



# Managing Environmental Impact Potential of Electronic Materials Usage in the Semiconductor Industry

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Materials suppliers to the semiconductor industry are required to handle and process chemicals and gases which are potentially hazardous to both people and the environment. As one of these companies, Linde identifies and manages the environmental risks associated with the handling of electronic materials throughout their lifecycle from synthesis to disposal, including transportation and usage at the customer site.

## Potential Effects

Electronic materials can potentially have an adverse effect on the environment in two ways. The unexpected instantaneous release of large volumes of hazardous material caused by an equipment or process failure, such as a pressure vessel rupture, can have a severe impact on the surrounding environment. This scenario is a concern across all process industries. There have been numerous high profile incidents where this has happened, such as the 1984 toxic gas leak in Bhopal, India; a 2010 oil rig explosion in the Gulf of Mexico, US; and the 2013 ammonium nitrate explosion in Texas, US.

The second potential source of environmen-

tal impact caused by electronic materials is a long-term, relatively low-level release of material causing a gradual change in environmental conditions. This can be caused by insufficient abatement of materials which are not hazardous to people at low levels, but which nevertheless have an environmental impact. An example of this is the release of nitrogen trifluoride (NF<sub>3</sub>), or sulphur hexafluoride (SF<sub>6</sub>), both of which are greenhouse gases, with Global Warming Potentials (GWP) of 17,200 and 23,900 times that of CO<sub>2</sub>. The potential severity of releasing these materials to the environment is apparent, and provides a clear imperative for those who deal with these gases to employ robust controls to manage the risk of such an event.

## Managing Risks

Linde is active in reducing and managing the risk of both kinds of environmental impact throughout the lifecycle of our electronic materials via our Product Stewardship program. This program focuses on ensuring that Linde's products are produced, transported, used, and disposed of in a safe and environmentally re-

sponsible manner, achieving this through a program of supplier audits and assessments, and working collaboratively with customers to implement best operating practice.

In addition to this consideration of upstream and downstream processes, Linde applies a high level of focus on each aspect of our operations that has an effect on the environmental impact of our products. In its most fundamental form this involves developing products and technologies that reduce the impact of customer processes on the environment. For example Linde provides on-site Fluorine (F<sub>2</sub>) Generation plants to enable customers to replace NF<sub>3</sub> or SF<sub>6</sub> used in their processes with F<sub>2</sub>, which has a GWP of zero. In addition to this, Linde has developed technology to reclaim and recycle various gases from the waste streams of customer processes, reducing the consumption of these materials and therefore the environmental impact of their production. The environmental impact of Linde's electronics industry operations is further reduced by improvements in ASU efficiency, decreasing the carbon footprint of supplying air gases, such as nitrogen (N<sub>2</sub>) and

oxygen (O<sub>2</sub>), and rare gases, such as neon (Ne) and xenon (Xe), to electronics customers.

Linde's focus on managing the risk of our products causing harm to the environment also pervades our equipment design activities. This starts at the process design phase, during which safety reviews such as HAZOP are conducted, and the appropriate number and type of safeguards required to prevent an unexpected product release are specified using techniques such as Safety Integrity Level (SIL) Assessment. The focus on preventing product release extends into the detail equipment design phase, through selection of materials compatible with the properties of the materials being handled, which may be corrosive or highly reactive. Application of these design processes and standards enables Linde's equipment to achieve compliance with internationally recognized codes, such as CE.

Beyond the design phase, environmental considerations are also central to Linde's project execution activities, from assisting customers with selecting suitable process and emergency abatement and emergency response systems for the products being handled, to site-level safety reviews and risk assessments such as site-HAZOP and our Major Hazards Review Program (MHRP), which ensures that local conditions are taken into account when establishing the safety procedures to be implemented at a new site. By applying these processes Linde ensures our sites are, at a minimum, compliant with applicable local environmental codes, such as those administered by bodies such as the United States' Environmental Protection Agency (EPA). Linde works closely with such organizations to ensure our activities are aligned with legislative requirements.

The risk of product release to the environment is further managed by Linde's operational standards. From a personnel perspective this is achieved by integrating environmental factors into operational personnel training programs, and our Behavioral Safety program, which empowers every employee to frankly and openly discuss safety and environmental issues with colleagues wherever they arise. From an equipment perspective the focus is on ensuring hardware is inspected and maintained in accordance with pre-determined schedules, which ensures that all safety devices remain operational throughout the plant lifetime. Linde's focus on operating plants in an environmentally conscious manner has enabled numerous sites to achieve ISO 14001 certification.

It is evident that the use of materials that are

potentially harmful to the environment is a necessity for the electronics industry in which Linde operates. As such we have a responsibility to apply our skills, experience, and standards in such a way that the risks are understood and managed. By ensuring that this focus is built in to every step of our activities, demonstrating diligence in assessing the activ-

ities of our suppliers, and providing innovative solutions to support our customers, Linde is able to fulfill this requirement. ■



## Gasflo