Developing a National Emissions Inventory for 4, 4'-Methylene Diphenyl Diisocyanate

William Robert
BASF Corporation and American Chemistry Council's Diisocyanates Panel

Dennis Miller
American Chemistry Council's Diisocyanates Panel

Jeffrey Holmstead and Scott Schang
Latham & Watkins

Anne Pope
U.S. Environmental Protection Agency, Emission Factor and Inventory Group

Stephanie Finn
Eastern Research Group, Inc.

ABSTRACT

Over the last decade, the U.S. Environmental Protection Agency (EPA) has been developing, refining, and updating the National Toxics Inventory (NTI), a nationwide emissions inventory of 188 compounds and classes of compounds that are listed as hazardous air pollutants (HAPs) under the federal Clean Air Act. One of these compounds is 4, 4'-methylene diphenyl diisocyanate (MDI), which is widely used in the production of rigid polyurethane foams and also used to a lesser extent in coatings, adhesives, sealants, and elastomers.

Both EPA and the manufacturers of MDI recognized that early NTI estimates of MDI emissions suffered from two major flaws: (1) because of the methodology used to collect NTI data, many MDI-emitting facilities were not included in the NTI; and (2) much of the available data on MDI emissions is based on the incorrect assumption that all MDI used by a facility is emitted when, in fact, MDI is normally reacted with a polyol and is therefore largely "consumed" in the manufacturing process. Thus, on one hand, early versions of the NTI omitted many facilities that should have been included. On the other hand, for facilities that were included in the NTI, MDI emissions tended to be overestimated – often substantially.

In order to develop a more accurate inventory of nationwide MDI emissions, the Diisocyanates Panel of the American Chemistry Council (the Panel) has worked with EPA over the last several years to develop a more accurate inventory of MDI emissions. The Panel used a variety of sources, including EPA's "Toxics Release Inventory" (TRI), in an effort to identify all sources of MDI emissions in the country. It then divided these sources into categories (eventually numbering 32) based on the way in which MDI is used in their manufacturing processes. Using a calculation method developed by what is now known as the Alliance for the Polyurethanes Industry (and approved by EPA in the early 1990s), the Panel then developed emissions estimates

for "typical" and the largest expected sources in each of the 32 categories. In addition, to confirm these estimates, the Panel developed and obtained EPA approval for a test method that allowed MDI emissions to be monitored at a fraction of the cost of previous methods. It then undertook a substantial stack sampling program to verify its emissions estimates. Finally, in conjunction with EPA, the Panel developed (1) MDI emissions estimates for over 800 facilities not listed in early versions of the NTI and (2) corrected emissions estimates for facilities in the NTI that likely misreported MDI emissions.

Based on this effort, the number of MDI-emitting facilities included in the NTI increased from 248 to 1,088. Total MDI emissions in the inventory, however, decreased substantially – from 129.24 tons (from 248 facilities) to 32.65 tons (from 1,088 facilities).

INTRODUCTION

MDI is widely used in the production of rigid polyurethane foams and is also used to a lesser extent in the production of coatings, adhesives, sealants, and elastomers. In addition, MDI is used in wood binding facilities to form polyurea. MDI reacts very quickly when forming polyurethane and, in most applications, virtually all MDI is reacted. MDI's vapor pressure is approximately 1×10^{-6} mm Mercury at 20° C. Thus, emissions from handling and storage of MDI are known to be quite low.

Most MDI is used in a mixture with polymeric MDI (PMDI), which has a vapor pressure an order of magnitude lower than MDI's vapor pressure. The most widely used mixture consists of 50% MDI and 50% PMDI.

Historical Estimates of MDI Emissions

Since the creation of the Toxics Release Inventory (TRI) in 1986, virtually all facilities that process or use MDI have been required to report their MDI "releases" (including their air emissions) on an annual basis. For a number of years, however, both EPA and the Panel have realized that MDI users frequently over-report MDI emissions on their TRI reports. Based on numerous contacts between MDI producers and their customers, it is clear that many MDI users simply assume – incorrectly – that their MDI emissions are equivalent to their MDI usage or PMDI usage.

In response to concerns about over-reporting, the Society of the Plastics Industry's Polyurethanes Division, which is now a part of the American Plastics Council known as the Alliance for the Polyurethanes Industry, developed a detailed method (often referred to as the "Notebook Method") that a number of industry sectors can use to estimate their MDI emissions more accurately.[1] The Notebook has been updated several times, most recently in 1999, and companion software is now available for many industry sectors. EPA has reviewed and approved the Notebook as an appropriate method for estimating MDI emissions and has included a link to the software on its web site.[2]

Over the last several years, the Panel has undertaken to educate MDI users by distributing the Notebook and calling attention to the TRI overestimates. For example, a boat manufacturing facility reported over *47 tons* of MDI emissions to the TRI, while the Notebook predicted less than *1 pound* of annual emissions. Subsequent monitoring conducted by the Panel confirmed that less than 1 pound of MDI was emitted annually by this facility. In another dramatic example, a foundry reported 130.5 tons of annual MDI emissions to the TRI, while the Notebook Method calculation estimated the likely maximum emissions at 13 pounds.

In connection with an EPA project, the Panel estimated 1990 nationwide emissions of MDI based upon 1990 TRI reports. To do this, the Panel divided the facilities reporting MDI emissions on the 1990 TRI into source categories, and then used the Notebook Method to estimate the reasonable worst-case MDI emissions for facilities in each source category. The source category estimate was used in place of all likely overestimates except for the wood binders (for which actual sampling had been done) and MDI producers (which were not covered by the Notebook Method). The total MDI emissions reported on the 1990 TRI were 265.59 tons. The Panel estimated, however, that total emissions from all these facilities could not have exceeded – and were probably less than – 7.23 tons. Thus, the 1990 TRI appeared to overstate MDI emissions from these facilities by at least 97%.

The National Air Toxics Assessment and the National Toxics Inventory

EPA's National Air Toxics Assessment (NATA) calls for the Agency to measure reductions in HAP emissions from 1993 to 2010 and to evaluate risk reductions attributed to Clean Air Act programs. As part of this effort, EPA needs a model-ready national inventory of HAP emissions that it could update periodically. The NTI is intended to meet this need.

In 1993, EPA released the first NTI, which contained emissions data on major sources (stationary facilities that have the potential to emit annually 10 tons of one HAP or 25 tons of more than one HAP), area sources (stationary facilities that emit smaller amounts of HAPs than major sources), and mobile sources. The 1993 NTI lacked facility-specific information, however, that would allow modeling. The Agency addressed this shortcoming in the next version of the NTI, which was based on 1996 emissions data.

The five primary sources of data for the 1996 NTI were: (1) HAP inventories reported by state and local air pollution control agencies; (2) existing data from EPA's development of certain regulations known as "maximum available control technology" (MACT) standards; (3) TRI data; (4) emissions estimates for mobile sources based upon EPA Office of Transportation and Air Quality estimation methods; and (5) emissions estimates for 30 area source categories based upon emission factors and activity data.

As noted above, EPA wanted the 1996 NTI to be model-ready, which required detailed facility-specific information. For major sources, facility-specific data, such as location and number and height of stacks, were included in the 1996 NTI based upon the HAP emissions inventories provided by thirty-six states. EPA evaluated and supplemented these data with MACT and TRI data. Efforts were also made to supply missing facility location information by consulting other EPA data bases. Where facility-specific stack data were not available, EPA used default parameters associated with the facility's Source Classification Codes (assigned at process level) or Standard Industrial Classification (SIC) Code (assigned at facility level).

For non-point stationary sources in the NTI, EPA aggregated emissions at a county level. Based upon the data sources noted above, EPA created a list of non-point stationary source categories. If sufficient data were available from the data sources to derive a source category emissions estimate, this estimate was used. Otherwise, EPA relied upon emission factors from published documents, such as AP-42, to estimate source category emissions in a top-down fashion.[3] The emissions were allocated geographically based on location surrogates, such as population and SIC Code employment.

For mobile sources, EPA relied upon models of both on-road and non-road emissions assembled by the EPA Office of Transportation and Air Quality coupled with vehicle miles traveled from the Department of Transportation's Federal Highway Administration's 1996 Highway Statistics. Aircraft, locomotive, and marine emissions were also estimated using similar methods. MDI is not emitted by mobile sources; such sources are not discussed further in this article.

MDI Emissions in the 1996 NTI

The 1996 NTI reflected total MDI emissions of 129.24 tons, with some facilities emitting as much as 26.5 tons of MDI per year. The MDI emissions of the 10 facilities reporting the largest MDI emissions on the 1996 NTI totaled more than 75 tons. Given the high reactivity and low volatility of MDI, the Panel believed that these emissions were likely significantly overstated.

State and local HAP inventories were the sole data source for the 1996 NTI emissions of MDI. These inventories showed 248 facilities emitting approximately 129.24 tons of MDI. Because HAP inventories were submitted by only 36 states, no MDI emissions were reported in several states, including New Jersey. No data were based upon TRI reports because the NTI was compiled by searching for TRI data using Chemical Abstract Service (CAS) numbers. Beginning in 1994, EPA combined MDI with other diisocyanates to form the "diisocyanates" reporting category in the TRI. Therefore, the 1996 TRI does not list the CAS number for MDI. As a result, facilities listed in the TRI as emitting diisocyanates were not included in the NTI unless they were also included in a state or local HAP inventory submitted to EPA.

METHODOLOGY FOR ESTIMATING 1996 MDI EMISSIONS

Based upon its review of the 1996 NTI and several years of TRI data, the Panel approached EPA and Eastern Research Group, Inc. (the EPA contractor working on the NTI) to suggest a cooperative effort to address the two major flaws in the NTI data for MDI: (1) the omission of many known sources of MDI emissions; and (2) the need to develop more accurate emissions estimates for all MDI-emitting facilities based on the data gathered by the Panel in attempting to address the issue of over reporting on the TRI. In order to improve the NTI, the EPA encourages stakeholder participation in the development of emissions estimates and in the review of the data. EPA and ERG welcomed the improvements to the MDI inventory and have suggested that other industries follow the Panel's example of how to improve the NTI emissions estimates. The three parties agreed on the following approach.

Identification of Facilities Emitting MDI

As its first step, the Panel compared the list of MDI emitters in the 1996 NTI to the list of facilities reporting "diisocyanate" emissions in the 1996 TRI. Based on an earlier effort to compare the 1996 TRI data to the 1993 TRI data (the last year for which MDI was reported separately in the TRI), the Panel had already identified the facilities reporting 1996 emissions of diisocyanates that were likely using MDI. Based on this earlier effort and further analysis of the 1993 and 1996 TRI data, the Panel identified those facilities in the TRI that likely used and emitted MDI. The Panel added these facilities to the NTI if they were not already listed in the NTI as emitting MDI. This increased the number of MDI-emitting facilities in the 1996 NTI from 248 to 1,088

Creation of MDI Source Categories

The Panel then divided the universe of facilities emitting MDI into 30 categories to reflect their use of MDI. These categories are listed in Table 1. The Panel assigned each facility to one of these categories based on the SIC Code listed for the facility. If the SIC Code did not provide a sufficient basis for assignment to a category, the Panel contacted the source to determine the manner in which it utilized MDI. The Panel contacted many other sources to confirm that their SIC Code reflected the manner in which they utilized MDI. The Panel also relied on the expertise of its member companies, who count MDI emitting facilities among their customers, to refine the allocation of facilities to source categories.

This process led to several adjustments among the source categories. It was discovered, for example, that some truck manufacturers use MDI as an adhesive, not as an insulating or foaming agent. Further, the Panel added two source categories to reflect processes not accurately portrayed by existing categories. The first, agri-fiber, is a relatively new process involving the production of fiberboard using agricultural waste products much as wood products are used in the production of particle board. The second, belt manufacturing, involves the dipping of fiber cords into vats of MDI.

Derivation of MDI Emissions Estimates

The Panel grouped the 32 source categories according to the manner in which they use MDI: enclosed processes, open processes, and specialty applications. Enclosed processes are ones in which MDI or PMDI is injected, poured or sprayed into a cavity, mold, or other enclosed space and the injected MDI reacts to fill the space. Open processes are ones in which the MDI or PMDI is injected, poured, sprayed, or coated onto a surface that is exposed to the atmosphere. Specialty applications make up the remainder of the processes and include wood binders, agri-fiber particle board manufacturing, repackagers, and belt manufacturing.

Table 1. Initial List of Source Categories

Air filter	Custom molder	Producers
Appliance	Door	Rebond
Appliance - truck	Electronics	Recreation
Auto	Filter devices	Repackagers
Boat	Foam producer	Shoe sole
Coating - adhesive	Foundry	Spandex
Coating - elastomeric	Laminator	Specialty product
Coating - other	Mobile home	Tire fill
Coating - sealant	Oil	Water heater
Coating - TPU	Packaging	Wood binders

The Panel used the Notebook Method to derive reasonable worst-case emissions estimates for each type of open and closed process. The Notebook Method takes into account MDI emissions from both MDI and mixtures of MDI with PMDI. The Notebook Method relies on several conservative assumptions, such as assuming that a uniform concentration of ambient MDI is present throughout the facility. Fugitive emissions are then based on the volume of air in the entire facility and the number of air exchanges. In reality, most MDI sources use local ventilation to control MDI fugitive emissions in such areas to avoid excessive air exchanges and resultant heating and cooling losses. As a further conservative step, the Panel assumed that each facility operated 8,760 hours per year.

Stack Sampling to Validate Estimates

Historically, the only EPA approved method for sampling MDI emissions has been EPA Conditional Test Method 23. The Panel has used this method to monitor stack emissions from a boat manufacturing facility and several wood binding facilities. This method costs between $25,000 and $30,000 per stack, which makes it impractical to use on a widespread basis.

In order to generate more actual data on MDI emissions and evaluate the Notebook Method, Richard Ode, Manager of Environmental Testing Services at Bayer Corporation, developed a new stack sampling method, known as Conditional Test Method 31, which is a screening procedure based on 13 mm filters impregnated with 1,2-pyridyl piperazine. The method eliminates the complex equipment required in Conditional Test Method 23 and makes use of the fact that particulate sampling at conditions well below isokinetic will lead to over-sampling. Thus, the data generated will be biased high. The EPA reviewed and approved this procedure as a screening method subject to the provision that if the data obtained from the filter procedure are less than an action level, no additional testing is necessary because the data are biased high. However, if the data show emission rates higher than an action level, the more extensive Conditional Test Method 23 should be employed. Because very little equipment is necessary for the screening procedure, the cost to monitor one or more stacks was reduced to $5,000 to $7,000 per facility.

In conjunction with Roy Weston Associates, the Panel sponsored the monitoring of 66 stacks at 18 facilities nationwide that represent 13 different MDI applications. The Panel chose facilities to monitor by targeting those that reported high emissions to the TRI and that were representative of facilities in that source category. Collectively, the types of facilities monitored account for more than 95% of MDI emissions as reported in the 1996 TRI.

To estimate storage and fugitive emissions for facilities at which stack sampling was conducted, the Panel relied on the Notebook Method to estimate reasonable worst-case emissions. Based upon actual facility conditions, such as likely emissions from the process, size of the areas where MDI usage and storage occurred, and ventilation of the area, the Panel estimated reasonable worst-case fugitive emissions by assuming either 0.001 ppm or 0.003 ppm MDI present throughout the area in which MDI processing occurred. For the agri-fiber, appliance, and foundry categories, fugitive emissions were captured and funneled to the stacks monitored by the Panel's stack sampling. Therefore, the stack samples accounted for both stack and fugitive emissions for these three categories of facilities.

RESULTS AND DISCUSSION

Categorical Emissions Estimates Based on Notebook Method Compared to Emissions Estimates Based on Stack Sampling

Based upon the Notebook Method, the Panel estimated reasonable worst-case emissions from the source categories in the open and closed process categories. These are listed in Table 2. Using Conditional Test Method 31, the Panel measured the annual stack emissions per line based upon operation 8,760 hours per year for several sources. These are listed in Table 3.

The Panel calculated the likely facility-wide MDI emissions for facilities where stack sampling was done by including estimated storage and fugitive emissions for each facility as described above. The Panel compared these facility-wide estimates to the emissions estimates obtained using the Notebook Method. This comparison is presented in Table 4.

For nine source categories, the stack monitoring confirms that the emissions estimates derived using the Notebook Method are conservative and usually overstate MDI emissions. For six of these categories, the stack sampling revealed no MDI releases above the detection limit. Therefore, the values provided for these six categories are merely the detection limit of the stack monitoring coupled with the storage and fugitive emissions estimates.

Table 2. Reasonable Worst-Case Estimate for Open and Closed Processes

Source Category	Estimated Emissions (lb/year)
Air filter	15
Agri-Fiber	Specialty Application
Appliance	21
Appliance - truck	9
Auto	15
Belt manufacturer	Specialty Application
Boat	9
Coating - adhesive	15
Coating - elastomeric	15
Coating - other	15
Coating - sealant	15
Coating - TPU	15
Custom molder	9
Door	4
Electronics	15

Source Category	Estimated Emissions (lb/year)
Filter devices	9
Foam producer	21
Foundry	13
Laminator	17
Mobile home	15
Oil	9
Packaging	15
Producers	Specialty Application
Rebond	70
Recreation	15
Repackagers	Specialty Application
Shoe sole	15
Spandex	15
Specialty producer	10
Tire fill	4
Water heater	17
Wood binders	Specialty Application

For two source categories, appliance manufacture and foundries, the total facility emissions estimated using the Notebook Method were less than the total facility emissions estimated using stack sampling. These facilities' fugitive emissions were measured by stack sampling, and the sampling failed to detect MDI. Therefore, both the stack and fugitive emissions from these facilities were assumed to be equal to the detection limit of the sampling equipment. The sampling method detection limit applied to the volume of air in the area where MDI is processed leads to a relatively high fugitive emissions estimate. This compounded conservatism accounts for the stack sampling estimates exceeding the Notebook Method estimates. The Notebook Method was not shown to be insufficiently conservative by this comparison.

Revision of NTI Based upon Panel's Emissions Estimates

In order to suggest revisions to the NTI, the Panel compared the estimates obtained from the Notebook Method and the estimates obtained from the stack sampling method and developed its

Table 3: Stack Emissions Monitored at Certain Facilities

Annual Stack Emissions (lbs/yr/line)			
	Facility A	**Facility B**	**Facility C**
Enclosed Process			
Appliance	9.0**		
Appliance - Trucks	3.3**		
Auto	3.6		
Door	0.4**		
Laminator	0.13**	2.9**	
Rebond	0.19**		
Foundry	18.5**	40.7**	
Open Process			
Adhesive	1.2**		
Air Filter	0.4		
Agri-Fiber	71	108	126
Spray Foaming	1.5**		
Spandex	1.3**		
Specialty Application			
Belt Manufacturing	1368	6911	

***** Emission based upon operation schedule of 8760 hours per year
** Emissions below Equipment Detection Limit

best estimate of source category emissions. Generally, estimates based on stack sampling were preferred to estimates based solely on the Notebook Method. From the data obtained from the stack sampling and enhanced understanding of some facilities based upon the Panel's outreach efforts, some adjustments were also made to the inputs for the Notebook Method calculations or professional judgment was applied to correct the estimate.

For example, while total annual facility MDI emissions from three agri-fiber facilities were measured at 71, 129, and 219 pounds, these facilities were monitored during start-up when excess MDI emissions result from incomplete mixing of MDI with the fibers. Thus, these sampled emissions, which account for only 10-15% of operations at such facilities, were not

Table 4: Facility Emissions Based on Stack Sampling and Notebook Method

Source Category	Emissions Based on Stack Sampling (lbs/year)	Emissions Based Solely on Notebook Method (lbs/year)
Air filter	1	15
Agri-fiber	71/219/129	Specialty Application
Appliance	38.68*	21
Appliance - truck	3.3*	9
Auto	6	15
Belt manufacturing	1501/6942	Specialty Application
Coating - adhesive	10	15
Door	1*	4
Foam producer	1*	21
Foundry	35*/37*	13
Laminator	4*/1*	17
Rebond	1*	70
Spandex	1*	15

* Stack Sampling Below Detection Limit

representative of annualized emissions. The Panel used a reasonable worst-case estimate of 90 pounds per year for the agri-fiber source category. In addition, some source category names were changed to be more reflective of the SIC Codes they represent. The final estimated ranges of MDI emissions derived by the Panel for all source categories are included in Table 5. No estimate was provided for MDI manufacturers, who were assumed to have correctly reported their emissions on the TRI.

The emissions for each facility in the NTI were compared to the facility’s emissions reported in the TRI, and the highest categorical emissions estimate for that category as listed in Table 5. If the NTI emissions were comparable to the emissions reported in the TRI and the categorical

Table 5: Emission Estimates Used to Revise NTI

Category	SIC Code	Description	Estimated lbs./yr.
Agri-fiber			**0-90**
Appliance	**3632**	Household refrigerator and home and farm freezers	**0-9**
	3585	Air-conditioning, warm air heating equipment and industrial refrigeration	**0-9**
	3639	Household appliances, NEC	**0-9**
	3630	Household appliances	**0-9**
Automotive	**3711**	Motor vehicle & motor vehicle equipment	**0-6**
	3713	Truck & bus bodies	**0-6**
	3714	Motor vehicle parts & acc.	**0-6**
	3751	Motorcycles, bicycles and parts	**0-6**
Belt & Hose*	**2296**	Tire cord and fabrics	**0-6600**
	3052	Rubber & plastic hose and belting	**0-6600**
Blending/ Filling	**3087**	Custom compounding	**0-3**
Boat	**3732**	Boat building	**0-9**
Coating	**3471**	Electroplating	**0-3**
	3470	Coating, engraving, and allied services	**0-3**
	3479	Coating, engraving	**0-3**
	1721	Painting, paper hanging	**0-3**
	2851	Paints varnishes, lacquers, enamels, and allied products	**0-3**

Category	SIC Code	Description	Estimated lbs./yr.
	2891	Adhesive and sealants	**0-3**
Custom Molder	**2511**	Wood household furniture	**0-9**
	2521	Wood office furniture	**0-9**
	2542	Office & store fixtures	**0-9**
	2820	Plastic materials and synthetic resins, synthetic rubber & other manmade fibers	**0-9**
	2821	Plastic materials	**0-9**
	3069	Fabricated rubber prod. NEC	**0-9**
	3086	Plastic foam products	**0-9**
	3089	Plastic products, NEC	**0-9**
	3949	Sports athletic NEC	**0-9**
	2511	Wood household furniture	**0-9**
	2522	Furniture	**0-9**
	2531	Public building and related furniture	**0-9**
	2541	Wood office and store fixtures, partitions, shelving	**0-9**
	3061	Molded, extruded and lathe cut mechanical rubber products	**0-9**
	3081	Unsupported plastics film and sheet	**0-9**
	3084	Plastics pipe	**0-9**
	3088	Plastic plumbing fixtures	**0-9**
	3269	Vitreous china table	**0-9**

Category	SIC Code	Description	Estimated lbs./yr.
	3811	Laboratory apparatus and furniture	**0-9**
	3842	Orthopedic, prosthetic, and surgical appliance and supplies	**0-9**
	7812	Motion pictures and film industry	**0-9**
Door	**3442**	Metal doors, sashes, and trim	**0-3**
Electronics	**3644**	Non-current carrying devices	**0-3**
	3812	Search, detection, navigation	**0-3**
	3643	Current carrying devices	**0-3**
	3648	Lighting equipment, NEC	**0-3**
	3661	Telephone and telegraph apparatus	**0-3**
	3669	Communications equipment, NEC	**0-3**
	3670	Electronic components and acc.	**0-3**
	3674	Semiconductors and related devices	**0-3**
	3679	Electronic components	**0-3**
	3812	Search detection	**0-3**
	3823	Industrial instruments for measuring	**0-3**
Foam Producer	**2821**	Plastic materials	**0-3**
	3086	Plastic foam products	**0-3**
Foundry	**3321**	Gray ductile iron	**0-40**
	3322	Malleable iron foundries	**0-40**
	3325	Steel foundries	**0-40**

Category	SIC Code	Description	Estimated lbs./yr.
	3365	Aluminum foundries	0-40
	3498	Fabricated pipe and pipe fittings	0-40
	3499	Fabricated metal, NEC	0-40
	3561	Pump & pump EQ.	0-40
	3321	Foundry	0-40
	3369	Nonferrous foundry	0-40
	3429	Hardware, NEC	0-40
	3441	Fabricated structure metal	0-40
Laminator	3086	Plastic foam products	0-3
Machinery	3523	Farm machinery equipment	0-40
	3511	Steam, gas, hydraulic turbine	0-40
	3555	Printing trades machinery and equipment	0-40
	3585	Air conditioning and warm air heating equipment	0-40
	3621	Motors and generators	0-40
	3826	Oil & gas field machinery	0-40
MDI Manufacturing	3999	Manufacturing, NEC	As Reported
	2869	Industrial organic chemicals, NEC	As Reported
Mobile Homes	3716	Motor homes	0-3
	2451	Mobile homes	0-3

Category	SIC Code	Description	Estimated lbs./yr.
Oil	**2911**	Petroleum & refining	**0-3**
	2992	Lubricating oils and greases	**0-3**
Packaging	**2431**	Millwork	**0-3**
	2754	Commercial printing	**0-3**
	2011	Meat packing plants	**0-3**
	2673	Plastics, foil, and coated paper bags	**0-3**
	2731	Books, publishing	**0-3**
Producers	**2860**	Industrial organic chemicals	**0-15**
Rebond	**2273**	Carpets and rugs	**0-3**
Recreation	**3944**	Games, toys	**0-9**
	3949	Sporting and athletic goods, NEC	**0-9**
Repackagers	**5171**	Petroleum terminals and bulk stations	**0-3**
Shoe sole	**3143**	Men's footwear	**0-3**
Spandex	**2824**	Manmade organic fibers	**0-3**
Specialty Producer	**3861**	Photographic equipment and Supplies	**0-9**
Transportation	**3728**	Aircraft parts & acc	**0-40**
	3711	Motor vehicles passenger car bodies	**0-40**
	3713	Truck and bus bodies	**0-40**
	3714	Motor vehicle parts and acc.	**0-40**
	3721	Aircraft	**0-40**

Category	SIC Code	Description	Estimated lbs./yr.
	3761	Guided missiles and space vehicle	**0-40**
	3769	Guided missiles and space vehicle parts and auxiliary equipment	**0-40**
	3799	Transportation equipment	**0-40**
Water Heaters	**3639**	Household appliance, NEC	**0-9**
Woodbinders **	**2435**	Hardwood veneer and plywood	**0-2000**
	2490	Wood products	**0-2000**
	2493	Reconstructed wood prod	**0-2000**
	2421	Sawmills and planning mills, general	**0-2000**
	2436	Software veneer and plywood	**0-2000**
	2439	Structural wood members	**0-2000**
	2499	Wood products, NEC	**0-2000**

* Process equipment has partial control technology. When the system modified is with full control, the emissions range should be 0 -1500 lbs/year.
** Range is based upon 1996 conditions, Reverse thermal oxidizers have been installed in the industry, and the present emissions range is 0 - 200 lbs/year.

emissions estimate, the emissions were left unchanged. If the TRI emissions were lower than the NTI estimate, then the TRI emissions replaced the NTI estimate. The premise behind this replacement was that the facility directly reports the TRI data and was, therefore, more likely to be reliable and reflect the facility's correct understanding of its MDI emissions. If the categorical emissions estimate from Table 5 was significantly lower than the NTI and TRI estimate, then the categorical estimate was used. This reflects the record many facilities have of not correctly understanding and reporting their MDI emissions and the characteristics of MDI, which make most emissions relatively minor.

Overall Effect of Panel's Review on Number of Facilities and Emissions Estimates

As a result of this effort, 840 facilities were added to the 1996 NTI because they were listed in the 1996 TRI as emitting diisocyanates and known or projected by the Panel to utilize MDI. Overall emissions of the 248 facilities in the 1996 NTI decreased from 129.24 tons to 9.2 tons based upon modifications to 139 facilities' emissions. The emissions of the 840 facilities added to the NTI from the TRI decreased from 265.53 tons in the TRI to 23.45 tons in the revised NTI. Overall, the number of facilities increased from 248 to 1,088 while emissions decreased from 129.24 tons to 32.65 tons. Thus, despite the increase in number of facilities by 400%, nationwide MDI emissions decreased by 75%.

The effort of EPA and the Panel to improve the 1996 NTI was not exhaustive, and some facilities may not be reflected in the revised 1996 NTI because they were not required or did not report MDI emissions to the 1996 TRI or were not covered by the state and local HAP inventories that were reported to EPA. It is also possible that some individual facilities are utilizing unique processes of which EPA and the Panel are unaware so that their emissions are higher than the categorical estimate, although this is believed to be unlikely. Further, even the revised 1996 emissions estimates are likely to overstate actual MDI emissions due to the conservative nature of the Notebook Method.

CONCLUSION

Assembling a national inventory of MDI emissions based upon existing data sources is an ambitious undertaking. Data sources, such as the TRI and state and local air toxics inventories, need to be scrutinized for signs of misreporting by the facilities because misreporting can greatly affect the accuracy of the final inventory.

Continued outreach efforts like the Notebook and software by both industry and government may help to alleviate inaccurate reporting. Such over-reporting not only may subject the facility to regulatory and public scrutiny, it may cause inaccuracies in inventories such as the NTI and result in misinformed or misdirected regulatory decision making. Therefore, the willingness of regulators and industry to work together to refine such emissions estimates may result in a more accurate and complete understanding of MDI emissions.

IMPLICATIONS

Based upon the use of EPA-approved emissions estimation methods and confirmatory stack sampling, significant overstatement of the emissions of the hazardous air pollutant 4, 4'-methylene diphenyl diisocyanate was identified in the 1996 National Toxics Inventory and the 1996 Toxic Release Inventory. This overstatement appears to have been due to the misreporting of emissions by many facilities. Such inaccuracies can lead to faulty local, state, and national decision making regarding air toxics and the priority that should be given various air toxics. Such inaccuracies for MDI can be corrected, however, by relying on conservative emissions estimation methods and confirmatory sampling.

REFERENCES

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About the Authors

Anne Pope is an environmental engineer in the Emission Factor and Inventory Group in EPA's Emission Monitoring and Analysis Division. Stephanie Finn is a senior database specialist with Eastern Research Group. William Robert, CIH, is Manager, Product Stewardship and Regulatory Compliance, with BASF Corporation and chair of the American Chemistry Council's Diisocyanates Panel. Dennis Miller is an independent consultant to the Diisocyanates Panel. Jeffrey Holmstead is a partner and Scott Schang is an associate with Latham & Watkins, counsel to the Diisocyanates Panel. Address correspondence to Susan Lewis, American Chemistry Council, 1300 Wilson Boulevard, Arlington, VA 22209