was not detected in this sample.

No MDI was detected in the Sure-Spot® sample taken during spraying.

Based on these monitoring results, the sprayer, helper and onlookers were not exposed to airborne concentrations of MDI above the established exposure limits. Spraying of the ceiling did not occur. For all practical purposes, the area sampling results were negligible during and after spraying was completed. Based on the data obtained and the conditions that were present at this site, other tradesman could have probably worked safely in nearby rooms within a matter of minutes after spraying was completed, provided they maintained a distance of 15-30 feet from the sprayer while spraying was being performed in another room . However, results from this survey should not be applied across the board to other spray foam applications in residential homes under construction because each job is different. Environmental factors such as general ventilation availability, wind direction, spray application techniques, etc are also different at each site and difficult to control.

EXPOSURE LIMITS TO WHICH AIRBORNE CONCENTRATIONS ARE COMPARED

The OSHA Permissible Exposure Limit (PEL) for MDI is $0.2 mg/m^3$ = 20 ppb. This limit has a ceiling designation and should not be exceeded during the work shift. This exposure limit is legally binding.

The ACGIH Threshold Limit Value (TLV) 8-hour Time-Weighted Average (TWA) for MDI is $0.051 mg/m^3$ = 5 ppb.

Exposure limits – Threshold Limit Values - represent a scientific opinion based on a review of existing peer-reviewed scientific literature and set by a committee of experts in public health and related sciences who are members of the American Conference of Governmental Industrial Hygienists (ACGIH). Excursions above these limits are permitted provided that there are excursions below the limits so that the 8-hour TWAs are not exceeded.

DESCRIPTION OF SAMPLING/ANALYTICAL METHODS

1. INDIRECT SAMPLING METHODS

Monitoring was performed using SKC 224-PCXR7 or SKC 224-PCXR8 air sampling pumps. Calibration was performed before and after use with a Bios DryCal DC – Lite, S/N 2145 calibrator. The relevant calibration data are not included with this report but are available upon request.

Midget impingers were used to obtain personal and area samples. Each midget impinger contained about 10-ml toluene/1,2-MP solution The impingers were connected with Tygon tubing to calibrated, battery operated sampling pumps.

Personal samples were taken by placing the impinger in the sprayer's breathing zone and attaching it to the lapel of the Tyvek coverall. The outlet of the impinger was connected via clear plastic tubing to the air sampling pump that was attached to the worker's waist. Area samples were taken in a similar fashion except that the samplers were placed at stationary locations in the rooms of the house.

At the completion of the sampling period, each impinger solution was placed in a glass vial having a Teflon-lined cap. Each impinger was initially rinsed with toluene solution, then with acetonitrile to dissolve any moisture that may have been collected during sampling. All the rinsates were added to each of the glass vials.

The samples were forwarded to Clayton Group Services Industrial Hygiene Analytical Laboratory, an AIHA accredited laboratory, located in Novi, MI for analysis by high performance liquid chromatography (HPLC) using Huntsman Method I1024G, Revision 2.3.

2. DIRECT SAMPLING METHOD

One area sample was taken using the GMD Sure-Spot® test kit. Air is drawn through a chemically treated card with a sampling pump for a given time period at a nominal flow rate of 1.5 liters/minute. After completion of the sampling period, the color intensity on the card, which develops if MDI is present, is compared to a color chart to obtain the airborne concentration in parts per billion (ppb).

Table I
Personal Sampling Results – MDI
Spray Foam Application, Hudson Ohio
May 12, 2005

Name SSN Job	Sample ID	Duration (minutes)	Volume (liters)	Analytical Result (µg)	Sample Result (mg/m^3)	TWA[1] (mg/m^3)	Comments
R. Osburn xxx-xx-9342 Sprayer	513-1	18	19.9	0.31	0.016		Wore Tyvek coveralls and 3M GVP 1 powered air purifying respirator with HEPA/OVA and Tyvek snap-on cap hood. Spray application began at 10:44 am and ended at around 12:43 pm.
	513-2	19	21.0	1.1	0.054		
	513-3	19	21.0	1.7	0.082		
	514-4	19	21.0	1.3	0.060		
	514-5	20	22.1	1.3	0.057		
	513-6	23	25.5	0.43	0.017		
		118	-----	-----	-----	0.047	
R. Dansizen xxx-xx-2713 Helper	483-1	15	17.1	<0.1	<0.0058		Wore half-mask air-purifying respirator with HEPA/OVA cartridges.
	483-2	21	24.0	0.48	0.020		
	483-3	14	16.0	0.11	0.0066		
	483-4	23	26.3	0.36	0.014		
	483-5	19	21.7	0.31	0.014		
	483-6*	23	26.3	0.96	0.036		
		115	-----	-----	-----	≤0.018	
Area	486-1	20	22.4	<0.1	<0.0045	<0.0045	Sampler on ring stand ~15-20 feet from sprayer @ 10:44-11:04 am
Area	486-2	35	39.2	0.16	0.0041	0.0041	Sampler in middle of room adjacent to the sun room @ 11:34 am - 12:10 pm.
Area	486-3	22	24.6	<0.1	<0.0041	<0.0041	Same as # 486-2, @ 12:10 – 12:32 pm.
Area	491-1	42	45.8	<0.1	<0.0022	<0.0022	Sampler ~ 2-3 feet above floor level in the middle of kitchen @ 11:06 – 11:48 am.
Area	491-2	42	45.8	<0.1	<0.0022	<0.0022	Same as # 491-1 @ 11:48 am -12:32 pm.
Area	489-1	30	32.8	<0.1	<0.0030	<0.0030	Middle of great room @ 11:18 – 11:48 am.
Area	489-2	42	45.9	<0.1	<0.0022	<0.0022	Middle of great room @ 11:49 am – 12:31 pm.
Area	489-3	23	25.1	<0.1	<0.0040	<0.0040	Middle of room to the right of main entrance @ 12:39–1:03 pm; spraying completed at 12:43 pm.

[1] TWA results represent airborne concentrations of MDI for the total sampling duration of the consecutive samples.
All the area samples were located about 2-3 feet above the floor level of the respective rooms.
*Helper performed a small amount of spraying in the last room to be sprayed, which may account for the slightly elevated result.
OSHA PEL = 0.2 mg/m^3 (20 ppb), ceiling.
< = less than 0.1 µg = reporting limit

HUNTSMAN
Polyurethanes

June 21, 2005

Mr. Timothy J. Eberling
Safety and Regulatory Manager
Fomo Products, Inc.
2775 Barber Road
Norton, Ohio 44203

Dear Tim:

This memorandum is to correct an error you noted in the report I sent to you dated June 3, 2005 regarding the respirator worn by the Fomo employee who substituted as the sprayer's helper during the spray application of polyurethane foam insulation on the walls of a home under construction in Hudson, Ohio. The application of the spray foam occurred on May 12, 2005. The Fomo employee wore a 3M 6000 series half-mask air-purifying respirator with combination 5N11 dust-mist/organic vapor cartridges, and not with combination HEPA/organic vapor cartridges as stated in the report.

Sincerely,

Bill Karoly

Bill Karoly
Industrial Hygiene Consultant

CC: Monica Ntiru

HUNTSMAN POLYURETHANES
286 Mantua Grove Road • West Deptford, New Jersey 08066-1732 USA • 856-423-8300 • 800-257-5547 • Fax 856-423-8501

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1-15

HUNTSMAN
Polyurethanes

January 4, 2004

Mr. Timothy J. Eberling
Safety and Regulatory Manager
Fomo Products, Inc.
2775 Barber Road
Norton, Ohio 44203

Dear Tim:

Enclosed is the report of the air monitoring performed for MDI at Fomo Products on December 18, 2003 by Bill Karoly.

If after reviewing the report you have any questions, please call me at (856) 423-8408.

Sincerely,

John Flatley, CIH
Industrial Hygiene Manager

CC: File

HUNTSMAN POLYURETHANES
286 Mantua Grove Road • West Deptford, New Jersey 08066-1732 USA • 856-423-8300 • 800-257-5547 • Fax 856-423-8501

SUMMARY/RESULTS

Personal and area samples were taken to determine airborne concentrations of MDI during discharging foam kits manufactured by Fomo (Silent Seal), Convenience (Touch'n Seal) and RHH Industries (Versi-Foam). The kits were sprayed on to 4'8"x3'8" cardboard sheets that were hung on the back wall of the walk-in hood. The cardboard sheets were changed out after each run. The exhaust ventilation on the hood was shut off to simulate worst case conditions. – smoke tests performed periodically during spraying indicated very little air movement. The sampling duration for each run ranged from 15-17 minutes.

The personal impinger sampling results ranged from 0.038 mg/m^3 for the Silent Seal product to 0.066 mg/m^3 for the Touch'n Seal and Versi-Foam products. All the personal filter sampling results were lower than the impinger sampling results for the Silent Seal and Touch'n Seal products. A personal filter sample was not taken for the Versi-Foam product.

Personal protective equipment worn by the sprayer was: safety glasses with side shields, lab coat, nitrile gloves and a half-mask air-purifying respirator with a combination pre-filter/organic vapor cartridge.

For the area impinger sampling results, airborne concentrations of MDI were lowest for the Silent Seal Foam, somewhat higher for the Touch'n Seal and still higher for the Versi-Foam products.

MDI was not found in the back-up filters of the impingers in all the area samples except those taken when foaming the RHH Industries product. However, these results were very low and at the limit of quantification of our analytical method (0.007 mg/m^3 for a 15 liter sample).

MDI was not found in any of the area filter samples that were taken side-by-side with the area impinger samples.

All the monitoring results are below the OSHA Permissible Exposure Limit (PEL) of 0.2 mg/m^3. See Table 1.

No MDI was detected in two Sure-Spot® samples taken during spraying runs. The samples were taken on the workbench that was located in front of the walk-in hood.

DESCRIPTION OF AREA SAMPLERS

The area samplers were attached to the plastic sheet overhang attached to the top front of the walk-in hood, and extending the entire length of the hood. The left-side area samplers were located 41" from the wall. The hood dimensions were 73" high (to the plastic overhanging sheet) x 48" deep x 144" long.

The impingers and side-by-side filters for the two area samplers were located 4" below the plastic overhang sheet or about 69" above floor level. All the area impinger samplers had a back-up filter attached to the exit end of the impinger to trap MDI aerosols that might have passed through the impinger.

EXPOSURE LIMITS TO WHICH AIRBORNE CONCENTRATIONS ARE COMPARED

The OSHA Permissible Exposure Limit (PEL) for MDI is $0.2 mg/m^3$ = 20 ppb. This limit has a ceiling designation and should not be exceeded during the work shift. This exposure limit is legally binding.

DESCRIPTION OF SAMPLING/ANALYTICAL METHODS

1. INDIRECT SAMPLING METHODS

Monitoring was performed using SKC 224-PCXR7 or 8 air sampling pumps. Calibration was performed before and after use with a Bios DryCal DC – Lite calibrator. The relevant calibration data are not included with this report but are available upon request.

Side-by-side area samples were taken using midget impingers and filters. The midget impingers contained about 10-ml toluene/1,2-MP solution. A back-up 13-mm glass fiber filter was connected to the exit end of each impinger to trap any MDI aerosol that might break through the impinger solution. The 13-mm glass fiber filter impregnated with 1,2-MP derivatizing agent, and housed in a 13-mm Swinnex cassette was located in close proximity to the impinger. The impinger/filter combination and filter were connected with Tygon tubing to calibrated battery operated sampling pumps.

The impinger and filter personal samples were taken in a similar manner as the area samples, except that the impingers did not have back-up filters. The impinger and filter were placed in the sprayer's breathing zone and attached to the lapel of his lab coat. The devices were connected via clear plastic tubing to air pumps that were attached to the worker's waist. .

At the completion of the sampling period, each impinger solution was placed in a glass vial having Teflon-lined caps. The impinger was rinsed several times with toluene solution. The rinsate was added to the glass vial.

Likewise, after completion of the sampling period, the 13-mm filters were removed from their holders and put into small glass vials having Teflon-lined caps. About 1 ml of derivatizing solution was added to each filter in each vial.

All the samples were forwarded to Huntsman Polyurethanes' Industrial Hygiene Analytical Laboratory; an AIHA accredited lab located in West Deptford, NJ, for analysis by high performance liquid chromatography (HPLC) using Method I1024G, Revision 2.3.

2. DIRECT SAMPLING METHOD

Two area samples were taken using the GMD Sure-Spot™ test kit. Air is drawn through a chemically treated card with a sampling pump for a given time period at a nominal flow rate of 1.5 liters/minute. After completion of the sampling period, the color intensity on the card, which develops if MDI is present, is compared to a color chart to obtain the airborne concentration in parts per billion (ppb)

TABLE 1
AREA & PERSONAL SAMPLING RESULTS – MDI
FOMO PRODUCTS, INC, NORTON, OHIO
DECEMBER 18, 2003

	Hood- left side (mg/m^3) Impinger/BF/F	Hood – right side (mg/m^3) Impinger/BF/F	Sprayer (mg/m^3) T.Taylor PR #1158 Impinger/F	Comments
Background	<0.007	<0.006	-----	
Fomo Silent Seal				
Kit #1,Run #1	<0.007/<0.007/<0.006	0.010/<0.007/<0.006	0.034/0.016	Used standard nozzle, spray distance from cardboard about 2 feet. Spray time/run ~ 5-7 min.
Kit #1,Run #2	<0.007/<0.007/<0.006	<0.006/<0.007/<0.006	0.018/0.012	
Kit #1,Run #3	<0.007/<0.007/<0.006	<0.006/<0.007/<0.006	0.013/0.012	
Average	<0.007/<0.007/<0.006	≤0.008/<0.007/<0.006	0.022/0.012	
Kit #2 Run #1	0.009/<0.007/<0.006	0.011/<0.006/<0.006	0.038/0.033	Used long nozzle, spray distance ~6" from cardboard. Spray time/run ~ 5-7 min
Kit #2 Run #2	---/---/<0.006	---/---/<0.006	---/0.024	
Kit #2,Run #3	---/---/<0.006	---/---/<0.006	---/0.019	
Average	0.009/<0.007/<0.006	0.011/<0.006/<0.006	0.038/0.022	
Convenience Touch'n Seal AB U2-200FR				
Run #1	0.038/<0.006/---	0.044/<0.006/---	---/0.033	Used Convenience's standard nozzle. Spray time/run ~ 5-7 min, except run #3 ~ 11 min. 24"
Run #2	0.074/<0.006/---	0.039/<0.006/---	0.066/0.024	
Run #3	0.053/<0.007/---	0.15/<0.013*	---/---	
Average	0.055/<0.007/---	0.062/<0.007/---	0.066/0.029	
RHH Industries, Versi-Foam Systems				
Run #1	0.13/0.007/---	0.13/0.007	0.066/---	Foamed out entire contents in one run, foam time ~ 12 min. 24"

*Pump stopped after 7 minutes of operation.
Impinger/BF/F = Impinger/back-up filter/filter adjacent to impinger.
Limit of quantification (LOQ) = 0.1 μg = 0.007 mg/m^3 for a 15 liter sample.
Sampling times for all runs (but one) were 15-17 minutes; sampling rates were about 1 liter/minute for impingers and filters.
< = less than ≤ = less than or equal to
Results in red and blue are MDI levels above the LOQ; results in blue are averages.
OSHA PEL = 0.2 mg/m^3 (20 ppb)

Polyfoam Study

3M Industrial Adhesives and Tapes Division

3M Center, Building 230-BS-19
St. Paul MN 55144-1000
651-733-8454 (phone)
651-737-3146 (fax)

October 30, 2009

Pat Donohue
Operations Manager
Polyfoam Products, Inc
PO Box 1539
11715 Boudreaux Rd
Tomball, TX 77375-1539

Dear Mr. Donohue:

As per your request, I am summarizing the industrial hygiene exposure data obtained during a study of Polyfoam products conducted on November 18 and 19, 2008 at your Tomball, Texas facility. Air sampling for methylenebis(phenyl isocyanate) (MDI) was conducted using Iso-Chek® filters, which collect both isocyanate monomer and oligomer separately. Both area and personal samples were collected using calibrated sampling pumps during simulated use of several different Polyfoam products, during both indoor and outdoor applications. Results are listed on the attached table.

Sampling locations included a small laboratory room, the general plant area, and outdoors. The lab location had general HVAC ventilation available and local exhaust ventilation in the form of a walk-in spray booth, but both were off for the duration of sampling. Product was sprayed in the booth for a worse-case potential exposure scenario. The general plant location had only general ventilation available, which was not controlled during the sampling, and the conditions during the outdoor study were very light winds, sunny and about 70º F. Both personal and area samples were collected, with the personal sampling done on the spray gun operator and area sampling done at both near (~1-3 feet from spraying) and far (~10-20 feet from spraying) locations.

Occupational Exposure Limits (OEL) have been set for MDI, with the ACGIH TLV® being one of the most recognized and widely used limit. That OEL for the MDI monomer is 5 ppb as an 8 hour Time-Weighted Average and 20 ppb as a 15 minute Short Term Exposure Limit. Note there is no TLV® for the MDI oligomer, but conservative practice would be to consider it equivalent to the monomer and therefore the individual results could be added when comparing them to the limit. Other isocyanate monitoring methods might not separate these two forms yet may produce a response to oligomer, and therefore would give a result that represents more than just the monomeric form but was compared to the monomer limit. New developments in isocyanate monitoring methods and exposure limits should continue to be evaluated when conducting health risk assessments for products containing isocyanates.

If you have questions about this information, please contact me at 1-651-733-8454.

Sincerely,

Kathy Thompson, CIH
Advanced Product Stewardship Specialist
Industrial Adhesives and Tapes Division
kthompson@mmm.com

3M Industrial Adhesives and Tapes Division

3M Center, Building 230-BS-19
St. Paul MN 55144-1000
651-733-8454 (phone)
651-737-3146 (fax)

Polyfoam Product Letter
October 30, 2009
MDI Results Table

Isochek Results in ppb MDI

Product	Location	Sample type	Monomer	Oligomer	Total
PolySet One	Lab - used ~ 30 lbs/15 min	Personal	<0.1	<0.6	<0.7
PolySet One	Lab - used ~ 30 lbs/15 min	Area - Near	<0.1	<0.6	<0.7
PolySet One	Lab - used ~ 30 lbs/15 min	Area - Far	<0.09	<0.5	<0.59
Tite-Set	Lab - used ~ 22 lbs/16 min	Personal	<0.1	<0.6	<0.7
Tite-Set	Lab - used ~ 22 lbs/16 min	Area - Near	0.1	1	1.1
Tite-Set	Lab - used ~ 22 lbs/16 min	Area - Far	<0.09	2.7	<3.6
PolySet Pro-Pack	Plant - used ~ 29 lbs/7 min	Personal	0.5	<1	<1.5
PolySet Pro-Pack	Plant - used ~ 29 lbs/7 min	Area - Near	1.7	2	3.7
PolySet Pro-Pack	Plant - used ~ 29 lbs/7 min	Area - Far	<0.2	<0.1	<0.3
PolySet Pro-Pack	Outside - used 1/3 of PP100/15 min	Personal	<0.1	1	<1.1
PolySet Pro-Pack	Outside - used 1/3 of PP100/15 min	Personal	<0.1	<0.6	<0.7
PolySet Pro-Pack	Outside - used 1/3 of PP100/15 min	Area	<0.1	<0.6	<0.7
PolySet Pro-Pack	Plant - 60 patties, 15 sec apart/15 min	Personal	<0.1	<0.6	<0.7
PolySet Pro-Pack	Plant - 60 patties, 15 sec apart/15 min	Area - Far	<0.1	<0.6	<0.7
PolySet Pro-Pack	Plant - 60 patties, 15 sec apart/15 min	Area - Near	0.2	<0.6	<0.8
InsulSeal	Plant	Area - Far	<0.2	<1	<1.2
InsulSeal	Plant	Area - Near	0.84	<1	<1.84
InsulSeal	Plant	Personal	1.3	<1	<2.3
InsulSeal	Lab - spray 5 min	Personal	<0.6	<3	<3.6
InsulSeal	Lab - spray 5 min	Area - Near	0.6	5	5.6
InsulSeal	Lab - spray 5 min	Area - Far	<0.6	25	<25.6

3M Industrial Adhesives and Tapes Division

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RHH
Study

MDI Testing Protocol

Weston was tasked with measuring potential MDI exposure during application of the Versi-foam product for mining ventilation control. Since application in an actual mine was impractical, WESTON constructed a simulated 20'X6' shaft 80' long with a 100' crosscut at 60' into the shaft. Shaft and crosscut were constructed of 2" PVC pipe and specialty unions (used to produce lawn furniture) covered with heavy (6 mil) plastic sheet and sealed with duct tape. Flow was induced in the 80' shaft using three large axial flow fans. Air flows mimicking a worst case mine ventilation rate of 75 lfm were induced in the main shaft. Air flows were verified using a TSI Model 8330 anemometer. A cinderblock stoppage was constructed at the terminal end of the 100' cross cut. A second test was performed with the stoppage re-located 15' into the crosscut off the main shaft. Ambient temperature during testing was 73 degrees Fahrenheit.

MDI exposures were measured according to OSHA Method 47. Both personnel and area samples were collected during application of the Versi-foam product to the cinder block stoppages. Duplicate samples were collected in the breathing zone of the person applying the foam product and on tripod stands at three distances from the stoppage. Duplicate samples were collected using commercial SKC #225-9002 filter cassettes containing glass fiber filters trested with 1,2-PP derivatizing reagent per the method. Sample flow rates were determined before and after testing using a BIOS Dry-cal flow calibrator. The average flow and sample time was used to calculate sample air volumes. Samples were analyzed in WESTON's AIHA accredited laboratory using a Hewlett-Packard 1050 High Pressure Liquid Chromatograph (HPLC) and Ultraviolet absorbance (UV) detector. Standards and laboratory control samples were prepared from SUPELCO certified standard MDI-1,2-PP derivative solutions. Analytical and quality assurance procedures met or exceeded OSHA method requirements.

Regards,

Brian L Benson, CIH
Senior Industrial Hygienist
Weston Solutions, Inc.
1625 Pumphrey Ave
Auburn, Alabama 36832
(334) 466-5644

Weston Solutions, Inc
1625 Pumphrey Ave
Auburn, AL 36832
(334) 466-5600

MDI Exposure per OSHA Method 47

Client : Stockham, Stockham & Carrol - Bice v. RHH Foam
WESTON W.O. # : 05116.002.004.0002
Date Recieved : 08 July 2004
Date Analyzed : 13 July 2004
Analyst : B Benson
Inst. Detection Limit (µg/mL): : 0.010
Method Reporting Limit (mg/m3) : 0.008 (ppm): 0.0008

Sample Identification	Laboratory Control #	Solvent Vol. (mL)	Sample Air Volume (L)	Analyzed MDI (µg/mL)	MDI (mg/m³)	MDI ppm
100' Stopage - Benson -Personnel	CK 3558	4	15.8	0.0226	0.0057	0.0006
-Duplicate	CK 3559	4	15.4	0.0168	0.0044	0.0004
-Triplicate	CK 3560	4	15.7	0.0165	0.0042	0.0004
-Quadruplicate	CK 3561	4	15.4	0.0130	0.0034	0.0003
	CK 3561 Rep	4	15.4	0.0088	<0.0026	< 0.0003
100' Stopage - Area -10' from stop	CK 3562	4	16.1	0.0144	0.0036	0.0004
-Duplicate	CK 3563	4	15.4	0.0126	0.0033	0.0003
100' Stopage - Area - 40' from stop	CK 3564	4	15.4	0.0000	<0.0026	< 0.0003
-Duplicate	CK 3565	4	16.1	0.0000	<0.0025	< 0.0002
100' Stopage - Area - 80' from stop	CK 3566	4	16.7	0.0000	<0.0024	< 0.0002
-Duplicate	CK 3567	4	15.8	0.0000	<0.0025	< 0.0002
15' Stopage - Benson -Personnel	CK 3568	4	15.3	0.0154	0.0040	0.0004
-Duplicate	CK 3569	4	15.1	0.0320	0.0085	0.0008
-Triplicate	CK 3570	4	15.1	0.0250	0.0066	0.0006
-Quadruplicate	CK 3571	4	14.9	0.0312	0.0084	0.0008
15' Stopage - Area -10' upstream	CK 3572	4	15.5	0.0000	<0.0026	< 0.0003
	CK 3572 Rep	4	15.5	0.0000	<0.0026	< 0.0003
-Duplicate	CK 3573	4	15.4	0.0000	<0.0026	< 0.0003
15' Stopage - Area - Center crosscut	CK 3574	4	15.3	0.0113	0.0030	0.0003
-Duplicate	CK 3575	4	15.2	0.0192	0.0051	0.0005
15' Stopage - Area - 10' Downstream	CK 3576	4	15.1	0.0000	<0.0026	< 0.0003
-Duplicate	CK 3577	4	15.5	0.0031	<0.0026	< 0.0003
[1] Field Blank	CK 3578	4	15.0	0.0000	<0.0027	< 0.0003
[1] Field blank	CK 3579	4	15.0	0.0000	<0.0027	< 0.0003
[1] Lab Method Blank	CK 3580	4	15.0	0.0000	<0.0027	< 0.0003
[1] Lab Method Blank	CK 3581	4	15.0	0.0000	<0.0027	< 0.0003
[1] Lab Spiked Filter*	CK 3582	4	15.0	0.4386	0.1170	0.011
	CK 3582 Rep	4	15.0	0.4385	0.1169	0.011
[1] Lab Spiked Filter*	CK 3583	4	15.0	0.8105	0.2161	0.021
	CK 3583 Rep	4	15.0	0.8187	0.2170	0.021

[1] Assumed 15 L air sample volume for comparison - no actual sample drawn
* Sample CK 3582 spiked with 4 µL, and CK 3583 spiked with 7 µL, of 0.4339 µg/µL (as free MDI) Supeco MDI Cert. Std. Lot#LA76576 - then desorbed in 4.0 mL 10%DMSO/ACN - should yield 0.4339 and 0.7595 µg/mL as analyzed
Spike Recovery = (Analyzed Amount ÷ Spiked Amount)* 100% = 101% & 107%
Relative Percent Difference of Spiked Filter Replicates = 0.04% 0.40%

Brian Benson, CIH
Senior Industrial Hygienist

Weston Solutions, Inc
1625 Pumphrey Ave
Auburn, AL 36832
(334) 466-5600

MDI Exposure per OSHA Method 47

Client : Stockham, Stockham & Carrol - Bice v. RHH Foam
WESTON W.O. # : 05116.002.004.0002
Date Recieved : 08 July 2004
Date Analyzed : 13 July 2004

Exposure Summary

Sample Identification	MDI ppm	Fraction of ACGIH TLV and NIOSH REL @ 0.005 ppm	Fraction of OSHA PEL @ 0.02 ppm
100' Stopage - Benson -Personnel	0.0006	11.2%	2.8%
-Duplicate	0.0004	8.5%	2.1%
-Triplicate	0.0004	8.2%	2.0%
-Quadruplicate	0.0003	6.6%	1.6%
100' Stopage - Area -10' from stop	0.0004	7.0%	1.8%
-Duplicate	0.0003	6.4%	1.6%
100' Stopage - Area - 40' from stop	< 0.0003	n/a	n/a
-Duplicate	< 0.0002	n/a	n/a
100' Stopage - Area - 80' from stop	< 0.0002	n/a	n/a
-Duplicate	< 0.0002	n/a	n/a
15' Stopage - Benson -Personnel	0.0004	7.8%	2.0%
-Duplicate	0.0008	16.6%	4.1%
-Triplicate	0.0006	12.9%	3.2%
-Quadruplicate	0.0008	16.3%	4.1%
15' Stopage - Area -10' upstream	< 0.0003	n/a	n/a
-Duplicate	< 0.0003	n/a	n/a
15' Stopage - Area - Center crossent	0.0003	6.6%	1.6%
-Duplicate	0.0005	9.9%	2.5%
15' Stopage - Area - 10' Downstream	< 0.0003	n/a	n/a
-Duplicate	< 0.0003	n/a	n/a
****Quality Control Samples****			
(1)Field Blank	< 0.0003	n/a	n/a
(1)Field blank	< 0.0003	n/a	n/a
(1)Lab Method Blank	< 0.0003	n/a	n/a
(1)Lab Method Blank	< 0.0003	n/a	n/a
(1)Lab Spiked Filter*	0.011	228.2%	57.1%
	0.011	228.2%	57.0%
(1)Lab Spiked Filter*	0.021	421.7%	105.4%
	0.021	423.4%	105.9%

ACGIH and NIOSH recommended exposure limits are eight hour time weighted averages (TWA_8) BUT we measured short term maximum exposures. Measured levels are maximum exposure concentrations - TWA_8 exposures would involve considerable periods of nondetectable exposure, thus TWA_8 exposures would be even less than short term values presented.Based on this data, is appears inconceivable that the OSHA PEL and ceiling of 0.02 ppm could be exceeded using the product as intended.

Brian Benson, CIH
Senior Industrial Hygienist

APPENDIX B

Overview of Spray Polyurethane Foam Systems

CPI-SPFA
Do-It-Yourself Workgroup

December 1, 2009

American Chemistry Council™ | Spray Polyurethane Foam Alliance SPFA

Agenda

- Welcome & Introductions *(Neeva-Gayle Candelori & Chris Bloom)*
  - Webinar Scope
  - Webinar Goals
- Overview of SPF Systems *(Mark Spence)*
  - Basic PU Chemistry
  - Spray PU Foam Characteristics
- Worker Health & Safety with SPF Systems *(Mark Spence)*
  - Worker Exposure Monitoring
  - PPE Guidance
  - Applicability to DIY Uses
- Summary & Conclusions *(Mark Spence)*
- Discussion & Next Steps *(Chris Bloom)*

1 Dec 2009 / MWS

American Chemistry Council™ | Spray Polyurethane Foam Alliance SPFA

2

DIY Work Group : Formed as part of the Tier II SPF Program

- **DIY Work Group**
  - **Brief Background & Definition**
  - **Scope**
- **Key Objectives for Webinar**

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DIY Work Group : Formed as part of the Tier II SPF Program

For purposes of the DIY Work Group, we are generally saying a DIYer = Consumer

DIY Work Group Objective

To enhance the DIY users understanding of effective practices regarding the safe use and handling of SPF products.

Some Common Acronyms Defined:

OCF = One Component Foam
2KLP = Two Component Low Pressure Kits
2KHP = Two Component High Pressure Systems

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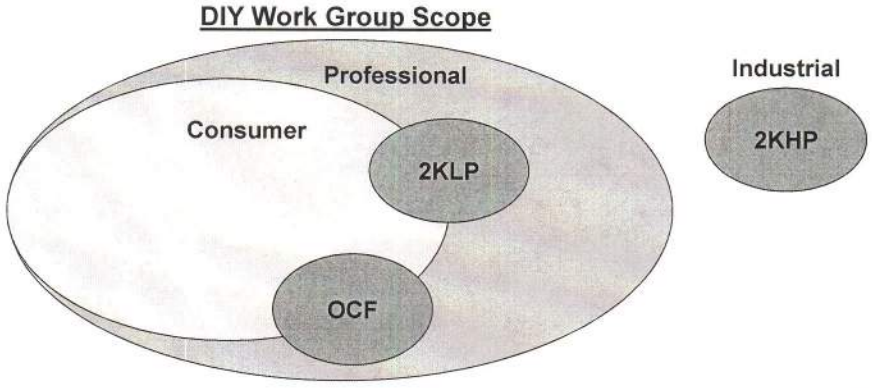
DIY Work Group Scope



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DIY Work Group : Scope Summary

Scope Summary:

- **OCF products available to DIYers / Consumers**
- **2KLP Kits available to both 'professionals' and DIYers / Consumers**

- **2KHP Systems are not generally available (or marketed) to DIYers / Consumers**
  - ***anecdotal information indicates that these systems are not being obtained by DIYers***

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DIY Work Group: Webinar Objectives

- Enhance understanding of PU Chemistry
- Provide a clear differentiation between SPF product types (with a focus on those available to DIYers / consumers)
  - Review Phys-Chem attributes
  - Review some existing monitoring information
  - Review PPE guidance
- Clarify the potential 'risk profile' associated with SPF products available to DIYers / consumers

American Chemistry Council™ SPRAY POLYURETHANE FOAM ALLIANCE SPFA

Overview of SPF Systems

American Chemistry Council™ SPRAY POLYURETHANE FOAM ALLIANCE SPFA

Basic PU Chemistry

- Polyurethane is formed by the mixing and reaction of two components:
  - "A Side" – diisocyanates
  - "B Side – polyol blend

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Basic PU Chemistry

Reaction of two basic chemical ingredients

R - (N=C=O)X
ISOCYANATE

Isocyanate "A"
basic component

+

R' - (OH)Y ----catalyst----> R - N-C O-R'
POLYOL

Resin "B" –
consist of at least five components:
- Polyols
- Surfactants
- Catalyst
- Blowing Agents
- Fire Retardants

O
||
R - N-C O-R'
POLYURETHANE FOAM

+

HEAT
Exothermic reaction

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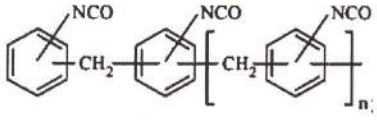
Basic PU Chemistry

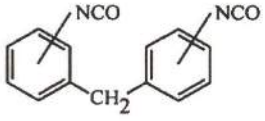
"A side" – Polymeric MDI (PMDI)

– A mixture of homologous compounds:



where n = 0,1, 2, or higher

- 45-55% MDI monomer (n=0):
  - 90+% 4,4'- isomer



- 45-55% MDI oligomers (n=1,2,3…
  - 50% "tri-iso" or "3-ring" (n=1)
  - 25% "4-ring" (n=2)
  - 12% "5-ring" (n=3)

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Basic PU Chemistry

MDI Properties

Property	MDI Monomer	Polymeric MDI
Melting Point (°C)	40	5
Boiling Point (°C)	>300	>300
Vapor Pressure (Pa)	6.2x10-4 @ 20 °C	3.1x10-4 @ 20 °C
Saturated vapor conc. (μg/m3)	64 @ 20 °C	32 @ 20 °C

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Basic PU Chemistry

"B side" – Polyol Blend

- Properties of PU result from polyol structure, additives composition:
  - Polyol (>60%)
    - *(affects structure: e.g., linear vs. branching)*
  - Blowing agents
    - *(low-boiling liquids, e.g., pentane, dimethyl ether, hydroflorocarbons; forms foam, determines foam characteristics)*
  - Fire retardants
    - *(modifies fire characteristics of foam)*
  - Surfactants
    - *(affects foam cell size, structure)*
  - Catalysts
    - *(tertiary amine or organo-metallic; stabilize reactants & accelerate reaction)*

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Basic PU Chemistry

PU Terminology

- *Cream Time* – Mix of isocyanate & polyol (brown liquid) turns opaque tan (reaction begins)
- *Tack-Free Time* – foam surface no longer sticky; second layer of foam can be applied
- *Cure Time* – maximum foam physical properties achieved

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SPF System Characteristics

- Basic Categories:
  - High-Pressure SPF systems
    - 2-component systems
  - Low-Pressure SPF systems
    - 2-component kits
    - 1-component foam products

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SPF Systems

1-Component vs. 2-Component Systems

- 2-Component:
  - Isocyanate and Polyol in separate containers
  - Mixed 1:1 at time of application; 50% PMDI
- 1-Component:
  - Isocyanate and Polyol combined in one container at time of manufacture
  - Mixed at slightly greater than 1:1 into container
  - Forms NCO-terminated PU in container
  - 5-15% PMDI in container as marketed
  - Reaction completed at time of application by reaction with ambient moisture
  - CO_2 secondary blowing agent /propellant produced:
    - **2(R - N=C=O) + H2O ---> R-N-C-N-R + CO2**

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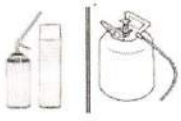
SPF Systems

SPF Delivery Systems

- Containers
  - Refillable Cylinders:
    - 2-component, Low-P only

  - Single-use Drums / Cylinders:
    - 2-component only, High- & Low-P
  - Pressurized Cans / Single-use cylinders:
    - 1-component only



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SPFA

SPF Systems

SPF Delivery Modes

- Spray
  - 2-component only, high & low pressure
  - Product application: insulation, coating

- Stream / Bead
  - 1-component & 2-component, low pressure only
  - Product application: adhesive, sealant

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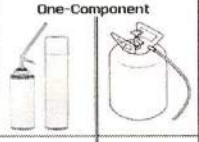
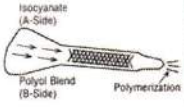
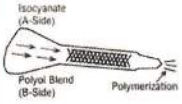
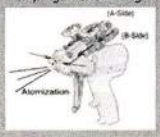
SPF Systems

	Low Pressure				High Pressure
	One-Component		Two-Component Kits	Refillable Systems	High Pressure Spray Systems
					
Delivery Systems Pressure	<150 psi	<250 psi	<250 psi	<250 psi	1000 psi-1300 psi
Contents	.5lbs - 2lbs	10lbs - 23lbs	2lbs - 110lbs *Combined*	250lbs - 1700lbs *Combined*	900lbs - 1000lbs *Combined*
Output	Full Trigger: up to 2-5 lbs per min		Full Trigger: up to 5-7 lbs per min *Standard fan or cone nozzle*	Full Trigger: up to 5-7 lbs per min *Standard fan or cone nozzle*	Full Trigger: up to 30 lbs per min
Mixing	Prepolymer	Prepolymer	Static Mixing	Static Mixing	Impingement Mixing
	Shake Well				
Mixer			Static Mixer	Static Mixer	Chamber Mixing
Housing			Nozzle	Nozzle	Spray Gun
Container *Most Popular Size Sold*	Metal Cans	Single Use Cylinder	Single Use Cylinders	Refillable Tanks	55 gallon drums
Hoses		5-9 ft Hose Assembly	9-15 ft Hose/Gun Assembly	30ft to 60 ft Hoses 30ft to 150ft Heated Hoses	transfer pump system up to 400ft Heated Hoses
Product Temperature Recommended Use	70°F-90°F (21°C-32°C)		70°F-90°F (21°C-32°C) *optimal temp for std systems*	70°F-90°F (21°C-32°C) *optimal temp for std systems*	120°F-150°F (49°C-65°C) *machine heater system*
Foam Properties Curing Tack-Free Time	Moisture Cure 3-20 minutes		Chemical Cure < 1 minute	Chemical Cure < 1 minute	Chemical Cure < 15 seconds
How it is used	Bead Application		Bead Application Spray Coating	Bead Application Spray Coating	Large Area Spray Coating

Worker Health & Safety with SPF Systems

American Chemistry Council

SPRAY POLYURETHANE FOAM ALLIANCE SPFA

Exposure Monitoring

Worker Exposure Monitoring

- Species monitored:
  - MDI
  - MDI & main oligomer ("3-ring", n=1)
- Occupational Exposure Guidelines
  - OSHA: 200 $\mu g/m^3$ MDI (20 ppb; ceiling)
  - ACGIH TLV®: 51 $\mu g/m^3$ MDI (5 ppb; 8-h TWA)

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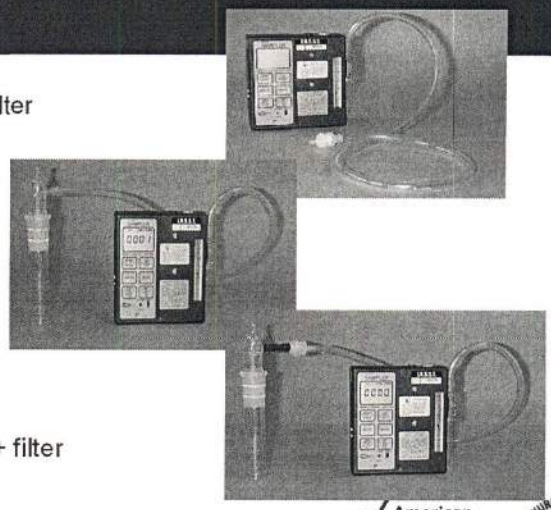
Exposure Monitoring

Sampler Types

- Coated Filter
- Impinger
- Impinger + filter



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Exposure Monitoring

Iso Check Sampler

Exposure Monitoring

High-Pressure Spray Foam Worker MDI Exposures

10 studies, 240+ task and shift samples

	MDI Conc. (mean *[range]*; µg/m³)	
	All samples	8-h TWA
Applicators	**577** *[5 – 2100]*	**320** *[10 – 460]*
Helpers	**113** *[0.1 – 408]*	**51** *[1 – 308]*
Exposure Guidelines	200 (ceiling) OSHA PEL	51 TLV®

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Exposure Monitoring

Low-Pressure Spray Foam Worker MDI Exposures

5 studies, 41 personal (task) samples, 68 area / source samples

	MDI Conc. (mean *[range]*; μg/m³)	
	2-component SPF	1-component SPF
Applicators	**30** *[ND*(6) – 82]*	**ND(6)** *[ND(1) –ND(8)]*
Helpers	**12** *[ND(6) – 36]*	n/a
Exposure Guidelines	200 (ceiling) OSHA PEL	51 (8-h TWA) TLV®

*ND() = not detected @ (detection limit), ½ Detection Limit used for mean

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Exposure Monitoring

Low-Pressure SPF Exposure Study Details

- Lab application (4 studies)
  - Spray onto cardboard / plastic
  - In lab hood (fan off) or plant (general ventilation)
  - Extreme-case simulation
    - More foam applied over shorter period of time
    - Source samples can be taken near point of application
- Application of insulation in home (1 study)

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Exposure Monitoring

Exposure Studies: 2-Component Low-Pressure Kits

Study 1: Residential Wall Insulation Application (spray)
- Method: Impinger

Sample Type	MDI μg/m³ **Mean** *[range]*	n*	#ND
Personal - Applicator	**48** *[16-82]*	6	0
Personal – Helper (3-10' from Applicator)	**16** *[ND(6)-36]*	6	1
Area – 15-30' from Applicator	**1.9** *[ND(2)-4.1]*	8	7

*n= # of samples; #ND = # of samples that were below limit of detection

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Exposure Monitoring

Exposure Studies: 2-Component Low-Pressure Kits (con't)

Study 2: Lab Application; Area samples at hood entrance (fan off)
- 3 different single use kits used; 7-15 min application
- Methods: Impinger w/ backup filter, Filter

Sample Type	MDI μg/m³ **Mean** *[range]*	n*	#ND
Personal - Applicator	**37** *[13-66]*	7	0
Area – Kit A (5 min use periods (3)) *Crack filler / sealer - bead*	**4.9** *[ND(7)-9]*	4	3
Area – Kit B (5 min use periods (3)) *Insulation – spray*	**55** *[38-74]*	3	0
Area – Kit C *(full kit in 12 min)* *Insulation - spray*	**130**	1	0

*n= # of samples; #ND = # of samples that were below limit of detection

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Exposure Monitoring

Impinger / Filter Comparison

- Side-by-side sampling done in Study 2
  (2-component low pressure SPF exposure study)
- 5 data points; Results:
  - Mean Impinger / Filter ratio = 1.7
  - Range: 1.1 – 2.8

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Exposure Monitoring

Exposure Studies: 2-Component Low-Pressure Kits (con't)

Study 3: Lab Application

- 2 different single use kits, 1 refillable system used
- 7-15 min application
- Area samples:
  - near (1-3')
  - far (10-20')
- Method: Iso Check filter sampler
  - Dual filter, MDI & oligomers

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Exposure Monitoring

Study 3 Results (con't)

Sample Type	MDI μg/m³ ;**Mean** *[range]*	n*	#ND
Personal - Applicator	**5.7** *[ND(6)-13]* [olig= ND(10)–10]	6	5
Area, Kit 1: 1-3' 10-20' *Adhesive: bead*	1 [olig=10] ND(0.9) [olig=27]	1 1	0 1
Area, Kit 2: 1-3' 10-20' *Single-use kit: spray*	ND(6)–17 [olig=ND(6)–20] ND(1)–ND(6) [olig= ND(1)–ND(6)]	3 2	1 2
Area, Kit 3: 1-3' 10-20' *Refillable kit: spray*	6-8.4 [olig=ND(10)–50] ND(2)–ND(6) [olig= ND(1)–250]	2 2	0 2

*n= # of samples; #ND = # of samples that were below limit of detection

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Exposure Monitoring

Exposure Studies: 1-Component Foam Products

Study 3,4,5: Lab Application

- Adhesive, single use container; 11-24 min application
- Area samples at 1-20', source (≤ 18")
- Methods: Filter sampler (Study 3: IsoCheck; Studies 4,5: 13mm)

Sample Type	MDI μg/m³; Mean [range]	n*	#ND
Personal - Applicator	ND(6) [ND(1) –ND(8)]	11	11
Area: Near (1-3') Far (10-20')	ND(1) [olig=ND(6)] ND(0.9) [olig=ND(5)]	1 1	1 1
Area: Source	9.2 [ND(6) – 51]	15	13

*n= # of samples; #ND = # of samples that were below limit of detection

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PPE Guidance for Applicators and Helpers

	Low Pressure			High Pressure
	One-component Cans	Two-Component Kits	Refillable Systems	High Pressure Spray Systems
Routes of Exposure	PPE	PPE	PPE	PPE
Eyes	Safety Glasses Safety Glasses	Safety Glasses Safety Glasses or Goggles	Safety Glasses Safety Glasses or Goggles	or FF Mask/ Hood
Skin	Long Sleeves	Long Sleeves	Long Sleeves	Full Body Suits Full Suit
Hands	Gloves	Gloves	Gloves	Gloves
Lungs	Avoid Breathing Vapors Provide Good Ventilation	Respirator &/or Air Purifying OV / Pre-filter Provide Good Ventilation	Respirator &/or Air Purifying OV / Pre-filter Provide Good Ventilation	Air Supply or & FF Mask/ Hood or FF Air Purifying Airline OV/Pre-filter Provide Good Ventilation

For more available information see the Spray Polyurethane Foam Health & Safety Website at www.spraypolyurethane.com

Applicability to Do-It-Yourself Uses

- Low-pressure products studied were:
  - Representative of products for DIY use (2-component single-use kits)
  - Representative of extreme-case DIY use (1-component foams)
    - Professional products (single-use cylinders) used in exposure studies had higher PMDI content than consumer cans (13-15% vs. 6-11%)
    - More material applied during sampling
- Respirator use not necessary for typical 1-component DIY application.

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Summary & Conclusions

- Both 1- and 2- component low pressure foam products have significantly (~10x) lower worker MDI exposure profiles than high pressure foam systems.
- 1-component foam products have significantly lower exposure profiles than 2-component low pressure kits.
- Current PPE guidance for 1- and 2- component low pressure foam products provides adequate protection.
- Ongoing opportunity to provide enhanced outreach and education to DIY audiences regarding use and handling techniques – to be addressed in Tier 2.

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DIY Work Group : Webinar Objectives (re-visited)

- **Enhance understanding of PU Chemistry**
- **Provide a clear differentiation between SPF product types (with a focus on those available to DIYers / consumers)**
  - **Review Phys-Chem attributes**
  - **Review some existing monitoring information**
  - **Review PPE guidance**
- **Clarify the potential 'risk profile' associated with SPF products available to DIYers / consumers**

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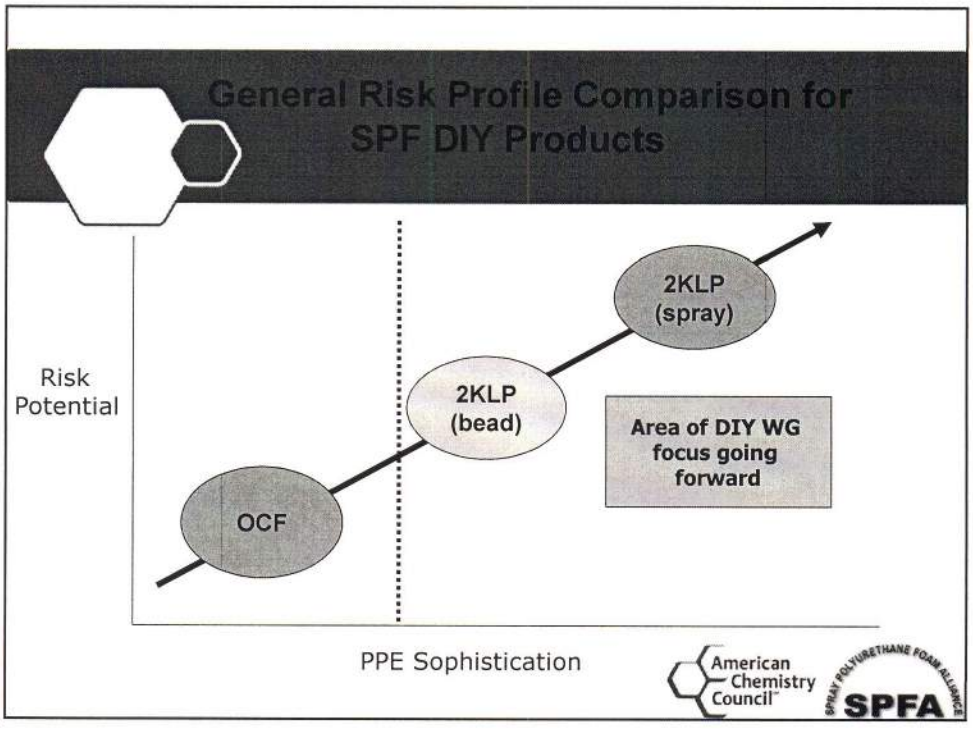
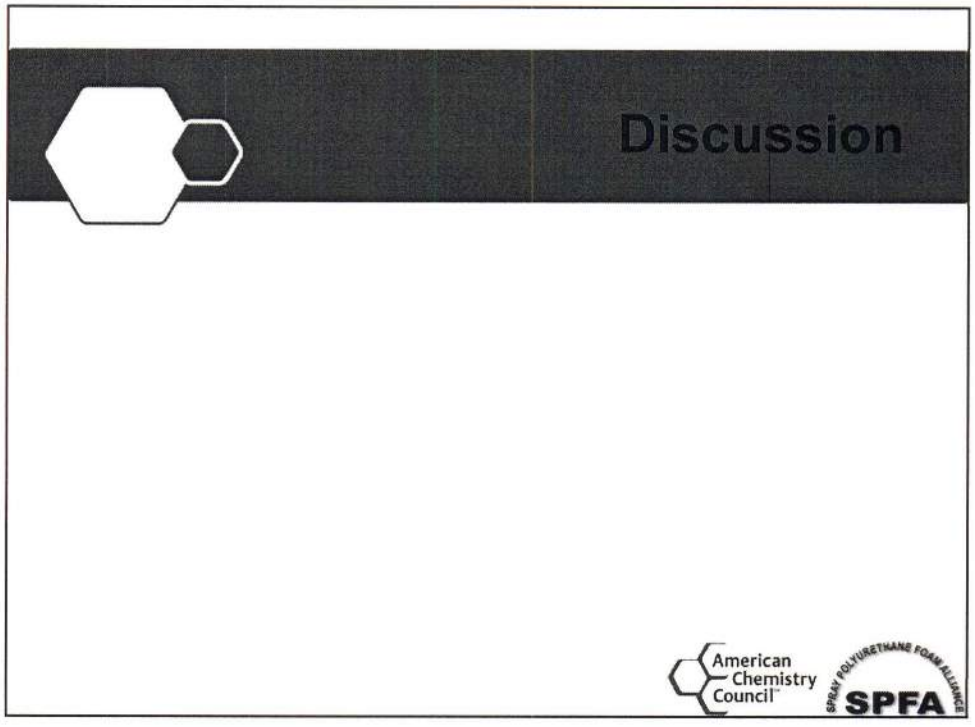

General Risk Profile Comparison for SPF DIY Products
Risk Potential
OCF
2KLP (bead)
2KLP (spray)
Area of DIY WG focus going forward
PPE Sophistication
American Chemistry Council
SPFA


Discussion
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APPENDIX C

The Current MDI Industrial Hygiene Data on Spray Foam

MARK SPENCE
Spence Consulting, LLC
1232 Holyrood St.
Midland, MI 48640

ABSTRACT

Spray application of polyurethane foam for thermal insulation of buildings represents the polyurethane application with the highest potential worker exposure to MDI. This paper reviews the existing work done to characterize the MDI exposures of the sprayed polyurethane foam workers as well as identifying several elements of an effective industrial hygiene program suggested by the existing work. In addition, areas for additional possible work are suggested.

The existing work shows clearly that MDI exposures for both the sprayed foam applicator and helper can exceed both task and shift occupational exposure limits. Additional feasible engineering controls are not obvious, so control schemes based on administrative controls (work practices, establishment of "work zones" and re-entry clearance times) and personal protective equipment (respirators, gloves, and protective clothing) are necessary. Suggestions for more work in the areas of establishing re-entry clearance times and work zones as well as characterizing amine catalyst exposures are made.

INTRODUCTION

The use of sprayed polyurethane foam based on 4,4'-methylene diphenyl diisocyanate (methyl di-p-phenylene isocyanate, or MDI) for thermal insulation in residential and commercial buildings has been growing steadily over the last two decades. With the current emphasis on energy conservation, this trend in sprayed polyurethane thermal insulation use is likely to continue. Sprayed polyurethane foam offers advantages of high thermal insulation value, good sealing and water-resistance characteristics, and avoidance of indoor air quality problems introduced by some other insulation choices. From an industrial hygiene perspective, sprayed polyurethane foam application is the operation presenting the highest airborne MDI exposure potential for workers of all MDI uses [1], and is second only to vehicle spray painting in presenting the highest airborne exposure potential for diisocyanates of all types [2]. For these reasons, an effective industrial hygiene program based on a good understanding of the details of the MDI exposure patterns is important for protecting workers involved in applying sprayed polyurethane foam. This paper is intended to review the MDI worker exposure data that exists for sprayed polyurethane foam, summarize practical conclusions that can be drawn from it, and suggest areas where further investigation could be considered.

BACKGROUND

MDI in Sprayed Foam Formulations

Sprayed polyurethane foam systems consist of two liquid parts which when mixed, react to form a polyurethane polymer: a diisocyanate (referred to commonly as the "A side"), and a polyhydroxy alcohol (polyol; referred to commonly as the "B side"). The B side also contains a blowing agent for foam cell formation (typically a low-boiling hydro-flourocarbon) and small amounts of amine catalysts and other additives. During application, the A and B sides are heated and fed separately to the spray gun, mixing in the spray gun just prior to application. The resulting spray consists of droplets of the warm, rapidly-reacting mixture, as well as vapor from the more volatile components of the system (the blowing agent, and, to some extent, the diisocyanate and the amine catalyst).

The properties of the foam produced are governed primarily by the composition of the B side of the formulation; systems differ in the polyol, catalysts and blowing agents used as well as the relative amounts of each. The A side used in sprayed polyurethane foam insulation is almost always "polymeric MDI" (PMDI) -- an undistilled mixture of MDI and higher molecular weight MDI oligomers. Like MDI, MDI oligomers have active isocyanate functional groups (-N=C=O) that react to form polyurethane polymers. In spray foam formulations, the PMDI used consists of 45-55% of each component (MDI and MDI oligomers) [3].

MDI is a skin, eye and respiratory tract irritant [4]. Exposure to excessive airborne concentrations of MDI can lead to respiratory sensitization, which may result in occupational asthma. MDI may cause skin sensitization in rare cases [4].

There is limited data in animals suggesting that dermal exposure to diisocyanates may also contribute to respiratory sensitization, but this has not been confirmed in humans [5].

Application of Sprayed Foam Insulation

Sprayed polyurethane foam insulation may be applied to residential and commercial buildings during initial construction or as a retrofit insulation improvement. It may be applied to the building exterior (roof tops and walls before sheathing is added), or to interior building spaces (walls, attics, crawl spaces). Because of the need for customized application, sprayed polyurethane foam insulation is usually applied by hand rather than by automated equipment. Application crews typically consist of an applicator, who operates the spray gun, and one or more helpers who work in close proximity to the applicator conducting support activities (guiding hoses, holding windscreens, etc.). Individual workers may switch between the applicator and helper role throughout the workday [3].

EXPOSURE MONITORING CONSIDERATIONS

The complex nature of the exposure environment in sprayed polyurethane foam application (i.e., the presence of both aerosol and vapor forms of air contaminants and the multiple isocyanate-containing species in PMDI) presents several complicating factors in conducting and interpreting MDI exposure monitoring.

Sampler Type

Since isocyanates are reactive species, exposure monitoring methods used for them employ a derivatizing agent, usually a primary amine which serves to stabilize the reactive isocyanate group by forming a urea derivative with them. In addition, the derivatizing agents often contain molecular features which enhance the analytical sensitivity of the resulting derivative [6]. The MDI exposure monitoring done during sprayed foam application reviewed for this paper employed a variety of derivatizing agents, but only two methods of sampling were used: (1) air was drawn through a glass fiber filter which was coated with the derivatizing agent or (2) air was drawn through a glass impinger or bubbler containing an organic solvent solution of the derivatizing agent. In one case [10], a combination of the two techniques was used: the sample train consisted of an impinger followed by an inline coated glass fiber filter.

The coated filter sampling technique has the clear practical advantage of ease of use in the field since the apparatus is less bulky and prone to breakage, and liquid organic solvents, which may evaporate or spill while an impinger is worn by a worker are not used. However, when sampling reactive aerosols such as those present during sprayed foam application, the impinger sampler offers a more accurate assessment of the MDI level present since the reacting droplets that enter the impinger are dissolved in solution with the derivatizing agent, facilitating rapid and complete reaction. In the case of coated filters, the aerosol droplet which is trapped on the filter must spread out and wet the filter in order to come into complete contact with the derivatizing agent. Lesage [7] compared the results of MDI monitoring in sprayed foam environments using both coated filter and impinger-based sampling methodologies, finding that filter sampling results were 6-40% of those obtained from side-by-side samples using impingers. In light of this finding, a practical solution to the dilemma of sampler type versus ease of use for the field industrial hygienist might be to use filter sampling and adjust results for undersampling by multiplying them by an appropriate compensating factor (e.g., twenty).

Exposure Guidelines

Exposure monitoring methods are generally designed to yield results that can be compared to established occupational exposure guidelines for interpretation. Such exposure guidelines are set by governmental or professional bodies based on a review of the toxicological, medical and human experience data. One of the most widely-recognized set of occupational exposure guidelines are the Threshold Limit Values (TLVs®), set by the American Conference of Governmental Hygienists (ACGIH®). The ACGIH TLV for MDI is 0.005 ppm (5 ppb or 51$\mu g/m^3$) as an 8-hour time weighted average. The Permissible Exposure Limit (PEL) set by the United States Occupational Safety and Health Administration (OSHA) for MDI is 0.020 ppm (20 ppb or 200 $\mu g/m^3$) as a ceiling (never to be exceeded) value.

These exposure limits are representative of the majority of those followed globally. A notable exception is the United Kingdom Health and Safety Executive, which has set an occupational exposure limit based on the determination of "total reactive isocyanate group" (TRIG). The HSE TRIG exposure guideline is 70 $\mu g/m^3$ as a ceiling (never to be exceeded) value, and 20 $\mu g/m^3$ as an 8-hour time weighted average [2]. While the TRIG method has the advantage of accounting for exposure to the isocyanate groups present in the MDI oligomers in addition to those in MDI alone, commentators in the U.S. and elsewhere have noted that neither it nor any other current analytical method is capable of accurately quantitating all reactive isocyanate groups [7].

Chemical Species Monitored

Exposure monitoring methods designed to produce data for comparison with the TRIG exposure guideline quantitate both the levels of MDI and the MDI oligomers. As such, they require a PMDI calibration standard, which is often difficult to obtain. The mass of MDI found in the sample is added to the mass of MDI oligomers found and the total is converted to a TRIG number based on the ratio of the monomer molecular mass to the isocyanate group mass; for MDI, this ratio is (250/89=) 0.34 [5].

For exposure monitoring methods whose data is designed to be compared with MDI-based values, only MDI monomer need be determined. In actual practice, a number of investigators determine MDI oligomers as well although comparison with occupational exposure limits is not clear [3,7,10].

The results from studies where both MDI and MDI oligomer data was obtained in sprayed polyurethane foam environments was examined for trends. A total of 53 personal breathing zone results where both MDI and oligomers were detected from four studies [3,5,7,10] were compared. The results of the comparison showed that the mean ratio of total PMDI found to MDI was 1.82 (SD = 0.67). Since the composition of the PMDI is 45-55% MDI, this ratio in the bulk PMDI would be 1.8 – 2.2. This result indicates that the most typical situation found is that the spray sample retained a composition similar to the bulk PMDI material being sprayed. However, there was variation in this relationship: in ten of the samples (20%), the MDI oligomer concentration was higher than that of MDI (i.e., PMDI / MDI ratio greater than 2.0) while in 28 cases, the PMDI / MDI ratio was less than 1.7 (i.e., MDI made up more than 60% of the total PMDI found).

Since analysis of samples for MDI oligomers is considerably more difficult (and therefore more expensive) than analyzing for MDI alone, a practical application of this observation for the practicing field industrial hygienist taking samples in sprayed polyurethane foam environments might be to determine MDI and multiply the results by an appropriate adjustment factor (e.g., two).

SPRAYED FOAM WORKER EXPOSURES

Worker exposure data during sprayed polyurethane foam application from several studies conducted over the last 30 years [2,3,5,7, 10-15] were examined. The data represented over 240 task and shift personal breathing zone samples taken on applicators and helpers during foam application.

The MDI exposure concentrations of spray foam applicators in the studies ranged from 5-2100 $\mu g/m^3$. Where 8-hour time weighted averages were calculated, they ranged from 10-460 $\mu g/m^3$. (The 8-hour time-weighted average takes into account the portion of the 8-hour workday for which the measured concentration applies. For instance, if an applicator's exposure concentration during spraying was 100 $\mu g/m^3$ and they sprayed four hours out of a workday and had no exposure for the rest of the day, their 8-hour time-weighted average exposure would be (100*4/8=) 50 $\mu g/m^3$.) The MDI exposure concentrations of workers in the spray foam helper role in the studies ranged from 0.1-408 $\mu g/m^3$. Where 8-hour time weighted averages were calculated, they ranged from 1-308 $\mu g/m^3$.

Both the spray applicator and helpers clearly have the potential for exposures over both the 8-hour TLV and the OSHA PEL (51 $\mu g/m^3$ and 200 $\mu g/m^3$ ceiling, respectively). The exposures for the spray applicator were consistently 2-4 times higher than those of the helper, but a high degree of variability was noted for both job roles. The high variability in MDI exposures for both the spray applicator and helper was affected by several factors. Indoor spraying resulted in higher exposures [11] while outdoor spraying resulting in more variability in exposure since keeping upwind of the point of application became more important [12]. Natural ventilation, atmospheric and seasonal conditions, building characteristics, surface area and thickness of foam sprayed, applicator's experience level, were also noted as factors affecting exposure levels [3, 11].

Two studies [7, 10] also measured spray foam workers' exposures to the foam blowing agent and one [10] measured exposures to the amine catalyst. In both studies, the exposure of both the applicator and helper to the blowing agent were below the relevant exposure guideline. In the one case where amine catalyst exposure levels were measured, detectable levels were found in some samples, but no exposure guideline for the amine catalyst was given, so evaluating the significance of these results is difficult.

EXPOSURE CONTROL

Given the clear potential for over-exposure to MDI during spray application of polyurethane foam, it is clear that exposure controls are important for workers involved. Ideally, engineering controls are the first tool to be used in exposure reduction efforts. Exploring the use of air curtains, reactive mist barriers, and remote control spraying have been suggested [14], but their application seems difficult given the variability of the construction environment. Since additional engineering controls

appear to be impractical, consistent, disciplined use of administrative controls and personal protective equipment must be relied upon.

Administrative Controls

WORK PRACTICES

One of the fundamental actions that workers can take to reduce exposures to MDI during spraying is positioning themselves upwind of the spray stream as much as possible. This concept should be included in spray applicator and helper training, and rigorously used in the preparation for each spraying session. While attention to upwind positioning has more importance for outside applications because of the variations in wind speed and direction that must be noted and adjusted to, even for indoor applications, there is usually a natural air flow direction that should be noted and taken into consideration.

THE "WORK ZONE" CONCEPT

Several authors [3, 7, 10, 12, 13, 15] report data on the reduction of MDI concentration with distance from the point of spray application. Some refer to the concept of a "work zone" – a distance around the spray gun where MDI concentrations are highest and outside of which significant exposure is not likely. For indoor application, work zone recommendations in the literature range from 6 m (20 ft) [10] to 8 m (25 ft) [12, 15]. For outdoor application, work zone recommendations range from 2m (7 ft) [13] to 3 m (10 ft) [12, 15]. One publication [16] suggests that, since outside spray application is highly influenced by wind speed, an "exclusion zone" be established for 6m (20 ft) on either side of the applicator in still air conditions, or 3 m (10ft) upwind and 8m (25 ft) downwind of the applicator.

Setting a work zone outside of which overexposure to MDI or other components of spray foam system is unlikely to occur is useful as a simple, practical workplace exposure management technique. It establishes a discipline for allowing other construction trades to complete their work safely in areas of the structure reasonably remote from the area to which foam is being applied. Additional data measuring the concentrations of MDI and other spray foam components in areas of the structure other than those being sprayed support this concept. While migration of MDI and other spray foam components to floors other than the one on which foam was being applied was noted, levels found were consistently well below exposure guidelines [3, 10].

CLEARANCE TIME

Another aspect of exposure management is consideration of when to allow re-entry of unprotected workers to the sprayed area. Several of the papers reviewed reported pertinent data.

Lesage et al. [7] report MDI levels in the room where sprayed foam was applied as high as 19 $\mu g/m^3$ in the first 15 minutes after spraying ceased. However, by the time 60 minutes had passed, all samples taken were below the analytical detection limit (0.036 μg).

Karlovich [10] studied the variation with time of concentrations of MDI, blowing agent, and amine catalyst following spray application in the interior of five residential structures. Of 64 samples taken to measure MDI concentrations up to 2 hours post-application, 62 were below the detection limits while two detected MDI at a level of 5 $\mu g/m^3$. All 64 samples were below detection limits for MDI oligomers. Area levels of blowing agent were determined for one of the structures over the period of 40-140 minutes post-application. These levels were well below applicable exposure guidelines and were reduced by a factor of approximately six in the period from 40 to 140 minutes after spraying. Similarly, amine catalyst post-spraying levels were followed in one of the structures. The amine catalyst levels were detectable throughout the period measured and were reduced by a factor of approximately two in the period from 40 to 140 minutes after spraying. Since exposure guidelines for the amine catalysts were not given, interpretation of the exposure significance of the levels found is difficult.

Other authors [3,5] report MDI and MDI oligomer measurements 2 hours after spraying. In all cases, MDI results were below detection limits or detected at levels of 0.03 $\mu g/m^3$ or lower. It is interesting to note that in one case [3] where MDI levels were measured 30 minutes, 60 minutes and 120 minutes post-spraying, on both the level sprayed and another level of the structure to which spray foam had not been applied, MDI levels were observed to peak at 60 minutes post-spraying on the level which was not sprayed while they decayed steadily with time on the level sprayed. This is probably an indication of the time it took suspended aerosol spray droplets to disperse through the structure as a result of diffusion and natural air currents. Achutan et al. [5] report collecting two samples 2 hours after application of sprayed foam on a rooftop in which detectable levels of MDI oligomers were found but MDI was below detection limits. The authors conclude that this was a reflection of the higher reactivity of the isocyanate groups on MDI compared to those on MDI oligomers.

The MDI and blowing agent clearance results point out the importance of ventilating the structure after spraying, and restricting entry for an appropriate period after spraying ceases. It is unclear what clearance time is sufficient to reduce exposure to the amine catalysts to safe levels as exposure evaluation criteria for the amine catalysts were not given. Since there are many factors that could affect this clearance time at a specific job, more work to develop a simple procedure for establishing reentry clearance would be useful.

Personal Protective Equipment

In situations where feasible engineering controls and administrative controls do not adequately lower the potential for overexposure, personal protective equipment is appropriate as a last line of defense. Spray polyurethane foam workers require protection from MDI exposure through both the inhalation and dermal route.

RESPIRATORY PROTECTION

The studies reviewed for this paper are unanimous in their opinion that respirators need to be used by spray applicators and helpers, although the type of respirators observed in use and the observed effectiveness of the employer respiratory protection programs and worker attention to appropriate respirator use procedures varies widely.

Supplied-air respirators (SARs) offer the highest levels of protection, supplying clean compressed breathing air from tanks worn by the worker (self-contained breathing apparatus, or SCBA) or through a hose (airline respirators). While offering the highest levels of protection, this type of respirator has the disadvantages of being relatively expensive and requiring ongoing attention to the maintenance of the equipment and breathing air source.

Air purifying respirators (APRs) offer protection by passing workplace air through cartridges which contain filters and / or adsorbents that remove contaminants from the air. APRs are generally less expensive and simpler to maintain, but since they are "negative-pressure respirators", relying on the wearer's breathing to draw air through the cartridges, APRs are heavily dependent on the wearer's ability to put the face piece on and tighten it correctly to prevent leakage around the face-to-face piece seal. APRs typically use elastomeric half- or full-face pieces; the full-face pieces include an integrated polycarbonate lens providing face and eye protection.

One type of APR minimizes the problem of face seal leakage by using a battery-powered air mover to draw air through the cartridges; these are referred to as powered APRs (PAPRs). PAPRs are available in hood or helmet styles that have an integrated face shield.

If APRs are selected for use by polyurethane foam spraying workers, APR cartridges that are NIOSH approved for both organic vapor protection and particulate (preferably P100 rated) are appropriate. Half-face APR face pieces are not preferred, both because the full-face piece provides a higher level of protection and because eye exposure to many of the amine catalysts used can produce a "halo vision" effect [10].

Whatever types of respirators are selected for use by sprayed foam workers, their use in the workplace should be governed by a respiratory protection program established by the employer (in the United States, this is an OSHA requirement). A respiratory protection program addresses such topics as medical approval, fit testing and training of respirator users; approved respirators and their maintenance; and responsibilities for program oversight. Assistance in establishing such a respiratory protection program that is designed for employers using MDI and PMDI is available [17].

PROTECTIVE CLOTHING

Spray foam workers may experience dermal exposure both by direct contact with the fresh foam surface as well as from spray drift or overspray; both gloves and body protective clothing are required. Lesage et al [7] monitored the foam surface with isocyanate-indicating colorimetric wipes at various times after application. Their results showed the presence of removable isocyanate on the foam surface immediately after spraying, but in all cases (20 samples) no removable isocyanate was detectable on the foam surface 15 minutes after application. However, some tasks (e.g., trimming excess foam) may result in dermal contact with the interior of the foam before final cure has occurred, so for these tasks wearing chemical resistant gloves will help avoid dermal contact with uncured foam.

Information is available on the resistance of many glove and protective clothing materials to MDI and PMDI [18]. Nearly any gloves designed and constructed to be liquid proof will keep the MDI from sprayed foam material from penetrating to the skin. The most highly permeation-resistant materials are needed only when workers are using solvents (as when cleaning spray guns and equipment); in these cases, the gloves should be selected based on permeation resistance to the solvent being used. Likewise, protective clothing used should be designed to keep the sprayed foam material off street clothes and shoes and be readily disposable. Many of the limited-use coverall and boot cover materials available today (e.g., Tyvek ™ and Kleenguard ™) do an excellent job of this.

Disposable or limited-use clothing and gloves offer the added advantage of reducing dermal contamination from contact with outside surfaces during storage or re-use.

CONCLUSIONS AND SUGGESTIONS

The literature reviewed in this paper suggest that many aspects of worker exposure and its control during sprayed polyurethane foam application have been well studied and the elements of an effective industrial hygiene program for this important energy conservation product can be reliably described.

Exposure Monitoring

An impinger-based sampling method with an analysis that quantitates MDI oligomers as well as MDI will produce the most accurate characterization of PMDI exposures in sprayed polyurethane foam environments. If a filter-based sampling technique is used, an appropriate multiplier (e.g., four) can help correct for filter under-sampling of reactive spray aerosols and MDI oligomer concentrations.

Exposure Control

Both the spray foam applicators and helpers can be exposed to MDI concentrations in excess of the relevant task and shift occupational exposure guidelines. Administrative controls such as keeping upwind of the spray drift, establishing a work zone around the point of spray application inside of which respiratory and dermal protection is required, and establishing a clearance time before which unprotected re-entry to the sprayed area is prevented are useful tools in controlling exposure. A set work zone distance in all directions from the point of spray application can be effective. Setting an appropriate re-entry clearance time after spraying is also advisable, although it should be noted that the types and levels of amine catalysts in the sprayed foam formulation could make the set distances and times variable. The work zone distance or re-entry clearance time could potentially be shortened or lengthened by considering conditions on a case-by-case basis.

Respiratory protection to prevent over-exposure to MDI is needed for both sprayed foam applicators and helpers while working in the work zone. Either supplied-air respirators or air purifying respirators with cartridges having both an organic vapor sorbent and a particulate filter can provide adequate protection. Where face and eye protection is needed, respirator styles with full-face pieces, hoods, or helmets with an integral face shield are appropriate for use. No matter which respirator is chosen, a respiratory protection program must be established and diligently adhered to if the expected respiratory protection is to be realized.

Protective clothing and gloves are essential to reduce MDI exposure by the dermal route. Clothing items (coveralls, boot covers, etc.) should be selected to keep the sprayed foam material off street clothes and any exposed skin surfaces. Except for the times when solvents are used, any liquid-proof glove should provide adequate protection. Disposal of contaminated gloves and clothing whenever they are removed is an important practice to reduce dermal exposure to MDI.

Further Work for Consideration

This review has suggested several areas where further work would be of benefit in clarifying the understanding or reduction of sprayed foam worker exposures.

ESTABLISHMENT OF RE-ENTRY CLEARANCE TIMES

The indication that some sprayed foam components (i.e., MDI oligomers, blowing agents, and amine catalysts) may remain present in the air following sprayed foam application for longer periods than indicated by MDI concentrations warrants further study in order to help provide additional guidance in setting clearance times for re-entry.

ESTABLISHMENT OF WORK ZONE LIMITS

The author suggests that an appropriate work zone be established around the point of application. Developing some sort of procedure based on reliable field measurements of MDI concentrations, as well as a better understanding of blowing agent and amine catalyst exposures, would help provide the information needed to understand the site conditions and variables that affect the size of the work zone.

EXPOSURES TO BLOWING AGENTS AND AMINE CATALYSTS

The data on exposure to blowing agents and amine catalysts during sprayed foam application is limited. While measures taken to protect workers from MDI exposure during foam spraying would likely provide protection from blowing agent and amine catalyst exposure, having a more complete database would support this assertion.

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BIOGRAPHY

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Mark Spence is currently a consultant specializing in health & safety programs for manufacturing operations and products in the chemical & plastics industry following a 30-year career with the Dow Chemical Company. Following assignments as industrial hygiene chemist and then Laboratory Director of Dow's AIHA-accredited Industrial Hygiene Laboratory, Mark served as a Senior Industrial Hygienist with Dow's Global Industrial Hygiene Expertise Center. While at Dow, Mark supported Dow's Polyurethanes business on industrial hygiene issues for 20 years. Mark has a Bachelor of Science degree in chemistry from Clarkson University, a Master of Science degree in chemistry from Michigan State University and is a Certified Industrial Hygienist.

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Residential Home Re-Occupancy and Ventilation After Crawl Space Sprayed with Low Pressure Polyurethane Foam

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ABSTRACT

Industrial hygiene air monitoring was conducted during two applications of spray polyurethane foam in the crawl space of a residential home as a part of a product stewardship program. The objective of the study was to determine personal exposure levels and area concentrations of Methylene Diphenyl Diisocyanate (MDI) and 2-Ethylhexanoic Acid during and after application of a closed cell spray polyurethane formulation to the rim joist of the crawl space using two different ventilation rates.

The crawl space was isolated from the other areas of the home by using a temporary barrier and ensuring that a separate source of makeup air was available. EPA and Center for the Polyurethanes Industry (CPI) Ventilation Guidance for Spray Polyurethane Foam Application, as well as the International Building code (IBC 2603.4) and International Residential code (IRC R316.4) principles were incorporated in the study.

The results of the study will be used to enhance Dow's product stewardship practices associated with re-occupancy times following the application of low pressure spray foams. As stated on CPI's website (www.SprayPolyurethane.Org), some manufacturers recommend a one hour re-occupancy time following an interior two-component, low-pressure Spray Polyurethane Foam (SPF) kit application.

BACKGROUND

An industrial hygiene survey was conducted in a home located in Sanford, MI, on November 7, 2012 to measure personal exposures and area concentrations of airborne Methylene Diphenyl Diisocyanate (MDI) and 2-Ethylhexanoic Acid during spray application of FROTH-PAK™ Foam Insulation, polyurethane spray foam, to the rim joist in a crawl space.

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Illustration 1. Residential home site in Sanford, MI.

FROTH-PAK™ Foam Insulation used in this study is a Class A, 2-component, low pressure, polyurethane spray foam produced by Dow Building Solutions, a market-facing business unit of The Dow Chemical Company. Two separate foam applications with a fan nozzle were conducted; one using a ventilation rate of approximately 1400 cfm, and the second using a ventilation rate of approximately 500 cfm.

The Michigan Occupational Safety and Health Administration (MIOSHA) Permissible Exposure Limit (PEL) for MDI is 20 ppb as a ceiling limit. The current American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for MDI is 5 ppb as a TWA (time-weighted average for 8 hours) with no Short-Term Exposure Limit (STEL) or ceiling suggested. The current ACGIH TLV for 2-Ethylhexanoic Acid is 5 mg/m3 as a TWA.

SAMPLING AND ANALYTICAL METHODS

MDI and 2-Ethylhexanoic Acid

Airborne concentrations of MDI and 2-Ethylhexanoic Acid were evaluated using standardized and validated methods at The Dow Chemical Company Industrial Hygiene Laboratory, in Midland, Michigan. The laboratory is accredited by the American Industrial Hygiene

Association. Lab spikes confirmed the validated method recoveries of both methods. Blank samples were treated and analyzed in the same manner as the field samples. The blank sample media were non-detectable at the method detection limit specified for each method.

PROCESS DESCRIPTION

FROTH-PAK™ Foam Insulation 620 Class A polyurethane foam was sprayed with a fan nozzle onto the rim joist in a crawl space under a home. The size of the crawl space was approximately 25 feet by 23 feet with an average height of 40 inches. The rim joists on west, north and east walls were sprayed during two separate applications on the same day.

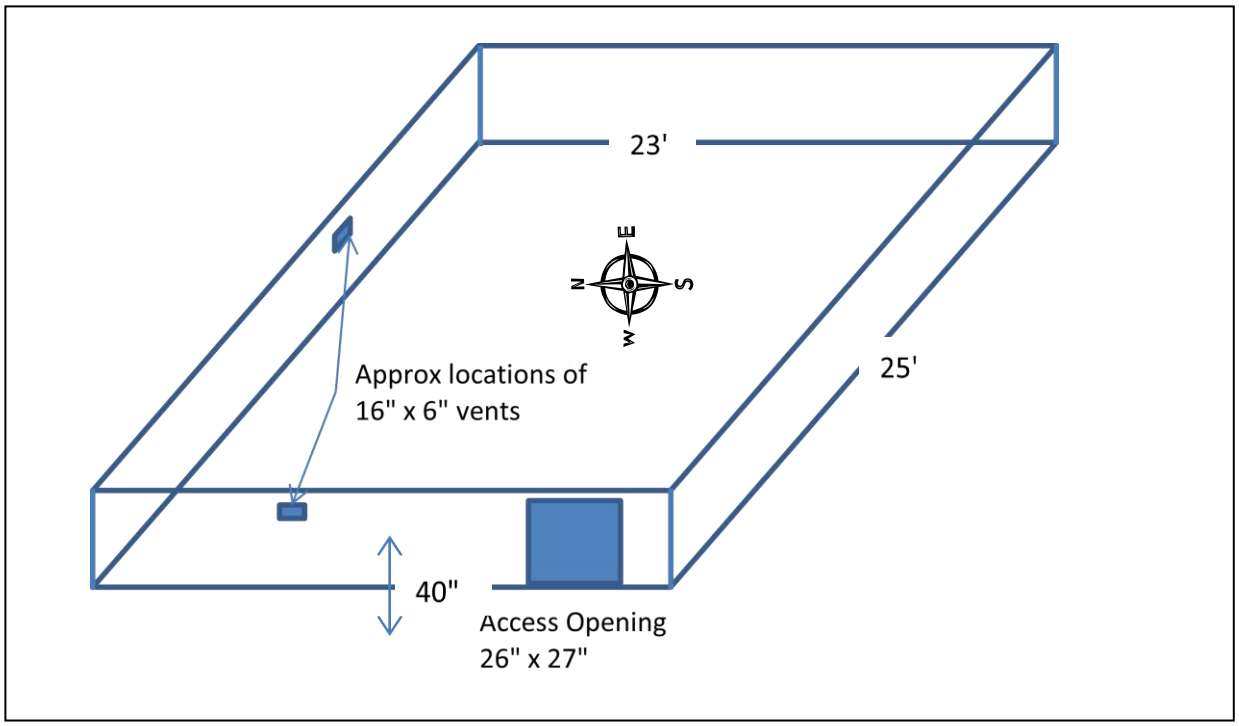

Illustration 2. Crawl space dimensions of home.

Illustration 3. Crawl space of home, Northeast corner & West wall with Northwest corner.

Personal monitors were worn by the spray applicator to measure MDI exposure during application of the low pressure spray foam. The spray applicator wore standard recommended personal protective equipment (PPE), including full body suit with head covering, steel toe shoes, gloves, goggles, and respirator equipped with an organic vapor/acid gas/particulate cartridge. Additionally, a fully PPE suited aide was in the crawl space during the spray period to assist with moving the material cylinders as needed. A safety technician was positioned external to the crawl space opening and wore a Powered Air Purifying Respirator (PAPR) with safety glasses and protective clothing. The applicator and aide were in constant verbal contact with the safety technician, and the safety technician was in contact via phone with the test monitoring personnel located outside of the home.

Illustration 4. Personal monitoring equipment.

The first application was done while using a 1 hp Vortex Axial Fan to exhaust air from the crawl space (approximately 1400 cfm measured at the end of the exhaust duct). This exhaust fan was on loan from a local contractor and is typical of those used during residential spraying of low pressure polyurethane foam. The exhaust fan was placed behind the spray applicator and approximately 2.5 feet inside of the opening to the crawlspace. The opening (on the west wall) was sealed with plastic film through which an approximately 12 inch diameter duct was attached to exhaust the air to the outside of the house. Make-up air was drawn from the outside into the crawlspace through two 16 x 6 inch vent openings located in the west and north walls of the crawl space.

Illustration 5. Crawl space ventilation with 1 hp Vortex Axial Fan & exhaust duct.

The second application was done while using a 20 inch box fan (approximately 500 cfm) to mechanically supply air from the adjoining room (that had an open window) into the crawlspace. The box fan was partially sealed into the crawlspace opening using corrugated cardboard and duct tape. Air in the crawl space was vented outside through two 16 x 6 inch openings located in the west and north walls of the crawl space. The Vortex fan was removed prior to this application.

Illustration 6. Crawl space ventilation with box fan and open external window.

The spraying time was 13 minutes during each of the two applications. The crawl space was mechanically ventilated using the fans during the time of spraying, as well as for a 60 minute period after spraying stopped. Area samples were taken in the center of the crawl space beginning 45 minutes after the spraying stopped to determine airborne concentrations after a 1-hour post-spray "waiting" period.

Illustration 7. Area monitoring location in the center of the crawl space.

The home was unoccupied at the time of spraying as well as for the 1-hour post-spray period. The temperature and relative humidity in the crawlspace was 67°F and 37 % during the first spray period and 62°F and 55% during the second spray period.

RESULTS AND CONCLUSIONS

The following results are based on conditions that existed the day of this survey, November 7, 2012. Changes in equipment, procedures, ventilation, or other conditions that affect exposures may alter or invalidate these conclusions. Conditions were typical.

Personal and Area Monitoring Results

• Table 1 describes the results of short term personal MDI monitoring for an individual who sprayed the FROTH-PAK™ Foam Insulation on the rim joist. There were two separate spray applications with a different ventilation rate used for each application. The first application used an industrial grade fan with a ventilation rate of approximately 1400 cfm and the second application used a typical household "box" fan with a ventilation rate of approximately 500 cfm. The sample time for each application was 13 minutes. Monitoring results were 16 ppb MDI for each of the two personal samples.

• Table 2 describes the results of area monitoring for airborne MDI and 2-Ethylhexanoic acid during two separate foam applications. Samples were taken in the center of the crawl space area; the first, during the 13 minute spraying period, and the second sample time started 45 minutes after the spraying had stopped and lasted for 15 minutes. Sample times ranged from 13 to 15 minutes. The ventilation fans were operating during the 13 minute spraying times as well as during the post-spray periods.

TABLE 1: Short Term Task Monitoring Results of Personal Air Monitoring for Methylene Diphenyl Diisocyanate (MDI) During Application of FROTH-PAK™ Foam Insulation to the Rim Joist in a Crawl Space at a home.

Sample Description	**Total Sample Duration (min)**	**Concentration ppb (v/v) MDI**
Foam Applicator Ventilation rate was approximately 1400 cfm.	13	16
Foam Applicator Ventilation rate was approximately 500 cfm.	13	16
Exposure Limit – ACGIH 8-hour Time Weighted Average (TWA)		5
MIOSHA Ceiling Limit		20

TABLE 2: Results of Short Term Area Monitoring for Airborne Methylene Diphenyl Diisocyanate (MDI) and 2-Ethylhexanoic Acid (EHA) During Application of FROTH-PAK™ Foam Insulation to the Rim Joist in a Crawl Space at a home.

Sample Description	Total Sample Duration (min)	Concentration	
		MDI (ppb)	EHA (mg/m3)
Center of crawlspace during application of foam using 1400 cfm ventilation rate	13	1.7	ND(0.2)
Center of crawlspace 45 minutes after application of foam using 1400 cfm ventilation rate	15	ND(0.4)	ND(0.2)
Center of crawlspace during application of foam using 500 cfm ventilation rate	14	2.2	ND(0.2)
Center of crawlspace 45 minutes after application of foam using 500 cfm ventilation rate	15	ND(0.4)	ND(0.2)
Exposure Limit – ACGIH 8-hour Time Weighted Average (TWA) MIOSHA Ceiling Limit		5 20	5

ND = not detected at the limit of detection indicated in parentheses.

Air change rates were calculated using crawl space area measurements and air speed measurements at fans. The Vortex ventilator air speed measurement was taken at the duct exhaust outside of the home, 1400 cfm. The box fan air speed measurement was taken at the fan face, 500 cfm. The crawl space is approximately 1917 cubic feet, thus the air change per hour (ACH) with the Vortex ventilator unit was approximately 44 AC and H, and with the box fan was approximately 16 ACH, or approximately 1 ½ times every 2 minutes & approximately 1 time every 4 minutes respectively.

Area samples for MDI taken at the center of the crawlspace during foam application were 1.7 ppb when using the 1400 cfm fan and 2.2 ppb when using the 500 cfm box fan. The results of

two area samples for MDI, taken 45 minutes following the end of each application, were both less than the detection limit of 0.4 ppb.

The results of four area samples for 2-Ethylhexanoic Acid were all less than the detection limit of 0.2 mg/m3. These samples were taken at the center of the crawlspace during the application and 45 minutes following the end of spraying.

REFERENCES

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www.SprayPolyurethane.Org

International Building code (IBC 2603.4)

International Residential code (IRC R316.4)

ACKNOWLEDGMENTS

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John Cikalo has worked for The Dow Chemical Company for 32 years in a variety of industrial hygiene related positions and is currently a member of Dow's Global Industrial Hygiene Expertise Center in Midland, Michigan. He serves as a technical expert for industrial hygiene practice in various Dow manufacturing locations throughout the United States and Canada and is the industrial hygiene focal point for Dow's Polyurethanes businesses. His responsibilities also include the support of key elements of Dow's corporate product stewardship program related to customers. John has a Bachelors degree in Honors Biology from The University of Western Ontario, a Bachelors degree in Honors Business Administration from the University of

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Appendix D

Trends in the Incidence/Prevalence of Diisocyanate Related Asthma in the Workplace, Prepared by MA Collins, International Isocyanate Institute Inc.

-AND-

Are Diisocyanate Occupational Asthma Cases Declining? Poster Presented at the Isocyanates and Health Conference

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

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

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

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

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

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

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

1. The incidence of TDI induced asthma may have been as high as 5 % in the early years of

the industry. Incidence rates have declined, paralleling the decline of exposure levels.

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

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

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

MDI and TDI Production Sites

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

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

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

Total exposed population: 185 at <4 hrs/ day and 438 at >4 hrs/day,

While the time basis and number of potentially exposed workers varies for each site, it can be concluded that with application of industrial hygiene practices meeting current regulations, the incidence of respiratory disease and asthma are well controlled.

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

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

EU National Data

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

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

Table 2 – Isocyanate related asthma - Germany

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

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

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

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

In the UK, during the period 1992 – 2001, the annual rate ascribed to isocyanate exposure as causal in the SWORD system was consistent at about 14% of all occupational asthma, or an

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

Table 3. New cases of asthma reported to SHIELD

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

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

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

Other Data

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

Discussion

The data from various national schemes present a broadly consistent picture, showing a reduction of diisocyanate related asthma cases over the last decade, against a background of increasing production and use. The absence of the actual numbers of potentially exposed individuals makes

it impossible to calculate the prevalence of disease. While some reports derive a prevalence, these are usually based on small group of workers often with ongoing health problems and subsequently exaggerate the overall prevalence for the whole industry. To understand the true prevalence of disease a reasonable approach is to use the national statistics and estimates of workers in the industry.

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

Conclusion

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

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

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Are Diisocyanate Occupational Asthma Cases Declining?

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Study Objective

To review recent publications and Surveillance databases in order to evaluate trends of diisocyanate-related occupational asthma (OA).

BACKGROUND

Diisocyanates are often cited as a leading cause of occupational asthma. We reviewed trends of diisocyanate-related OA in order to evaluate the effect of compliance with current occupational exposure limits aimed at preventing new cases.

METHODS

A literature search was done on recent publications. Information was gathered from national or state/province-base registries, surveillance schemes and compensation statistics of various metrics for rates of diisocyanate-related occupational asthma. European manufacturer data on occupational asthma incidence (unpublished data) was collected. Data was reviewed to assess possible trends.

RESULTS

USA, Center for Disease Control (CDC) Work-Related Lung Disease Surveillance System (eWoRLD):

The categories for Diisocyanates n.o.s. (221.00), TDI (221.01), MDI, (221.02), and HDI (221.04) were included for the years 1993-1999, 1993-2002, and 1993-2006. Unfortunately these numbers include work-aggravated asthma cases, reactive airways dysfunction syndrome cases, and confirmed but unclassified cases which may not be diisocyanate asthma.

An average of 30.7 cases per year have been reported during 1993-1999, which dropped to 21.33 cases per year during 2000-2002, and to 20.75 cases per year during 2003-2006.

Years	Number of cases	Number of new cases	New Cases per year
1993-1999	215		30.7
1993-2002	279	64	21.33
1993-2006	362	83	20.75

Michigan, USA:

MICHIGAN'S PROJECT SENSOR publishes annual reports on work-related illness and specifically, WRA (work-related asthma) to isocyanates are recorded. Asthma rates to Diisocyanates have fallen from 22.9 cases per year in 1988-1997 to a recent 6.4 cases per year in 2005-2010.

(http://www.oem.msu.edu/AnnualReports.aspx)

Years	Number of cases	% of cases	Number of new cases	New Cases per year
1988 - 1997	229	19.4		22.9
1988 - 2000	295	18	66	22.0
1988 - 2005	351	14.6	56	11.2
1988 - 2010	383	12.7	32	6.4

Ontario, Canada:

Annual rates of successful isocyanate-related worker compensation claims for occupational asthma have been recorded in the Canadian Province of Ontario. A recent publication reports a reduced annual rate of successful isocyanate-related worker compensation claims comparing **30.5 occupational asthma claims/year** during 1980-1993 with **7.4 claims/year** during the period 1998-2002 (Buyantseva *et al*., 2011).

EU production sites for TDI:

No asthma cases were reported and only one case of other respiratory disease occurred during 2000-2005 in all TDI production plants (III, Unpublished data).

United Kingdom:

Data from the period 1989-1991 showed the proportion of occupational asthma ascribed to isocyanates as **22%** (McDonald *et al*, 2000), while during the period 1992 – 2001 the annual rate attributed to diisocyanates was consistent at about **14%** of all occupational asthma, or an annual average of **84 cases** (McDonald et al 2005). Data for 2008-2010 gives an annual average of **44 cases** (UK HSE 2011).

Netherlands:

For the years 2009-2011 isocyanate-related cases were reported as **none to 4** (Nederlands Centrum voor Beroepsziekten, 2012).

Switzerland:

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

France:

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

Years	avg #cases/year	% of all WRA
2001-2003	49	12.1
2004-2006	38.6	12.3
2007-2009	12.3	4.8

Germany:

Total Diisocyanate asthma cases recorded as 'new pension because of recognized occupational disease' show a decline over the last 16 years (DGUV).

Years	Average/year
1995 - 1999	47
2000 – 2004	26.6
2005 – 2010	17.3

CONCLUSIONS

Metrics on diisocyanate-related asthma rates indicate a significant reduction in reported cases. The data variability can be accounted for by the difference in source and method of diagnosis, which varies from patient's association of symptoms with work and a physician diagnosis of asthma (UK) to specific challenge testing (Canada and Germany). We emphasize the importance of exposure control and medical surveillance which various authors advocate as strong methods of prevention.

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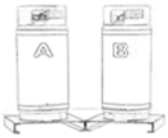
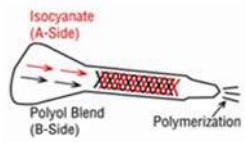
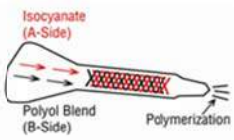
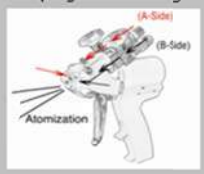
Appendix E

Chart Detailing SPF Product Types and Delivery Methods, Source: CPI Health and Safety Product Stewardship Workbook for High-Pressure Application of SPF

	Low Pressure				High Pressure
	One-Component		**Two-Component Kits**	**Refillable Systems**	**High Pressure Spray Systems**
					
Delivery Systems Pressure	<150 psi	<250 psi	<250 psi	<250 psi	1000 psi-1300 psi
Contents	.5lbs - 2lbs	10lbs - 23lbs	2lbs - 110lbs *Combined*	250lbs - 1700lbs *Combined*	900lbs - 1000lbs *Combined*
Output	Full Trigger: up to 2-5 lbs per min		Full Trigger: up to 5-7 lbs per min *Standard fan or cone nozzle*	Full Trigger: up to 5-7 lbs per min *Standard fan or cone nozzle*	Full Trigger: up to 30 lbs per min
Mixing	Prepolymer	Prepolymer	Static Mixing	Static Mixing	Impingement Mixing
	Shake Well				
Mixer			Static Mixer	Static Mixer	Chamber Mixing
Housing			Nozzle	Nozzle	Spray Gun
Container *Most Popular Size Sold*	Metal Cans	Single Use Cylinder	Single Use Cylinders	Refillable Tanks	55 gallon drums
Hoses		5-9 ft Hose Assembly	9-15 ft Hose/Gun Assembly	30ft to 60 ft Hoses 30ft to 150ft Heated Hoses	transfer pump system up to 400ft Heated Hoses
Product Temperature Recommended Use	70°F-90°F (21°C-32°C)		70°F-90°F (21°C-32°C) *optimal temp for std systems*	70°F-90°F (21°C-32°C) *optimal temp for std systems*	120°F-150°F (49°C-65°C) *machine heater system*
Foam Properties Curing Tack-Free Time	Moisture Cure 3-20 minutes		Chemical Cure < 1 minute	Chemical Cure < 1 minute	Chemical Cure < 15 seconds
How it is used	Bead Application		Bead Application Spray Coating	Bead Application Spray Coating	Large Area Spray Coating

Appendix F

Occupational Exposure Limits for Some Chemical Components of SPF Chemicals, Coatings, and Solvents, Source: CPI Health and Safety Product Stewardship Workbook for High-Pressure Application of SPF

Table C-1: Occupational Exposure Limits for Some Chemical Components of SPF Chemicals, Coatings, and Solvents				
Product Type	**Chemical Name (abbreviation)**	**OSHA PEL**	**NIOSH REL**	**ACGIH TLV**
A-side	Methylene bisphenyl isocyanate (MDI)	NA 0.02 ppm (C)	0.005 ppm (TWA) 0.020 ppm (C)	0.005 ppm (TWA) NA
Aromatic Polyurethane Coatings	2,4- Toluene diisocyanate (TDI)[4]	 0.02 ppm (C)	NA NA	0.005 ppm (TWA)[1] 0.02 ppm (STEL)[2]
Aliphatic Polyurethane Coatings	1,6-Hexamethylene diisocyanate (HDI)	NA NA	0.005 ppm (TWA) 0.020 ppm (C)	0.005 ppm (TWA) NA
Butyl Polyurethane Coatings	o-, m-, and p-Xylene	100 ppm (TWA) NA	100 ppm (TWA) 150 ppm (STEL)	100 ppm (TWA) 150 ppm (STEL)
Polyurethane Coatings	n-Butyl acetate	150 ppm (TWA) NA	150 ppm (TWA) 200 ppm (STEL)	150 ppm (TWA) 200 ppm (STEL)
Polyurethane Coatings	Methyl Isobutyl ketone (MIBK)	100 ppm (TWA) NA	50 ppm (TWA) 75 ppm (STEL)	50 ppm (TWA)[3] 75 ppm (STEL)
Polyurethane Coatings	Toluene	200 ppm (TWA) 300 ppm (C)	100 ppm (TWA) 150 ppm (STEL)	20 ppm (TWA) NA
Polyurethane Coatings and Solvents	Methyl ethyl ketone (MEK)	200 ppm (TWA) NA	200 ppm (TWA) 300 ppm (STEL)	200 ppm (TWA) 300 ppm (STEL)
Polyurethane Coatings and Solvents	v-, m-, and p- Naphtha	100 ppm (TWA) NA	100 ppm (TWA) NA	NA NA
Solvents	2-Ethoxyethanol	200 ppm (TWA) NA	0.5 ppm (TWA) NA	5 ppm (TWA)[4] NA
Solvents	Isopropyl alcohol	400 ppm (TWA)	400 ppm (TWA) 500 ppm (STEL)	200 ppm (TWA) 400 ppm (STEL)
Solvents	Triorthocresyl phosphate (TCP)	0.1 mg/m^3 (TWA) NA	0.1 mg/m^3 (TWA) NA	0.1 mg/m^3 (TWA)[4] NA

[1]ACGIH has requested comments regarding a proposed Notice of Intended Change for the TLV-TWA for TDI. The Notice includes a proposal for a TLV-TWA for inhalable fractions and vapors of TDI, lowering the TLV-TWA from 0.005 ppm to 0.001 ppm, and adding a skin notation due to the potential for skin absorption.

[2]ACGIH has requested comments regarding a proposed Notice of Intended Change for the TLV-STEL for TDI. The Notice includes a proposal for a TLV-STEL for inhalable fractions and vapors of TDI, and lowering the TLV-STEL from 0.02 ppm to 0.003 ppm.

[3]ACGIH has requested comments regarding a proposed Notice of Intended Change for the TLV-TWA for MIBK. The Notice includes a proposal to lower the TLV-TWA from 50 ppm to 20 ppm.

[4]ACGIH assigned a "SKIN" notation to these chemicals because they can be readily absorbed through the skin.

Source: CPI Health and Safety Product Stewardship Workbook for High-Pressure Application of SPF