Polyurethanes are generally made by reacting a diisocyanate, such as toluene diisocyanate (TDI) or methylene diphenyl diisocyanate (MDI), and a blended polyol. When a polyurethane foam is desired, the process uses additional chemicals, such as amine and/or metallic salt catalysts, auxiliary blowing agents, and silicone surfactants, to achieve the desired properties.

Amine catalysts are used to control and/or balance both the gelling reaction and the gas-forming or foaming reaction responsible for foam formation. Although several organometallic compounds or salts may be used as catalysts in the production of polyurethanes, many polyurethane manufacturers use either tertiary aliphatic amines or alkanolamines. Amine catalysts are typically 0.1 to 5.0 percent of a polyurethane formulation.

Chemical Composition

Amine catalysts are a class of organic compounds derived from ammonia (NH₃) by substituting one or more of the hydrogen atoms with alkyl groups (carbon and hydrogen containing molecular chains)—e.g., dimethylcyclohexylamine [(CH₃)₂NC₆H₁₁]. An amine is primary, secondary, or tertiary depending on whether one, two, or three of the hydrogen atoms of ammonia are replaced. Most amines are basic and can combine readily with acids to form salts, some of which are useful as delayed-action catalysts. Catalytic activity of...
Note to Readers:

This document reviews the requirements and offers guidance for reporting releases of certain listed chemicals of interest to members of the polyurethane industry under the provisions of Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). Its principal purposes are to:

- Assist companies in the polyurethane industry in completing the Environmental Protection Agency’s [EPA] Form A or Form R,
- Outline suggested techniques for estimating toluene diisocyanate (TDI) fugitive air emissions under EPCRA, and
- Provide examples of calculating TDI emissions associated with fugitive releases based on applied applications.

The methodologies used to estimate releases of toluene diisocyanate (TDI) have been developed using standard techniques, but may not be suitable for estimating releases of other chemicals. The information provided in this document is offered in good faith and believed to be reliable, but is made WITHOUT WARRANTY, EXPRESS OR IMPLIED, AS TO MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR ANY OTHER MATTER. This document is not intended to provide emissions data for any particular product or process. Scenarios that have been selected are believed to be representative of situations where releases may occur. Other scenarios not reflected in this document may involve releases as well. It is the responsibility of all manufacturers, processors or users of any listed chemical to know and understand the reporting obligations, and to provide accurate information, in accordance with the provisions of the law. Consult your own legal and technical advisors for specific advice applicable to your own facility.

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Center for the Polyurethanes Industry
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Introduction and Background

The purpose of this document is to provide manufacturers, processors and other users of certain chemicals in the polyurethane industry with guidance on reporting releases of listed chemicals in accordance with the provisions of Section 313 of the Emergency Planning and Community Right-to-Know Act (EPCRA). In particular, this document outlines approaches for estimating emissions from the processing and use of toluene diisocyanate (TDI) and TDI mixtures in the absence of specific data on emissions. TDI is an EPCRA-listed chemical with three separate listings for TRI: 2,4’ TDI, 2,6’ TDI, and mixed-isomer TDI.

EPCRA Section 313 (TRI) requires affected facilities to provide information on {1} routine and accidental releases of specific listed chemicals and mixtures of chemicals into the environment, {2} transfers to off-site facilities, and {3} waste treatment methods, and the efficiency of those methods. It also requires reporting on the name, location and type of business; the identity of the listed chemical(s) or chemical mixture(s) involved, and whether the chemical is manufactured, processed or otherwise used at the facility; and an estimate of the maximum amount of the chemical present at the facility at any time during the year. EPCRA-required information is reported on the Annual Section 313 Toxic Chemical Release Form R. In certain circumstances, however, facilities may be able to report using the 313 Toxic Chemical Release Form A, which requires significantly less information.

Facilities are also required to comply with the provisions of the Pollution Prevention Act of 1990 (PPA). The PPA requires that source reduction and detailed information about on-site waste treatment and recycling be reported. Review definitions of “source reduction,” “treatment,” “recycling” and your activities, which are required to be reported accordingly.

Reported information is placed in the Environmental Protection Agency’s (EPA) Toxic Release Inventory (TRI) database, where it is made publicly available via the Internet and through the annual publication of the Toxic Release Inventory by EPA.

Use of TRI Database

Under Section 313(h) of EPCRA, Congress provides for the wide distribution of the industry information gathered. The forms required under this section are intended to provide information to federal, state and local governments and the public. This includes citizens of communities surrounding the covered facilities. These forms provide information about chemical releases to the environment to enable government agencies, researchers, and other individual conducting research and data gathering to
develop appropriate regulations, guidelines, and standards. Since the TRI data has become available, it has become a useful resource for many different organizations:

- Federal, state and local governments use TRI data to set the priorities and allocate environmental protection resources.
- Regulators use TRI data to set permit limits, measure compliance with those limits, and target facilities for enforcement activities.
- Governments use TRI data to assess or modify taxes and fees based on toxic emissions or overall environmental performance.
- Communities use TRI data to begin dialogues with local facilities and to encourage them to reduce their emissions, develop pollution prevention plans, and address safety measures.
- Industry uses TRI data to identify pollution prevention opportunities, set goals for toxic chemical release reductions, and demonstrate its commitment to and progress in reducing emissions.
- Public interest groups use TRI data to identify the potential need for new environmental regulations or improved implementation and enforcement of existing regulations.
- Consultants and others use TRI data to identify business opportunities, such as marketing pollution prevention and control technologies to TRI reporting facilities.

Therefore, it is important that reports be as accurate as possible. Overestimating emissions can lead regulators and others to seek imposition of controls that are not scientifically justified, while underestimating emissions can risk enforcement action by the Agency.
EPCRA Overview

To put the EPCRA Section 313 (TRI) requirements in perspective, this chapter very briefly reviews the provisions of the EPCRA, and the PPA. Additional materials addressing EPCRA requirements are available from the Center for the Polyurethanes Industry (CPI).

EPCRA, also known as Title III of the Superfund Amendments and Reauthorization Act of 1986 (SARA), was enacted on October 17, 1986. EPCRA has four major sections: emergency planning (Section 301-303), emergency release notification (Section 304), hazardous chemical inventory reporting requirements (Section 311-312), and toxic chemical release reporting/emissions inventory (Section 313). A summary of these sections follows.

Section 301-303: Emergency Planning

The emergency planning provisions of EPCRA are specifically designed to allow for emergency response and preparedness through coordination and planning at the state and local level. The concept involves a multi-tiered system capable of coordinating activities. The governor of each state designates a state emergency response commission (SERC), which, in turn, designates local emergency planning districts (LEPD), and appoint local emergency planning committees (LEPC). SERCs are responsible for supervising and coordinating the activities of the LEPCS, for establishing procedures for receiving and processing public requests for information, and for reviewing local emergency plans. These commissions and committees are required to have broad representation from the public and the private sector, including community groups, representatives of the media, and representatives of facilities subject to emergency planning requirements. The LEPCs develop emergency response plans that meet EPA’s minimum criteria.

Section 304: Emergency Release Notification

Any time there is a release of a listed CERCLA hazardous substance (see 40 CFR Section 302.4) or an EPCRA extremely hazardous substance (see 40 CFR Part 355) that exceeds the reportable quantity (RQ) for that substance, the facility is required to immediately notify the LEPC, SERC and National Response Commission (NRC). In addition to following the notification requirements, the facility will submit a follow-up written emergency notice that sets forth the actions taken to respond to the release and any risks posed by the incident.
Section 311-312: Hazardous Chemical Inventory Reporting

The chemical inventory reporting requirements under EPCRA Sections 311 and 312 apply to manufacturers, importers, processors, and users of substances for which safety data sheets (SDSs), formerly known as material safety data sheets (MSDSs), must be maintained under the Occupational Safety and Health Act (OSHA). Under EPCRA Section 311, such facilities must prepare or have available SDSs and submit either copies of the SDSs or a list of the hazardous chemicals to the LEPC, SERC, and local fire department if more than a threshold level is stored onsite at any one time (see 40 CFR Sections 370.20-.28).

The threshold level varies depending on how the chemical is classified. For hazardous chemicals that are not extremely hazardous substances (EHS), the threshold is 10,000 pounds. On the other hand, if the hazard chemical is also an EHS (listed in 40 CFR Part 355, Appendices A and B), the reporting threshold is 500 pounds or that chemical’s threshold planning quantity (TPQ), whichever is lower.

Section 312 requires an annual submission of an emergency and hazardous chemical inventory form, known as the Tier One or Tier Two Report, to the LEPC, SERC and local fire department (see 40 CFR Sections 370.40-.41).

Section 313: Toxic Chemical Release Reporting/Emissions Inventory

As noted above, EPCRA Section 313 (TRI) requires affected facilities to provide information on routine and accidental releases of specific chemicals, among other things. A “release” includes vaporization or discharge of the chemical into the air, discharge of the chemical into a sewage system, and disposal of the chemical in landfills, either directly or via a waste management contractor.

10 full-time employees = 20,000 hours of work in a year.
Add the hours worked by all employees during the calendar year, including the hours worked by contract employees, part-time employees, and sales and support staff. Divide by 2,000; if the resulting number is greater than 10, the criterion has been met. See 40 CFR 372.22.

EPCRA Section 313 (TRI) requires that a report be filed by an owner and/or operator of a facility that meets all of the following criteria:

- The facility has the equivalent of 10 or more full-time employees;
- The facility is included in a listed North American Industry Classification
System (NAICS) code; and

- The facility manufactures (defined to include importing), processes, or otherwise uses any EPCRA Section 313 (TRI) chemical in quantities greater than the established threshold in the course of a calendar year.

See 40 CFR Section 372.22 for further explanation of when a facility falls within a listed NACIS code. Reporting documents, including the Form R and Form A, may be accessed at [http://www.epa.gov/tri/report/index.htm](http://www.epa.gov/tri/report/index.htm).

**Form R Toxic Release Inventory Reporting Form**

Facilities that are subject to the requirements of Section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 are required to file a Form R for each EPCRA chemical for which the applicable threshold limits are exceeded. (An exception is that, if certain low use/low emission criteria are met, the facility may be able to submit a Form A rather than a Form R – see below).

Form R consists of two parts:

- Part I: Facility Identification Information
- Part II: Chemical-Specific Information

The Facility Identification Information that must be provided in Part I of Form R includes five sections:

- Section 1: Reporting Year
- Section 2: Trade Secret Information
- Section 3: Certification
- Section 4: Facility Identification
- Section 5: Parent Company Information

The Chemical-Specific Information that must be provided in Part II of Form R includes eight sections that must be completed for each listed EPCRA chemical that meets the reporting criteria. The sections are:

- Section 1: Toxic Chemical Identity
- Section 2: Mixture Component Identity
- Section 3: Activities and Uses of the Toxic Chemical at the Facility
• Section 5: Quantity of the Toxic Chemical Entering Each Environmental Medium Onsite

• Section 6: Transfers of the Toxic Chemical in Wastes to Off-Site Locations

• Section 7: On-Site Waste Treatment Methods – Energy Recovery Processes – Recycling Process

• Section 8: Source Reduction and Recycling Activities

This document is intended to provide guidance that will enable processors or users of TDI and TDI mixtures to estimate fugitive air releases of these chemicals for purposes of completing Part II, Section 5 of Form R. Information regarding the filing of Form R, frequently asked questions, filing software, forms, etc. can be obtained on EPA’s TRI Home Page [www.epa.gov/tri](http://www.epa.gov/tri).

Form A Certification Statement

EPA established the Form A Certification Statement, known as Form A, to simplify and reduce the compliance burden associated with EPCRA Section 313. Like the Form R, Form A must be submitted annually, but instead of a five-page report, the Form A consists of only two pages. Part I requires facility identification information, and Part II requires information on the toxic chemical’s identity.

A facility may submit a Form A rather than a Form R if --

1. The total annual reportable amount for the toxic chemical does not exceed 500 pounds; and

2. The facility does not manufacture, process, or otherwise use greater than 1 million pounds of the toxic chemical.

Form A is not used for the reporting of any PBT chemical, as identified under 40 CFR Section 372.28.

The “total annual reportable amount” is equal to the combined total quantities of the toxic chemical released at the facility, disposed within the facility, treated at the facility (as represented by amounts destroyed or converted by treatment process), recovered at the facility as a result of recycle operations, combusted for the purpose of energy recovery at the facility, and amounts transferred from the facility to off-site locations.
for the purpose of recycle, energy recovery, treatment, and/or disposal. These volumes correspond to the sum of amounts reported on the Form R, section 8 (data elements 8.1 through 8.7).

The Form A may be used to report up to four chemicals that meet the criteria listed above. If more than four chemicals meet the criteria, they may be listed on additional copies of Part II: Chemical Identification [page 2]. A complete report for Form A consists of at least two pages for each submission. Reporting documents, including the Form A, may be accessed at http://www.epa.gov/tri/report/index.htm.
Are You Subject to EPCRA Reporting Obligations?

This section of the booklet summarizes the general steps to determine if you report releases under EPCRA Section 313 (TRI) for chemicals that you manufacture, process, or otherwise use.

Is Your Facility Subject to Section 313 Reporting?

EPCRA Section 313 (TRI) reporting requirements apply to facilities in specified North American Industry Classification System (NAICS) codes. The full list of codes is available at www.epa.gov/tri. These codes correspond to Standard Industrial Classification (SIC) Codes 20-39, among others and include chemical manufacturers, coating manufacturers, plastic resin, foam, and other plastic product manufacturers, foundries, boat builders, and automotive and recreational vehicle manufacturers.

Do You Manufacture, Process or Otherwise Use TDI?

Toluene diisocyanate (2,4'-TDI, 2,6'-TDI, or TDI) is not included in the diisocyanate category. TDI is identified by Chemical Abstract Services (CAS) Registry Numbers (RN) 584-84-9 (2,4'-TDI), 91-08-7 (2,6'-TDI), and 26471-62-5 (mixed isomers, such as 80/20 and 65/35 TDI).

The most widely used TDI mixture consists of approximately 80% 2,4-TDI and 20% 2,6-TDI. As described in the discussion above, TDI is not aggregated with other isocyanates for TRI reporting. It does not belong to the Diisocyanates Category Code N120. Please note that the Center for the Polyurethanes Industry (CPI) has developed a separate guidance document and emissions tool to assist in estimating releases under the diisocyanates category. The guidance document and tool for reporting under the diisocyanates category can be found at http://polyurethane.americanchemistry.com/.

Do You Manufacture, Process or Otherwise Use Greater Than a Threshold Amount of a Section 313 Chemical?

Application of the TRI reporting requirements is based on whether a facility manufactures processes or otherwise uses greater than a threshold amount of a listed chemical. Historically, if you met the requirements above, and either (1) manufactured or processed more than 25,000 pounds of a listed chemical or chemical category, or (2) otherwise used more than 10,000 pounds of a listed chemical or
chemical category, you had to comply with the EPCRA reporting requirements.\(^1\)

\begin{quote}
**Manufacture:** to produce, prepare, compound or import a listed toxic chemical, including the coincidental production of a toxic chemical (e.g., as a byproduct or impurity).

**Process:** preparation of a listed toxic chemical, after its manufacture, for distribution in commerce (e.g., the intentional incorporation of the chemical into a product).

**Otherwise use:** any activity involving a listed toxic chemical that does not fall within the definition of “manufacture” or “process.”

Source: 40 CFR 372.3.
\end{quote}

In 1999, however, EPA created a subset of listed chemicals, known as persistent and bioaccumulative toxic (PBT) chemicals that are subject to lower thresholds. Dioxin and dioxin-like compounds that are subject to a 0.1 gram threshold; other listed PBTs are subject to either a 10 pound or 100 pound threshold for amounts manufactured, processed or otherwise used (see 40 CFR Section 372.28).

The 25,000 pounds manufacturing and processing and 10,000 pounds otherwise use thresholds, however, still apply to TDI.

The 25,000 pound threshold will likely apply to most TDI “users” since most applications, including polyurethane manufacturing involve “processing” for purposes of EPCRA Section 313 (TRI) reporting. EPA considers utilization of TDI-based products in making foundry molds that are used on-site and are not distributed in commerce as an “otherwise use” of TDI and TDI mixtures for EPCRA Section 313 (TRI) reporting. In such applications, the 10,000-pound reporting threshold applies, according to EPA.

Your purchases of Section 313 listed chemicals may serve as a benchmark in determining what amounts you manufacture, process, or “otherwise use”; however, it is the actual amount of a substance that is manufactured, processed, or “otherwise used” in the reporting year that determines your reporting status. For example, a facility that purchased 30,000 pounds of TDI, a listed chemical, but processed only 24,000 pounds in the reporting year would not be required to report. Alternatively, a facility that purchased and processed 20,000 pounds of TDI and processed an additional 6,000 pounds from the previous year’s inventory, thereby processing a total of 26,000 pounds in one reporting year, would be required to report by EPA.

\(^1\) The reporting threshold for Sections 311/312 of EPCRA should be distinguished from the Section 313 threshold. Under Sections 311/312, you are required to file an MSDS and annual inventory reports with state and local agencies if you store TDI on site in quantities greater than 10,000 pounds at any one time.
If you have a mixture or trade name product that contains a toxic chemical, determine the amount of the toxic chemical in the mixture and combine that amount with the total quantity of the chemical processed or otherwise used at the facility in order to determine whether or not the reporting threshold has been reached.

EXAMPLES

Example #1: In one year, a facility processes 40,000 pounds of a mixture that contains 50% 2,4 TDI and 50% chemicals not listed under TRI. The same facility otherwise uses 20,000 pounds of a mixture containing 40% 2,4 TDI and 60% chemicals not listed under TRI. In the same year, the facility neither processed nor otherwise used any 2,6 TDI.

The facility processed 20,000 pounds of 2,4 TDI (versus the 25,000-pound threshold) and otherwise used 8,000 pounds of 2,4 TDI (versus the 10,000-pound threshold). The facility also processed 20,000 pounds of TDI (mixed isomers) (versus the 25,000-pound threshold) and otherwise used 8,000 pounds of TDI (mixed isomers) (versus the 10,000-pound threshold). No threshold has been exceeded.

Example #2: In one year, a facility processes 200,000 pounds of a mixture that contains 80% 2,4 TDI and 20% 2,6 TDI.

The facility processed 160,000 pounds of 2,4 TDI (versus the 25,000-pound threshold) and processed 40,000 pounds of 2,6 TDI (versus the 25,000-pound threshold), and 200,000 pounds of TDI (mixed isomers) (versus the 25,000-pound threshold). The facility exceeded thresholds for 2,4 TDI, 2,6 TDI, and TDI mixed isomers. The facility could submit Form Rs for 2,4 TDI and 2,6 TDI or submit one Form R for TDI (Mixed Isomers).
Example #3: In one year, a facility processes 30,000 pounds of a mixture that contains 80% 2,4 TDI and 20% 2,6 TDI.

The facility processed 24,000 pounds of 2,4 TDI and processed 6,000 pounds of 2,6 TDI and 30,000 pounds of TDI (mixed isomers). The facility exceeded thresholds for neither 2,4 TDI nor 2,6 TDI, but it did exceed for TRI (mixed isomers). The facility must submit one Form R for TDI (mixed isomers).

Are You Subject to State TDI Permit Reporting Obligations?

If you exceed an EPCRA Section 313 (TRI) reporting threshold, then emissions need to be estimated and reported. The estimation techniques in this book are directed primarily toward calculating emissions for the purpose of EPCRA Section 313 (TRI) reporting, but may be useful in providing TDI emission estimates for state permitting purposes as well. Refer to your state and local regulations for more information.
Identifying Release Sources & Estimating Quantities Released

The main goal and objective of this document is to provide information and guidance that will help processors or users of TDI and TDI mixtures to estimate fugitive air releases of these chemicals in accordance with the EPCRA Section 313 (TRI).

The first step in estimating the release of TDI and/or TDI mixtures is to identify all possible emission sources. To do this, it may be helpful to develop a process flow diagram, outlining and depicting the activities in which TDI and TDI emissions can be released. A general plant flow diagram presented in Figure 1 provides a broad overview of where emissions can occur and will be used to outline the general approach in calculating emissions throughout this document.

![Figure 1](image)

- A: Transfer from Tanker or Railcar
- 1: Working Losses
- 2: Breathing Losses
- P: Transfer from Storage Tank to Day Tank
- 4: Day Tank Breathing Losses
- C: Transfer to Process
- 6: Process Stack Losses
- 7: Fugitive Emissions
- 8: Disposal and Treatment

Once the activities have been identified for your facility, a systematic approach to calculating your overall emissions can be established. Each facility is unique and even though the regulation does not require you to generate a process flow diagram, preparation of a process flow diagram can and will demonstrate your efforts to comply with the EPCRA reporting requirements.
Estimating Fugitive Air Releases of TDI

General Techniques

EPCRA Section 313 (TRI) requires all releases to air, water, land, and transfers to off-site facilities for each toxic chemical meeting the threshold reporting requirements be reported to EPA. Once all the possible release sources for TDI have been identified, estimates of the quantity released from each source can be made.

In general, there are four basic techniques used to estimate emissions.

- Direct Measurement
- Mass Balance
- Emission Factors
- Engineering Calculations

The following section summarizes each basic technique that can be used to determine emissions. It may become necessary to employ a combination of all these techniques to obtain the total amount of estimated emissions for your facility.

Direct Measurement

The use of direct measurement or monitoring data to determine release measurement is based upon measured concentrations of a chemical in a waste stream and the flow rate/volume of that stream. Direct measurement gives you a more accurate account of what amounts of chemicals are being released. Even though this method is more costly than using other estimation techniques, this additional effort can be justified in instances where other estimation techniques may significantly overestimate releases. Direct data measurement consists of process equipment bagging studies and waste stream contaminant analysis data. Industrial hygiene data is useful for evaluating worker exposure and estimating fugitive emissions.

Mass Balance

The use of mass balance to determine release estimates are based upon the assumption that the amount of chemical entering the process must be the same as the amount of chemical that leaves the process. If the input and output streams for a particular process are known, the difference would be the amount of material that is lost through waste streams and as fugitives. However, EPA stated that using mass balance is inappropriate to use in situations where a chemical is consumed during a process were the chemical goes under a chemical reaction with another chemical to
form a new compound. It is also inappropriate to use mass balance in situations where a chemical is destroyed by heat or combustion. Nearly all applications that use TDI fall into this category.

Emission Factors

Emission factors express releases as a ratio of the amount of a substance released relative to process or equipment throughput. Emission factors are commonly used for air releases and are typically based upon the average measured emissions measured at several facilities in the same industry. The EPA has compiled a large number of emission factors for different chemicals used in many industries. However there is very little emission factor data available for TDI and TDI mixtures. Thus, it is possible that the use of EPA emission factors could result in inaccurate reporting.

Engineering Calculations

Engineering calculations are assumptions and/or judgments used to estimate quantities of EPCRA Section 313 (TRI) chemicals and chemical categories released or otherwise managed as waste. The quantities are estimated by using physical and chemical properties and relationships [e.g., ideal gas law, Raoult’s law, Henry’s law] or by modifying an emission factor to reflect the chemical properties of the chemical in question.

Engineering calculations can also include computer models. Several computer models are available for estimating emissions from landfills, wastewater treatment, water treatment and other processes.

Non-chemical-specific emission factors, Synthetic Organic Chemicals Manufacturing Industry (SOCMI) emission factors, industry-determined emission factors for processes or equipment, and site-specific emission factors also can be used, but must be classified as “Engineering Calculations” for EPCRA Section 313 reporting.

General equations and assumptions are used repeatedly throughout these guidelines. Examples in these guidelines were selected to reflect major scenarios where releases are likely to occur. There may be release scenarios particular to your facility that is not described in this guidebook. The best judge of the use of any release source or release estimation technique is always an individual with knowledge of a specific operation at your facility. Consider using the estimation techniques that follow.
Table 1
Potential Data Sources for Release and Other Waste Management Calculations

<table>
<thead>
<tr>
<th>Monitoring Data</th>
<th>Mass Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>* Air Permits</td>
<td>* Air Emissions Inventory</td>
</tr>
<tr>
<td>* Continuous Emission Monitoring</td>
<td>* SDS’s</td>
</tr>
<tr>
<td>* Effluent Limitations</td>
<td>* Pollution Prevention Reports</td>
</tr>
<tr>
<td>* Hazardous Waste Analysis</td>
<td>* Spill Event Records</td>
</tr>
<tr>
<td>* Industrial Hygiene Monitoring Data</td>
<td>* Supply Records</td>
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<tr>
<td>* NPDES Permits</td>
<td>* Hazardous Waste Manifests</td>
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<tr>
<th>Engineering Calculations</th>
<th>Emission Factors</th>
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<td>* Facility Non-specific Emission Factors</td>
<td>* AP-42 Chemical Specific Emission Factors</td>
</tr>
<tr>
<td>* Henry’s Law</td>
<td>* Facility or Trade Association Derived Chemical Factors</td>
</tr>
<tr>
<td>* Raoult’s Law</td>
<td></td>
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<tr>
<td>* Solubilities</td>
<td></td>
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<tr>
<td>* Volatilization Rates</td>
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</tbody>
</table>

Guidance Documents

EPA has a number of EPCRA Section 313 (TRI) documents that provide information and guidance to help assist one in completing and filing Form R and Form A Certification Documents. It is recommended that one obtain and read these documents before starting to fill out the forms. Guidance Documents can be obtained from the EPA by downloading from: [http://www.epa.gov/tri/guide_docs/index.htm](http://www.epa.gov/tri/guide_docs/index.htm).

Techniques for Estimating Fugitive Emissions

Direct Measurement

Fugitive emissions are air releases of volatile chemicals that typically occur due to leaks from fittings and seals in chemical process equipment, transfer operations or storage systems. Direct measurement or monitoring data can be used to estimate fugitive emissions. In the absence of direct measurement or monitoring data, industrial hygiene data on TDI concentrations in the workplace can be used to estimate TDI fugitive emissions. *This technique may overestimate fugitive air emissions if the industrial hygiene data are higher than the average concentrations throughout the year and throughout the building, but it is a
**TDI Fugitive Air Emissions Reporting Guidelines for the Polyurethanes Industry**

**technique worth considering.**

The fugitive emissions can be estimated from the following expression:

\[
L_{fg} = C_{TDI} \times \left( \frac{V_B}{359} \right) \times N_{year} \times \frac{273.15}{T_{amb}} \times M_w \times K_{fg}
\]

Where:

- \( L_{fg} \) = the fugitive emissions in lb/year
- \( C_{TDI} \) = the average TDI concentration, in ppmv, in the air within the building
- \( V_B \) = the volume of the workspace building in ft\(^3\)
- \( N_{year} \) = the number of air exchanges per year
- \( T_{amb} \) = the ambient temperature in K
- \( M_w \) = the molecular weight of TDI (174.15)
- \( K_{fg} \) = the adjustment factor to the TDI concentration in the building air. CPI uses a value of 1.10

**Example 1: Fugitive Emissions**

The average concentration of TDI throughout the year was measured at 0.001 ppm for a process area that measured 50 ft W x 100 ft L and 20 ft in height. There is an average of 5 air changes per hour and the plant operates 16 hours/day, 250 days/year. The average temperature of the facility is 77°F. Calculate the fugitive emissions.

The fugitive emissions can be estimated from the following expression:

\[
L_{fg} = C_{TDI} \times \left( \frac{V_B}{359} \right) \times N_{year} \times \frac{273.15}{T_{amb}} \times M_w \times K_{fg}
\]

- \( L_{fg} \) = the fugitive emissions in lb/year
- \( C_{TDI} \) = the average TDI concentration, expressed as weight fraction
- \( V_B \) = the volume of the workspace building in ft\(^3\)
- \( N_{year} \) = the number of air exchanges per year
- \( T_{amb} \) = the ambient temperature in K
- \( M_w \) = the molecular weight of TDI (174.15)
- \( K_{fg} \) = the adjustment factor to the chemical concentration in the building air. CPI uses 1.10
Calculating:

\[
\begin{align*}
C_{TDI} &= 0.001\text{ppm} = 1.0 \times 10^{-9} \\
V_B &= (50 \text{ ft} \times 100 \text{ ft} \times 20\text{ ft}) = 100,000 \text{ ft}^3 \\
N_{\text{year}} &= \text{the number of air exchanges per year} \\
N_{\text{year}} &= \{5 \text{ changes/hr} \times 16 \text{ hr/day} \times 250 \text{ days/yr}\} = 20,000 \text{ changes/yr} \\
T_{\text{amb}} &= 298.2 \text{ K} \\
M_w &= \text{the molecular weight of TDI} \{174.15\} \\
K_{fg} &= 1.10
\end{align*}
\]

Therefore:

\[
\begin{align*}
L_{fg} &= (1.0 \times 10^{-9}) \times \frac{100,000 \text{ ft}^3}{359} \times 20,000 \times \frac{273.15}{298.2}\times \frac{174.15}{1.1} \\
L_{fg} &= 1.0 \text{ lbs/yr}
\end{align*}
\]

**Equipment Leaks**

In cases where monitoring data are not available, EPA has developed a method using emission factors based upon the type of fittings and number of fittings used in the process. The methodology used for TDI is an adaptation of an EPA Correlation Method (”1995 Protocol for Equipment Leak Emission Estimate” - EPA-453/R-95-017). The method presented here uses the actual formulas recommended by the EPA except that saturated vapor concentrations are used instead of screening values. Since the vapor concentration of TDI cannot exceed the saturation vapor pressure at a given temperature, the predicted screening values are limiting and conservative values. The calculation methodology involves the following steps:

1. Determine the saturated concentration of TDI.
2. Calculate emission factor for each equipment type.
3. Determine emissions for each equipment type.
4. Determine total losses from equipment leaks.

The TDI emissions from equipment leaks using the Modified Correlation Approach can be determined using the following equations:

\[
SV_{TDI} = 10^{\left[\frac{-8.763-3096.326}{t-273.15}\right]}
\]
Where:

\[ SV_{TDI} = \text{Screening Value of the concentration of TDI in ppmv} \]

The calculated Screening Value (SV) is then inserted into the Leak Rate/Screening Value Correlation Formula for the appropriate equipment type (found in Table 2) and the leakage rate is determined.

### Table 2
Leak Rate/Screening Value Correlations

| Equipment Type              | Correlation Leak Rate \( (kg/hr) \) 
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( a \times [SV]^b )</td>
</tr>
<tr>
<td>Gas Valve</td>
<td>1.87 x 10^{-06} \times [SV] 0.873</td>
</tr>
<tr>
<td>Light Liquid Valve</td>
<td>6.41 x 10^{-06} \times [SV] 0.787</td>
</tr>
<tr>
<td>Light Liquid Pump Seals*</td>
<td>1.90 x 10^{-05} \times [SV] 0.824</td>
</tr>
<tr>
<td>Connectors</td>
<td>3.05 x 10^{-06} \times [SV] 0.885</td>
</tr>
</tbody>
</table>

* This equation can be used for liquid pump seals, compressor seals, pressure relief valves, agitator seals and heavy liquid pump seals.

The total emissions from equipment leaks will be equal to the emissions contributed from each gas valves, light liquid valves, light liquid pump seals, and connectors.

**For gas valves:**

For Gas Valves the emissions can then be estimated from the following expressions:

\[ K_{gas} = 1.87 \times 10^{-6} \times [SV_{TDI}]^{0.873} \]

\[ L_{gas} = K_{gas} \times n_{gas} \times t_{pr} \times 2.205 \text{ lb/kg} \]

Where:

\[ K_{gas} = \text{the emission factor for gas valves in kg/year-item} \]

\[ L_{gas} = \text{the annual losses from gas valves in lb/yr} \]

\[ n_{gas} = \text{the number of gas valves} \]

\[ t_{pr} = \text{the total time in hours/year that the process is operating} \]
For liquid valves:

For Liquid Valves, the emissions can then be estimated from the following expressions:

\[ K_{\text{liq}} = 6.41 \times 10^{-6} \times [S_{\text{F,liq}}]^{0.787} \]
\[ L_{\text{liq}} = K_{\text{liq}} \times n_{\text{liq}} \times t_{\text{pr}} \times 2.205 \text{ lb/kg} \]

Where:

- \( K_{\text{liq}} \) = the emission factor for liquid valves in kg/year-item
- \( L_{\text{liq}} \) = the annual losses from liquid valves in lb/yr
- \( n_{\text{liq}} \) = the number of liquid valves
- \( t_{\text{pr}} \) = the total time in hours/year that the process is operating

For liquid pumps, compressor seals, pressure relief valves, agitator seals and heavy liquid pumps:

For liquid pumps, compressor seals, pressure relief valves, agitator seals and heavy liquid pumps, the emissions can then be estimated from the following expressions:

\[ K_{\text{pump}} = 1.90 \times 10^{-5} \times [S_{\text{F,pump}}]^{0.824} \]
\[ L_{\text{pump}} = K_{\text{pump}} \times n_{\text{pump}} \times t_{\text{pr}} \times 2.205 \text{ lb/kg} \]
\[ L_{\text{pump}} = \text{the annual losses from liquid pump seals in lb/yr} \]
\[ n_{\text{pump}} = \text{the number of liquid pump seals} \]
\[ t_{\text{pr}} = \text{the total time in hours/year that the process is operating} \]

For connectors:

For Connectors the emissions can then be estimated from the following expressions:

\[ K_{\text{con}} = 3.05 \times 10^{-6} \times [S_{\text{F,con}}]^{0.885} \]
\[ L_{\text{con}} = K_{\text{con}} \times n_{\text{con}} \times t_{\text{pr}} \times 2.205 \text{ lb/kg} \]

Where:

- \( K_{\text{con}} \) = the emission factor for connectors in kg/year-item
\[ L_{\text{con}} = \text{the annual losses from connectors in lb/yr} \]
\[ n_{\text{con}} = \text{the number of liquid valves} \]
\[ t_{\text{pr}} = \text{the total time in hours/year that the process is operating} \]

Total emissions from equipment leaks can then be estimated from the following expression:

\[ E_{\text{tot}} = L_{\text{gas}} + L_{\text{liq}} + L_{\text{pump}} + L_{\text{con}} \]

Table 3 presents the emissions factors associated with each fitting in service at a temperature of 50°C. If you know the number of fittings, multiply the emission factor by the number of fittings and add the total up to get the annual emissions from equipment leaks.

### Table 3

**Equipment Leak Emission Factors (lbs/hr-component) @ 50°C**

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Temp °C</th>
<th>Screening Value (SV) [ppmv]</th>
<th>Equation Constant [a]</th>
<th>Equation Constant [b]</th>
<th>Emission Factor [kg/hr]</th>
<th>Emission Factor [lb/hr]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Valves</td>
<td>50</td>
<td>151.81</td>
<td>1.87x10^{-6}</td>
<td>0.873</td>
<td>1.50E-04</td>
<td>3.31x10^{-04}</td>
</tr>
<tr>
<td>Light Liquid</td>
<td>50</td>
<td>151.81</td>
<td>6.41x10^{-6}</td>
<td>0.787</td>
<td>3.34E-04</td>
<td>7.36x10^{-04}</td>
</tr>
<tr>
<td>Valves</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light Liquid</td>
<td>50</td>
<td>151.81</td>
<td>1.90x10^{-05}</td>
<td>0.824</td>
<td>1.19E-03</td>
<td>2.63x10^{-03}</td>
</tr>
<tr>
<td>Pumps</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connectors</td>
<td>50</td>
<td>151.81</td>
<td>3.05x10^{-06}</td>
<td>0.885</td>
<td>2.60E-04</td>
<td>5.73x10^{-04}</td>
</tr>
</tbody>
</table>

*Illustrative example 1:* Estimate TDI emissions from equipment leaks in a TDI manufacturing facility with the following equipment type counts:

1. 30 valves in light liquid service
2. 45 connectors
3. 2 pump seals
4. 2 agitators

The TDI concentration in the stream is 10%, the temperature is 50°C, and the process is operating 24 hours a day, 365 days a year (8,760 hours).

The total emissions due to equipment leaks using the Modified Correlation Emission Factors are found in Table 4.
Table 4
Equipment Leak Emissions Modified Correlation Screening Factors

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Service</th>
<th>Number</th>
<th>Weight</th>
<th>Modified Corr. Factors</th>
<th>Emissions [lbs/hr]</th>
<th>Emissions [lbs/year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves</td>
<td>Light Liquid</td>
<td>30</td>
<td>0.1</td>
<td>7.36x10^{-04}</td>
<td>0.0221</td>
<td>19.3</td>
</tr>
<tr>
<td>Pump Seals</td>
<td>Light Liquid</td>
<td>2</td>
<td>0.1</td>
<td>2.63x10^{-03}</td>
<td>0.00526</td>
<td>4.6</td>
</tr>
<tr>
<td>Agitators</td>
<td>Light Liquid</td>
<td>2</td>
<td>0.1</td>
<td>2.63x10^{-03}</td>
<td>0.00526</td>
<td>4.6</td>
</tr>
<tr>
<td>Connectors</td>
<td>All</td>
<td>45</td>
<td>0.1</td>
<td>5.73x10^{-04}</td>
<td>0.0258</td>
<td>22.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>51.1</strong></td>
</tr>
</tbody>
</table>

Spills

EPCRA Section 313 (TRI) requires that you account for material lost because the chemical was spilled onto the ground, resulting in an air release. Evaporative releases from spills depend upon many factors including:

1. The volatility of the material.
2. The size of the spill.
3. The temperature of the surrounding area.
4. The wind speed.
5. The time that the liquid from the spill is allowed to evaporate.

A fairly simple model proposed by the EPA that accounts for all these factors is provided by the following equation:

$$Q_R = \left(\frac{0.284}{82.05}\right) \times [u]^{0.78} \times A_{\text{spill}} \times \left(\frac{V_{\text{TDI}}}{T_{\text{spill}}}\right) \times (MW)^{2/3}$$

Where:

- $Q_R$ = the evaporation rate in lb/min
- $u$ = the airflow in m/sec. This is the airflow in the vicinity of the process
- $A_{\text{spill}}$ = the area of the spilled material in ft$^2$
- $V_{\text{TDI}}$ = the vapor pressure of TDI in mm °C at the filling temperature
- $T_{\text{spill}}$ = the average evaporation temperature in K
- $MW$ = the molecular weight of TDI [174.15]

The spill losses can be determined by multiplying the evaporation rate $[Q_R]$ in lb/min
by the time the spill is on the ground and converting the calculated value to the desired units:

\[ L_{\text{spill}} = QR \times t_{\text{spill}} \times [60] \]

Where:

- \( L_{\text{spill}} \) = the evaporation losses resulting from the spill in lb
- \( QR \) = the evaporation rate in lb/min
- \( T_{\text{spill}} \) = the time that the spill is on the ground in hours

A facility while transferring pure TDI from the storage tank to the day tank develops a leak at a flange that results in a spill of 75 gallons of material. A liquid pool that has a surface area of 200 ft\(^2\), remains on the floor for eight hours before a HAZMAT Team could clean up the spill. During that time, the wind speed remained at a constant 20 miles/hour (8.94 m/s). The temperature of the process area was a constant 70°F (294.1 K). Determine loss of material caused by evaporation.

Air emissions released because of the spill of TDI can be calculated using EPA’s proposed model:

\[ QR = \{0.284/82.05\} \times [u]^{0.78} \times A_{\text{spill}} \times \{\text{VP}_{\text{TDI}}/T_{\text{spill}}\} \times [\text{MW}]^{2/3} \]

Where:

- \( QR \) = the evaporation rate in lb/min
- \( U \) = the airflow speed in m/sec. This is the airflow in the vicinity of the process
- \( A_{\text{spill}} \) = the area of the spilled material in ft\(^2\)
- \( \text{VP}_{\text{TDI}} \) = the vapor pressure of TDI in mm Hg at the filling temperature
- \( T_{\text{spill}} \) = the average evaporation temperature in K
- \( \text{MW} \) = the molecular weight of TDI [174.15]

Therefore

\[ QR = \text{lb/minute} \]
\[ U = 8.94 \text{ m/sec} \]
\[ A_{\text{spill}} = 200 \text{ ft}^2 \]
VTDI = 0.012 mm H
T_{spill} = 294.1 K
MW = 174.15

Substituting the appropriate values into the equation, the emissions released due to the spill is equal to:

\[ Q_R = \frac{[0.284/82.05] \cdot [8.94]^{0.78} \cdot 200 \cdot [0.012/294.1] \cdot [174.15]^{2/3}}{0.005 \text{ lbs./min}} \]

Using the equation:

\[ L_{spill} = Q_R \cdot T_{spill} \cdot [60] \]

Where:

- \( L_{spill} \): the evaporation losses resulting from the spill in lb
- \( Q_R \): the evaporation rate in lb/min
- \( T_{spill} \): the time that the spill is on the ground in hours

The total amount of TDI from the spill is:

\[ L_{spill} = \frac{[Q_R = 0.005 \text{ lbs./min}] \cdot [8 \text{ hours}] \cdot [60 \text{ min/hr}]}{2.4 \text{ lbs}} \]
Overall Fugitive Air Emission Example

The basic formulas presented in the preceding pages can be used to estimate the amount of fugitive air emissions from a facility that handles TDI. Typically the total fugitive air emissions will be the sum of the amounts emitted from the following:

- Fugitive Emissions (non-point sources) Measured
- Fugitive Emissions [non-point Source] Equipment Leaks
- Spills

Although the above list represents the predominant sources of fugitive air emissions from most facilities, each facility and process is unique. One needs to consider whether there are other potential emission sources.

The example presented below utilizes the techniques described in the above-mentioned categories.

**Example:**

J & J Foam Products, Inc. operates a facility that utilizes TDI. Fugitive emissions from the process area include measured air exhaust concentration and from equipment leaks located outside. The facility had one spill during the year that resulted in a loss of 1,000 gallons of material.

The total manufacturing area measures 200 ft. by 300 ft. by 30 ft. (1.8 million cubic feet). The air exchange rate is 5 per hour. The operation manufactures 24 hours per day 365 days per year. The outside operation consists of a closed system that has 1,000 connectors, 8 pumps, 25 light liquid valves, 4 agitators, and 4 safety relief valves. The annual average air temperature was reported to be 78°F.

During the course of the year the facility had one spill of pure TDI. Total amount of material spilled was 1,000 gallons that resulted in exposed area 1,000 sq.ft. for 20 hours. The evaporation temperature was 85°F and the airflow velocity was 20 miles/hour. The percent of TDI in the material was 100.

Estimate the total fugitive emissions of TDI.

To estimate the total emissions will require calculating the emission from the following:

1. Fugitive Emissions (non-point sources) Measured
2. Fugitive Emissions (non-point Source) Equipment Leaks
3. Spills

1. Fugitive Emissions: Measured

Direct measurement or monitoring data can be used to estimate fugitive emissions. In the absence of direct measurement or monitoring data, industrial hygiene data on TDI concentrations in the workplace can be used to estimate TDI or TDI fugitive emissions. This technique may overestimate fugitive air emissions if the industrial hygiene data are higher than the average concentrations throughout the year and throughout the building, but it is a technique worth considering.

The fugitive emissions can be estimated from the following expression:

\[ L_{fg} = C_{TDI} \cdot \left( \frac{V_B}{359} \right) \cdot N_{year} \cdot \left( \frac{273.15}{T_{amb}} \right) \cdot M_W \cdot K_f \]

Where:

- \( L_{fg} \) = the fugitive emissions in lb/year
- \( C_{TDI} \) = the average TDI concentration, expressed as weight fraction
- \( V_B \) = the volume of the workspace building in ft\(^3\)
- \( N_{year} \) = the number of air exchanges per year
- \( T_{amb} \) = the ambient temperature in K
- \( M_W \) = the molecular weight of TDI (174.15)
- \( K_f \) = an adjustment factor to the TDI concentration in the building air. CPI uses a value of 1.10
- 359 = the molar volume of an ideal gas in ft\(^3\)/lb-mole @ 0°C and 1-atmosphere

Therefore:

- \( C_{TDI} = 0.001 \text{ppm} = 1.0 \times 10^{-9} \)
- \( V_B = 1,800,000 \text{ ft}^3 \)
- \( N_{year} = 43,800 \text{ per year} \)
- \( T_{amb} = 298.7 \text{ K} \)
- \( M_W = 174.15 \)
- \( K_f = 1.10 \)
Therefore:

\[ L_{fg} = \left(1.0 \times 10^{-9}\right) \times \left(1,800,000 \text{ ft}^3/359\right) \times \left(43,800\right) \times \left(273.15/298.7\right) \times \left(174.15\right) \times \left(1.1\right) \]

\[ L_{fg} = 38.5 \text{ lbs/year} \]

2. **Fugitive Emissions: Equipment Leaks**

Fugitive emissions are air releases of volatile chemicals that typically occur due to leaks from fittings and seals in chemical process equipment, transfer operations or storage systems. In cases where monitoring data is not available, EPA has developed a method using emission factors based upon the type of fittings and number of fittings used in the process. The methodology used for TDI is an adaptation of an EPA Correlation Method ("1995 Protocol for Equipment Leak Emission Estimate" - EPA-453/R-95-017). The method presented here uses the actual formulas recommended by the EPA except that saturated vapor concentrations are used instead of screening values. Since the vapor concentration of TDI cannot exceed the saturation vapor pressure at a given temperature, the predicted screening values are limiting and conservative values. The calculation methodology involves the following steps:

1. Determine the saturated concentration of TDI.
2. Calculate emission factor for each equipment type.
3. Determine emissions for each equipment type.
4. Determine total losses from equipment leaks.

The TDI emissions from equipment leaks using the Modified Correlation Approach can be determined using the following equations:

\[ SV = 10 \left[11.763 - 3096.326/(t+273.15)\right] \]

Where:

\[ SV = \text{Screening Value in ppmv and} \]

\[ t = \text{Temperature in } ^\circ C \]

The calculated Screening Value [SV] is then inserted into the Leak Rate/Screening Value Correlation Formula for the appropriate equipment type [found in Table 5-7] and the leakage rate is determined.
Table 5
Leak Rate/Screening Value Correlations

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Correlation Leak Rate [kg/hr] ([a*\text{SV}^b])</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Valve</td>
<td>1.87x10^{-6} x [SV] 0.873</td>
</tr>
<tr>
<td>Light Liquid Valve</td>
<td>6.41x10^{-6} x [SV] 0.787</td>
</tr>
<tr>
<td>Light Liquid Pump</td>
<td>1.90x10^{-5} x [SV] 0.824</td>
</tr>
<tr>
<td>Connectors</td>
<td>3.05x10^{-6} x [SV] 0.885</td>
</tr>
</tbody>
</table>

Table 6
Equipment leak Emission Factors lbs/hr-component @ 78°F

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Temp (^\circ)F</th>
<th>Screening Value (SV) [ppmv]</th>
<th>Equation Constant (a)</th>
<th>Equation Constant (b)</th>
<th>Emission Factor (lb./hr-item)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Valves</td>
<td>78</td>
<td>24.957</td>
<td>1.87x10^{-6}</td>
<td>0.873</td>
<td>6.84x10^{-5}</td>
</tr>
<tr>
<td>Light Liquid Valves</td>
<td>78</td>
<td>24.957</td>
<td>6.41x10^{-6}</td>
<td>0.787</td>
<td>1.78x10^{-4}</td>
</tr>
<tr>
<td>Light Liquid Pumps</td>
<td>78</td>
<td>24.957</td>
<td>1.90x10^{-5}</td>
<td>0.824</td>
<td>5.94x10^{-4}</td>
</tr>
<tr>
<td>Connectors</td>
<td>78</td>
<td>24.957</td>
<td>3.05x10^{-6}</td>
<td>0.885</td>
<td>1.16x10^{-4}</td>
</tr>
</tbody>
</table>

Table 7
Equipment Leak Emissions

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Service</th>
<th>Number of Components</th>
<th>Weight</th>
<th>Emissions Weight Fraction</th>
<th>Emissions [lbs/hr]</th>
<th>Emissions [lbs./year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valves</td>
<td>Light Liquid</td>
<td>25</td>
<td>1</td>
<td>4.44x10^{-3}</td>
<td>38.9</td>
<td></td>
</tr>
<tr>
<td>Pump Seals</td>
<td>Light Liquid</td>
<td>16</td>
<td>1</td>
<td>9.50x10^{-3}</td>
<td>83.2</td>
<td></td>
</tr>
<tr>
<td>Connectors</td>
<td>All</td>
<td>50</td>
<td>1</td>
<td>5.80x10^{-3}</td>
<td>50.8</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>50</strong></td>
<td><strong>1</strong></td>
<td><strong>5.80x10^{-3}</strong></td>
<td><strong>172.9</strong></td>
<td></td>
</tr>
</tbody>
</table>
Total Fugitive emissions due to emissions from process area and outside:

\[
L_{fg} = 38.5 \text{ lbs/year} + 172.9 \text{ lbs/year} \\
= 211.4 \text{ lbs/year}
\]

3. Spills:

A liquid chemical accidentally spilled onto the ground may spread out over an area, vaporize and cause an air emission. Such accidental releases must be reported under EPCRA Section 313 (TRI). Evaporative losses from spills (and other open processes) depend on a number of factors including:

1. The volatility of the material
2. The size of the spill
3. The temperature of the surrounding area
4. The wind speed
5. The time that the liquid from the spill is allowed to evaporate

A fairly simple model proposed by the EPA that accounts for all these factors is provided by the following equation:

\[
Q_R = (0.284/82.05) \times (u)^{0.78} \times A_{spill} \times (V_{TDI}/T_{spill}) \times (M_W)^{2/3}
\]

Where:

- \(Q_R\) = the evaporation rate in lb/min
- \(u\) = the airflow speed in m/sec. This is the airflow in the vicinity of the process
- \(A_{spill}\) = the area of the spilled material in ft\(^2\)
- \(V_{TDI}\) = the vapor pressure of TDI in mm Hg at the spill temperature
- \(T_{spill}\) = the average evaporation temperature in K
- \(M_W\) = the molecular weight of TDI (174.15)

During the course of the year the facility had one spill of pure TDI. Total amount of material spilled was 1,000 gallons that resulted in exposed area 1000 sq.ft. for 20 hours. The evaporation temperature was 85°F and the airflow velocity was 20 miles/hour. The percent of TDI in the material was 100.

The spill losses can be determined by multiplying the evaporation rate \(Q_R\) in lb/min
by the time the spill is on the ground and converting the calculated value to the desired units:

\[ L_{\text{spill}} = Q_R \times t_{\text{spill}} \times (60) \]

Where:

- \( L_{\text{spill}} \) = the evaporation losses resulting from the spill in lb
- \( Q_R \) = the evaporation rate in lb/min
- \( t_{\text{spill}} \) = the time that the spill is on the ground in hours

Therefore:

- \( Q_R \) = represents the evaporation rate in lb/min
- \( u \) = 8.94 m/sec (20 miles/hr)
- \( A_{\text{spill}} \) = 1,000 ft²
- \( V_{\text{PTDI}} \) = 0.026 mm Hg
- \( T_{\text{spill}} \) = 302.6 K (85°F)
- \( M_W \) = 174.15

Substituting the values into the equation:

\[ Q_R = \left( \frac{0.284}{82.05} \right) \times (8.94)^{0.78} \times 1,000 \times (0.026/302.6) \times (174.15)^{2/3} \]

\[ Q_R = 0.051 \text{ lb/min} \]

Therefore:

\[ L_{\text{spill}} = 0.051 \times 20 \times 60 \]

\[ L_{\text{spill}} = 61.2 \]
Appendix A – Vapor Pressure/Temperature Chart

TDI Vapor Pressure/Temperature Chart²

Table A-1: TDI Vapor Pressure Chart is a table that lists the Vapor Pressure of 2,4-TDI vapor pressure [VP] at temperature from 20°C to 207 °C. These values can also be used for 2,6-TDI and mixtures of 2,4- and 2,6-TDI without appreciable error.

To determine the vapor pressure of TDI at a temperature not listed, you may use the following equation:

\[
\log_{10} P = 9.66 - \frac{2120}{(T+203)}
\]

Where:

\[
P = \text{TDI vapor pressure in pascals (Pa)}
\]

\[
T = \text{Temperature in °C}
\]

Note \( P \) [mm Hg] = 0.0075 * \( P \) [Pa]

---

Table A-1: TDI Vapor Pressure Chart

<table>
<thead>
<tr>
<th>Temperature (Fahrenheit)</th>
<th>Temperature (Celsius)</th>
<th>Vapor Pressure (Pa)</th>
<th>Vapor Pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14</td>
<td>-10</td>
<td>0.047</td>
<td>0.00035</td>
</tr>
<tr>
<td>23</td>
<td>-5</td>
<td>0.09</td>
<td>0.00068</td>
</tr>
<tr>
<td>32</td>
<td>0</td>
<td>0.16</td>
<td>0.0012</td>
</tr>
<tr>
<td>41</td>
<td>5</td>
<td>0.29</td>
<td>0.0022</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>0.51</td>
<td>0.0038</td>
</tr>
<tr>
<td>59</td>
<td>15</td>
<td>0.86</td>
<td>0.0065</td>
</tr>
<tr>
<td>68</td>
<td>20</td>
<td>1.4</td>
<td>0.011</td>
</tr>
<tr>
<td>77</td>
<td>25</td>
<td>2.3</td>
<td>0.017</td>
</tr>
<tr>
<td>86</td>
<td>30</td>
<td>3.6</td>
<td>0.027</td>
</tr>
<tr>
<td>95</td>
<td>35</td>
<td>5.7</td>
<td>0.043</td>
</tr>
<tr>
<td>104</td>
<td>40</td>
<td>8.6</td>
<td>0.065</td>
</tr>
<tr>
<td>122</td>
<td>50</td>
<td>16</td>
<td>0.12</td>
</tr>
<tr>
<td>212</td>
<td>100</td>
<td>460</td>
<td>3.5</td>
</tr>
<tr>
<td>302</td>
<td>150</td>
<td>4,500</td>
<td>34</td>
</tr>
<tr>
<td>392</td>
<td>200</td>
<td>25,000</td>
<td>188</td>
</tr>
</tbody>
</table>
Appendix B – References


# Appendix C – List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACFM</td>
<td>Actual cubic feet per minute</td>
</tr>
<tr>
<td>CAS</td>
<td>Chemical Abstracts Service</td>
</tr>
<tr>
<td>CERCLA</td>
<td>Comprehensive Environmental Response, Compensation, and Liability Act (1990)</td>
</tr>
<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
<tr>
<td>EHS</td>
<td>Extremely Hazardous Substance</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Act</td>
</tr>
<tr>
<td>EPCRA</td>
<td>Emergency Preparedness and Community Right-to-Know Act (1986)</td>
</tr>
<tr>
<td>HAP</td>
<td>Hazardous Air Pollutant</td>
</tr>
<tr>
<td>LEPC</td>
<td>Local Emergency Planning Committee</td>
</tr>
<tr>
<td>LEPD</td>
<td>Local Emergency Planning District</td>
</tr>
<tr>
<td>SDS</td>
<td>Safety Data Sheet (formally known as Material Safety Data Sheet or MSDS)</td>
</tr>
<tr>
<td>NAICS</td>
<td>North American Industrial Classification System</td>
</tr>
<tr>
<td>NPDES</td>
<td>National Pollutant Discharge Elimination System</td>
</tr>
<tr>
<td>NRC</td>
<td>National Response Commission</td>
</tr>
<tr>
<td>OSHA</td>
<td>Occupational Safety and Health Act</td>
</tr>
<tr>
<td>POTW</td>
<td>Publicly Owned Treatment Works</td>
</tr>
<tr>
<td>PPA</td>
<td>Pollution Prevention Act of 1990</td>
</tr>
<tr>
<td>PSIA</td>
<td>Pounds per Square Inch Absolute</td>
</tr>
<tr>
<td>RCRA</td>
<td>Resource Conservation and Recovery Act (1976)</td>
</tr>
<tr>
<td>RIM</td>
<td>Reaction Injection Molding</td>
</tr>
<tr>
<td>RQ</td>
<td>Reportable Quantity</td>
</tr>
<tr>
<td>SARA</td>
<td>Superfund Amendments and Reauthorization Act of 1986</td>
</tr>
<tr>
<td>SCFM</td>
<td>Standard cubic feet per minute</td>
</tr>
<tr>
<td>SERC</td>
<td>State Emergency Response Commission</td>
</tr>
<tr>
<td>SV</td>
<td>Screening Value</td>
</tr>
<tr>
<td>TPQ</td>
<td>Threshold Planning Quantity</td>
</tr>
<tr>
<td>TDI</td>
<td>Toluene Diisocyanate</td>
</tr>
<tr>
<td>TRI</td>
<td>Toxic Release Inventory</td>
</tr>
</tbody>
</table>