Pumps & Compressors for Isocyanates/TDI Applications

Sundyne Pumps | Sundyne Compressors | ANSIMAG Sealless Pumps | HMD Kontro Sealless Pumps | Marelli Bombas | PPI Diaphragm Compressors | SUNFLO

This process brief will generically apply to a sealless ANSI or ISO pump. Technical limitations may dictate the type of pump (for example, high temperatures limiting use of a plastic lined pump). However, many processes could use either sealed (Marelli), sealless metallic (HMD) or sealless plastic lined (Ansimag/ALI) pump. It is critical to understand the customer needs (price, lead-time, technology preference and the competitive environment) when proposing a pumping solution.

Isocyanates – TDI

Diisocyanates are one of the primary ingredients used in the production of polyurethanes. Polyurethanes based on toluene diisocyanate (TDI) tend to be the flexible foams most often found in furniture, mattresses, carpet pads and automotive seating.

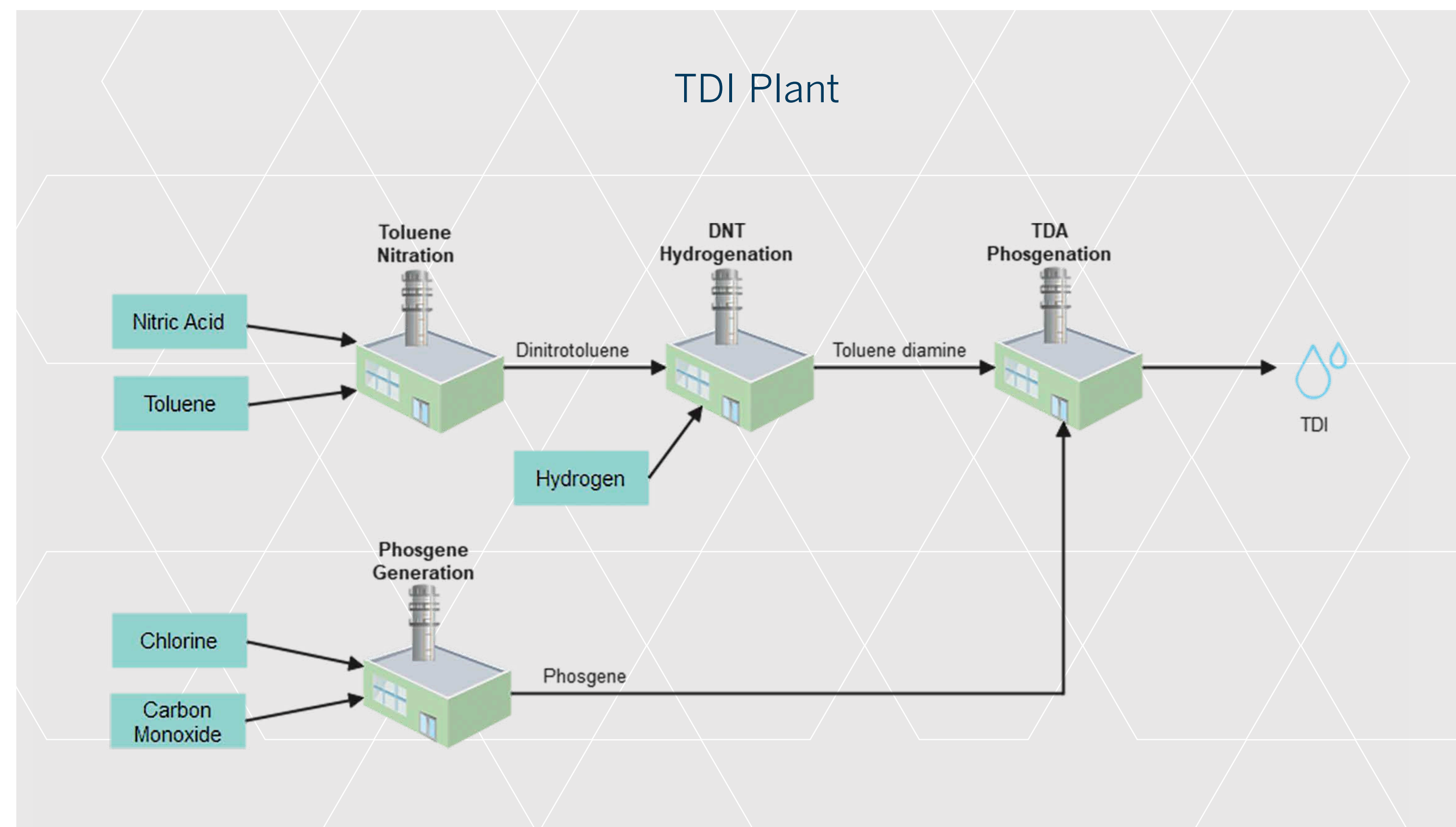
To produce polyurethane, isocyanates are reacted with Polyols and other chemicals. Many of the chemicals involved in the production of TDI are widely known to be either toxic corrosive, flammable, explosive or carcinogenic. Because of the environmental and health concerns associated with the safe handling of these chemicals, sealless mag-drive pumps such as HMD/Kontro and ANSIMAG are widely considered to be the best available technology for the production processes.

TDI Production

The primary feedstock for TDI is toluene. In the process of producing TDI, nitric acid, hydrogen and phosgene are also consumed. Production takes place in three key steps:

1. Toluene Nitration;
2. DNT Hydrogenation;
3. TDA Phosgenation.

Typically, a TDI plant will be closely located to a Chlor-Alkali plant to reduce the need to transport the chlorine that is consumed in the TDI production process. Due to safety concerns, a typical TDI plant will also have a Phosgene Generation Unit on site to produce the phosgene required for the final TDA Phosgenation step. The production process is shown in the following simplified flow diagram:



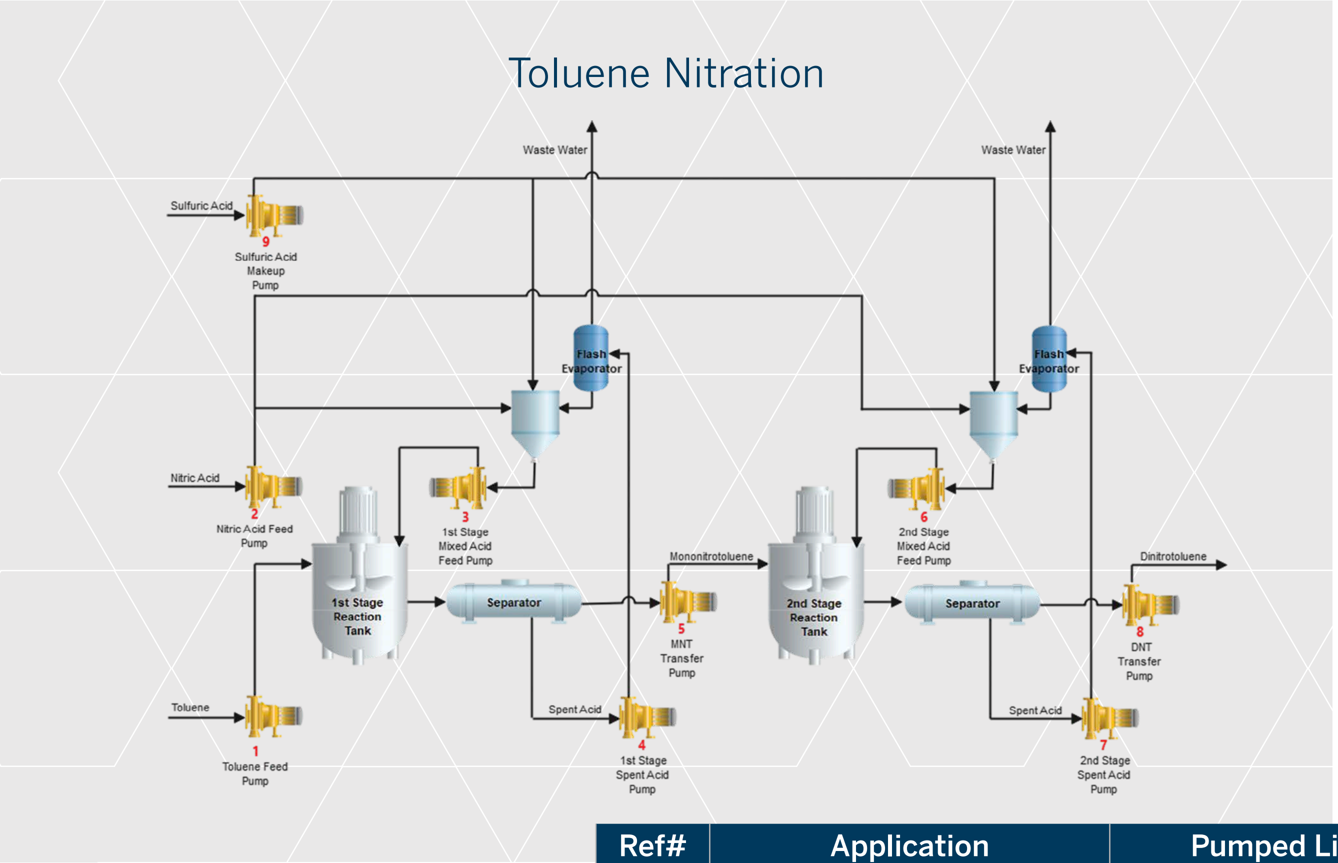
Toluene Nitration

Toluene, an aromatic hydrocarbon, is the primary feedstock used in the production of TDI. Typically, it is not produced in the TDI plant. It is usually shipped in (along with the nitric acid) from separate facilities. Toluene nitration is the first step in the production of TDI. In this step, dinitrotoluene (DNT) is produced. The reaction producing DNT takes place in two stages:

1. The reaction of toluene with nitric acid to produce mononitrotoluene (MNT);
2. Followed by the reaction of MNT with nitric acid to produce DNT.

In the first stage, Toluene is reacted with a dilute nitric acid solution to produce mononitrotoluene (MNT). To increase the efficiency of the reaction, sulfuric acid is mixed with the dilute nitric acid solution prior to being introduced into the reaction tank. The sulfuric acid acts as a catalyst and is not consumed in the overall reaction. Water is a by-product of the reaction. Once the reaction is complete, the aqueous sulfuric acid solution is separated from the organic MNT solution, where it is concentrated (by removing water), and recycled.

In the second stage of the process, the MNT is further nitrated with nitric acid (at a higher temperature) to produce dinitrotoluene (DNT). Like the first stage, sulfuric acid is mixed with the nitric acid prior to being introduced in the reaction tank to increase the efficiency of the reaction. The aqueous sulfuric acid solution is then separated from the organic DNT solution, where it is concentrated and recycled as shown in the following simplified process flow diagram:



Pumps typically associated with the Toluene Nitration process include:

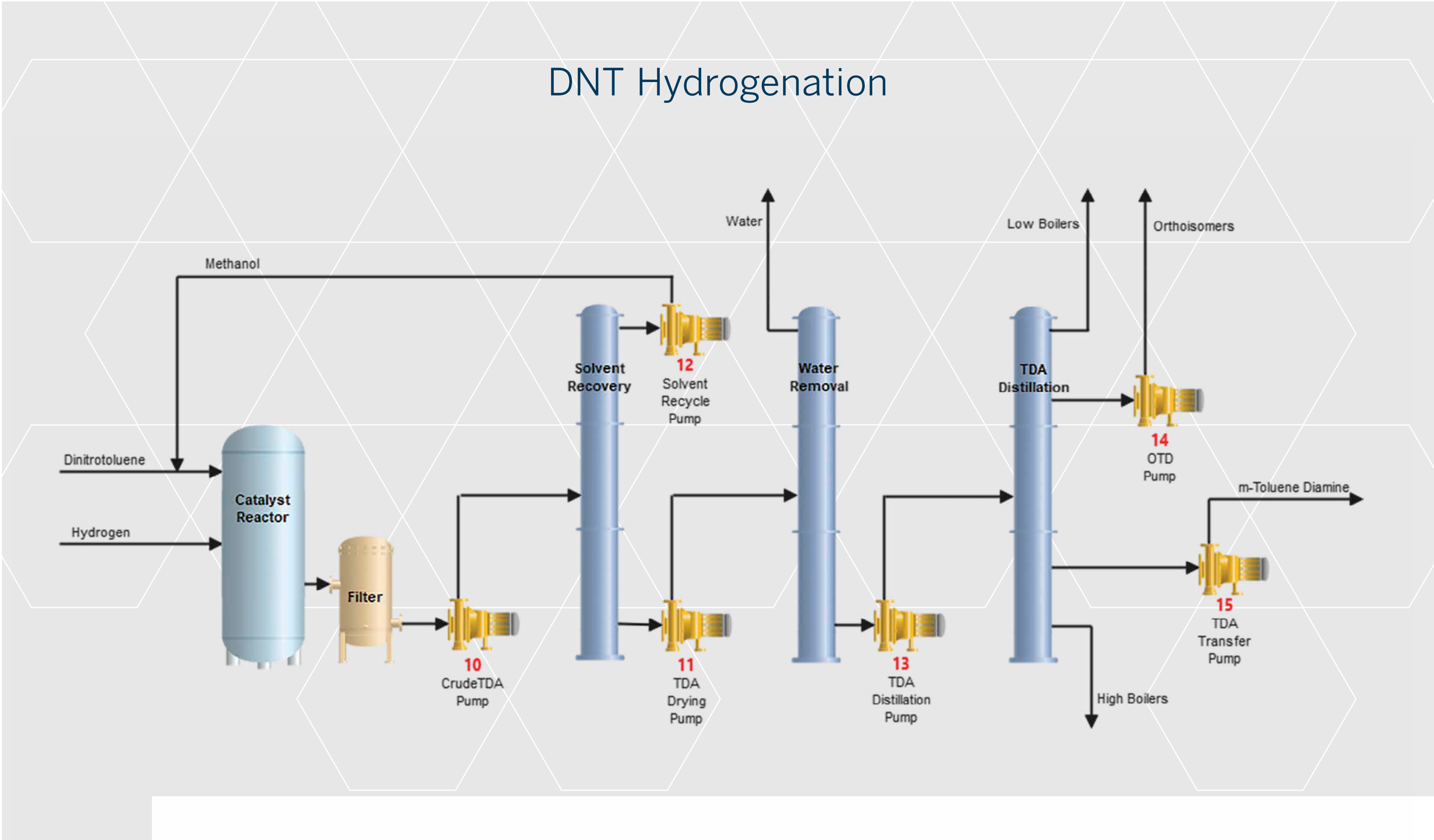
Ref#	Application	Pumped Liquid
1	Toluene Feed Pump	Toluene
2	Nitric Acid Feed Pump	Nitric Acid
3	1st Stage Mixed Acid Feed Pump	Nitric/Sulfuric Acid
4	1st Stage Spent Acid Pump	Spent Acid
5	MNT Transfer Pump	Mononitrotoluene
6	2nd Stage Mixed Acid Feed Pump	Nitric/Sulfuric Acid
7	2nd Stage Spent Acid Pump	Spent Acid
8	DNT Transfer Pump	Dinitrotoluene
9	Sulfuric Acid Makeup Pump	Sulfuric Acid

DNT Hydrogenation

Toluene diamine (TDA) is produced by the hydrogenation of dinitrotoluene (DNT). Hydrogenation is the reaction between hydrogen and another compound. It is a multi-phase reaction performed within a nickel catalyst reactor. Typically, methanol is mixed with the DNT to reduce the formation of undesired orthoisomers (OTD). Following the reaction, a reactor effluent (crude TDA) is filtered to remove any catalyst that may carry over. The crude TDA is then prepared for further use through three distillation steps:

1. Recovering (and recycling) the added methanol;
2. Removing the water generated in the reaction;
3. Separating unwanted low boilers, orthoisomers and high boilers from the TDA.

The process is illustrated in the following simplified process flow diagram:



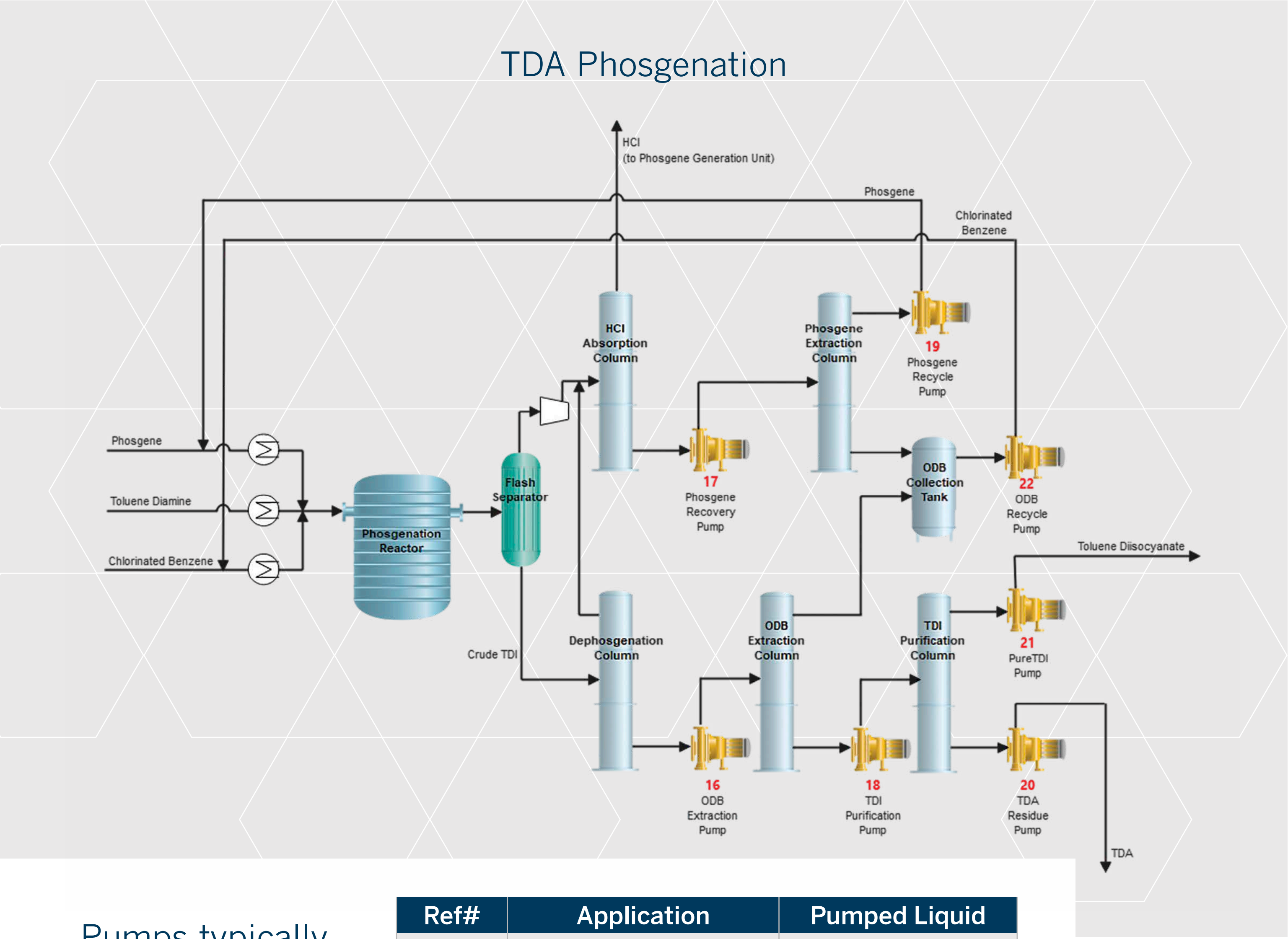
Pumps typically associated with the DNT Hydrogenation process include:

Ref#	Application	Pumped Liquid
10	Crude TDA Pump	Crude TDA
11	TDA Drying Pump	TDA/Water
12	Solvent Recycle Pump	Methanol
13	TDA Distillation Pump	TDA
14	OTD Pump	Orthoisomers
15	TDA Transfer Pump	m-Toluene Diamine

TDA Phosgenation

Toluene Diisocyanate (TDI) is generated through either a liquid or gas phase reaction between Toluene diamine (TDA) and phosgene (a highly toxic gas, also known as carbonyl chloride) in the presence of a solvent. The gas phase process is faster, more energy efficient and requires less solvent than the liquid phase process. It is for these reasons that the gas phase process will be discussed here.

In the gas phase phosgenation process, TDA, phosgene and a small amount of chlorinated benzene (solvent) are gasified and subsequently fed into – and mixed – in a reactor to generate TDI. The solvent, excess phosgene and hydrogen chloride (HCl, a by-product of the reaction) are separated from the reactor effluent and prepared for recycle/reuse through a series of distillation steps. The crude TDI from the reactor goes through a series of distillation steps to remove any trace phosgene, solvent and TDA residue, to produce purified TDI as shown in the following simplified process flow diagram:



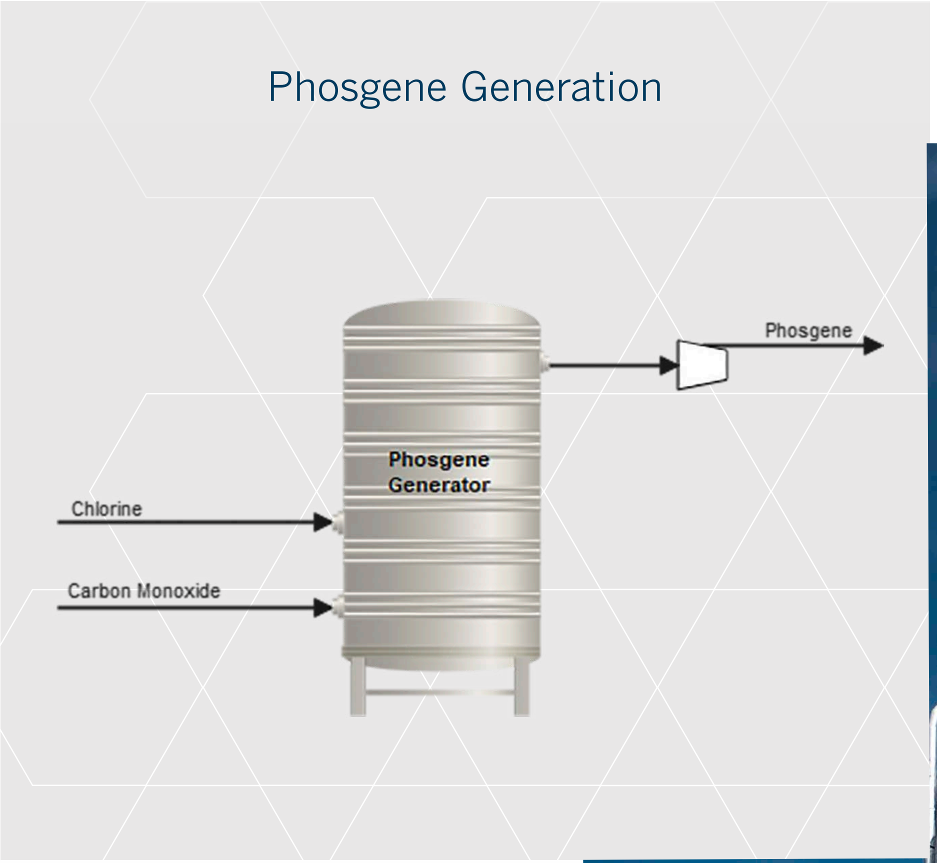
Pumps typically associated with the TDA Phosgenation process include:

Ref#	Application	Pumped Liquid
16	ODC Recovery Pump	TDI/OCB
17	Phosgene Recovery Pump	Phosgene/OCB
18	TDI Purification Pump	TDI/TDA
19	Phosgene Recycle Pump	Phosgene
20	TDA Residue Pump	TDA
21	Pure TDI Pump	TDI
22	OCB Recycle Pump	o-Chlorobenzene

Phosgene Generation

Phosgene ($COCl_2$) is a key ingredient in the production of TDI. Because of the extreme environmental, health and safety issues associated with the transportation and exposure to this chemical, the phosgene used to produce TDI is almost always produced within the plant.

Phosgene is produced by the gas phase reaction between carbon monoxide and chlorine (from a Chlor-Alkali plant) using active carbon as a catalyst. The phosgene produced is typically compressed prior to transport.



Criteria for Selecting Pumps Used with Isocyanates

Most of the chemical catalysts referenced in this document are reactive elements that are toxic and corrosive. They should not be inhaled by plant personnel, even at low concentrations. Operators should consider the following requirements when selecting pumps for Isocyanate production:

Worker Safety & Environmental Protection by Eliminating Leakage:

External emissions are one of the biggest issues relating to pumping equipment used in Isocyanate production. **Sealless pumps** are typically used to move materials through each stage of production. Sealless pumps have no seals to replace, which means fewer (or no leaks) and no emissions.

Reliability via Superior Chemical Resistance:

Materials of construction for a pump's internals must be carefully considered. The harsh nature of Isocyanate processing can wreak havoc on a pumps internals. A wide range of **metallic and ETFE materials of construction** should be available.

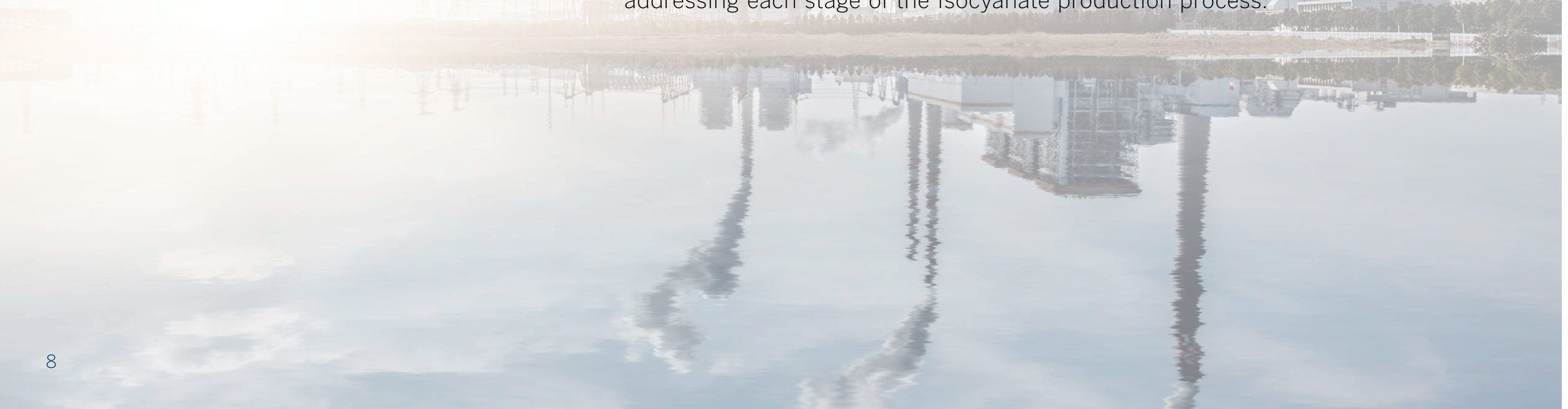
Simplified Maintenance:

The sheer volume of Isocyanate production illustrates the need for reliable equipment that minimizes plant downtime, as many plants producing these chemicals run operations around the clock. The ability to streamline maintenance (and plan predictive maintenance activities) helps operators increase plant uptime. Sealless pumps eliminate the need for seal support systems and they have fewer wetted parts – which minimizes maintenance costs and increases Mean Time between Maintenance (MBTM) intervals.

Energy Efficiency:

Isocyanate processing is an energy-intensive processes. Electricity can account for 40 to 50 percent of operating costs. In many cases, the ability to manage this expense determines the plant's profitability. Operators should seek pumps with an efficient hydraulic envelop and low net positive suction head (NPSH) hydraulics. Small footprints are always preferred, not only to save space on the shop floor, but also to facilitate simple access for maintenance.

Sundyne pumps are specifically designed to address these requirements. The chart that follows identifies a number of (sealed and sealless) pump options for addressing each stage of the Isocyanate production process.



TDI Plant Pump Summary

						Sundyne Pumps		
Equip No	**Unit**	**Application**	**Liquid**	**Pump Type**	**Construction[1]**	**ETFE Lined Mag Drive**	**Metallic Mag Drive**	**Metallic Sealed**
1	Toluene Nitration	Toluene Feed Pump	Toluene	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
2	Toluene Nitration	Nitric Acid Feed Pump	Nitric Acid	ANSI / ISO	ETFE / 304SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
3	Toluene Nitration	1st Stage Mixed Acid Feed Pump	Nitric/Sulfuric Acid	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
4	Toluene Nitration	1st Stage Spent Acid Pump	Spent Acid	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
5	Toluene Nitration	MNT Transfer Pump	Mononitrotoluene	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
6	Toluene Nitration	2nd Stage Mixed Acid Feed Pump	Nitric/Sulfuric Acid	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
7	Toluene Nitration	2nd Stage Spent Acid Pump	Spent Acid	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
8	Toluene Nitration	DNT Transfer Pump	Dinitrotoluene	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
9	Toluene Nitration	Sulfuric Acid Makeup Pump	Sulfuric Acid	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
10	DNT Hydrogenation	Crude TDA Pump	Crude TDA	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
11	DNT Hydrogenation	TDA Drying Pump	TDA/Water	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
12	DNT Hydrogenation	Solvent Recycle Pump	Methanol	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
13	DNT Hydrogenation	TDA Distillation Pump	TDA	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
14	DNT Hydrogenation	OTD Pump	Orthoisomers	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
15	DNT Hydrogenation	TDA Transfer Pump	m-Toluene Diamine	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
16	TDA Phosgenation	ODC Recovery Pump	TDI/OCB	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
17	TDA Phosgenation	Phosgene Recovery Pump	Phosgene/OCB	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
18	TDA Phosgenation	TDI Purification Pump	TDI/TDA	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
19	TDA Phosgenation	Phosgene Recycle Pump	Phosgene	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
20	TDA Phosgenation	TDA Residue Pump	TDA	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
21	TDA Phosgenation	Pure TDI Pump	TDI	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO
22	TDA Phosgenation	OCB Recycle Pump	o-Chlorobenzene	ANSI / ISO	ETFE / 316SS	Ansimag K+/KI HMD Kontro ALI	HMD Kontro CSA/I	Marelli ISO

[1] Construction materials referenced are a sample of the materials commonly specified in pump data sheets. Sundyne, LLC does not warrant the suitability of these (or any) materials in a particular service or application. Suitability is the sole responsibility of the purchaser and/or user.

When it comes to Isocyanate/TDI applications, Sundyne is the **Safer, Better, Best** choice.

Safer for Operations
Better for the Environment
Best Total Lifecycle Value

For more information please visit www.sundyne.com and fill out the Contact Me form. A Sundyne representative will contact you.

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