Effective emissions control is essential for the pharmaceutical processing industry, which relies on the use of a number of organic solvents for the manufacture of its products. Ever since the introduction of the EU Solvent Emissions Directive, adopted in the UK in 2002, such processors have been seeking ways to reduce their solvent consumption and enhance on-site emissions control, while maintaining efficiency.

When it comes to choosing an effective method of emissions abatement, pharmaceutical manufacturers have a choice of technologies available to them. For example, carbon adsorption systems are well established and have been demonstrated to be effective and are suitable for a wide range of solvent-using industries. While effective, such systems have become less popular in recent years as a result of changes in landfill regulations, which now require the disposal of these contaminated carbon beds as ‘active waste’.

The use of cryogenic technology in emissions control is nothing new. Ever since the late 1980s, cryogenic condensation systems have been used by chemical and pharmaceutical manufacturers to freeze and recover solvent emissions. Such systems work by cooling the exhaust gas stream – containing the solvents – to below the solvent’s own freezing point. Liquid nitrogen, which has a temperature of -196°C, provides the cooling power to literally freeze out the solvents, which can be recovered separately. The clean gas stream can then be released safely into the atmosphere.

In view of their efficiency, these early cryogenic condensation systems continue to be used and are particularly suited to larger-scale applications, requiring two heat exchangers, with flow rates of 300 to 2,000Nm³. However, until recently, many smaller processing plants preferred alternative methods of emissions control and regarded cryogenic technology as impractical or just too large.

Recent developments in cryogenic emissions control systems now mean that they provide a more compact solution, suited to lower gas flow rates, which is both efficient and flexible, extending the range of processing applications. Despite this innovation, the larger, more traditional cryogenic systems remain popular for larger flow rates.

SMALLER AND MORE EFFICIENT

With a strong track-record in solvent emissions control, cryogenic technology has evolved to meet the needs of modern pharmaceutical processors. In particular, the technology has become smaller in size and has been adapted to work effectively at lower gas flow rates, so it is suitable for smaller solvent-using plants. This size reduction has been achieved by developing a new technology to operate as a continuous single unit system, with just one heat exchanger.

By Luc Rijnbeek at Air Products

Luc Rijnbeek is Global Commercial Manager, Environmental Cryogenics, at Air Products. He joined the company in 1991 with a degree in Mechanical Engineering, and currently specialises in developing environmental cryogenic solutions for modern industrial processes.

How Solvents Are Used

Volatile organic compounds (VOCs) or solvents are used in a variety of pharmaceutical manufacturing processes including the chemical synthesis, fermentation, extraction, formulation and finishing of products. Emissions can typically occur in a number of process areas – reactor vents, storage tanks and vacuum pumps. The VOCs most commonly used include hexane, methyl chloride, dichloromethane, methanol, ethyl acetate, acetone, toluene, xylene, triethylamine, tetrahydrofurane, butyl acetate and isopropanol.
These new compact systems also allow maximum flexibility in production and can be adjusted relatively simply by an on-site operator. The cryogenic system can be adjusted to take account of the freezing temperature of the solvents being used, enabling pharmaceutical processors to run multi-purpose plants, using different solvents for different or new products.

Another significant development is that the industry has gained a better knowledge of a wider range of solvents or volatile organic compounds (VOCs), and how they behave under different conditions. By applying this knowledge, high-performance cryogenic condensation systems are now capable of recovering even the most complex VOCs at low gas flow rates, which means they are even more effective across a wider range of processes.

**ENVIRONMENTAL LEGISLATION**

Driving this demand for the improved efficiency of emissions control solutions is a tightening of European environmental legislation, and the sustained focus of policy-makers on emissions reduction and air quality.

The European Commission is planning a major shake-up of EU legislation on air quality, which will involve setting tighter emissions ceilings for all member states in the run-up to 2020, as well as the introduction of new policies. These tighter national emissions ceilings will include VOC emissions, although the Commission is expected to report that existing policies are already proving effective in some areas. In the UK, VOC emissions have already fallen below the target set by the 2001 EU Directive, to be achieved by 2010. Despite this achievement, industry should prepare for a further tightening of emissions reduction legislation as a result of these plans to streamline the air quality framework and its directives.

The main current legislative driver for efficient emissions control is the EC Solvents Directive (1999/12/EC), which established a goal for the reduction of solvent emissions across Europe by 67% by 2007.

Adding to this legislative pressure, roll-out of the Integrated Pollution Prevention and Control (IPPC) regime is encouraging companies to take a more holistic view of the environmental impact of each plant and includes a focus on emissions to air.
Just meeting these new legislative requirements is already proving testing enough for most solvent-using processes, and changes to Guidance Notes made in 2004 mean that some could find they are required to comply earlier than expected. The changes state that ‘substantial change’ to the installation leading to a significant increase in capacity, or any change resulting in a 10% increase in solvent emissions, could trigger regulatory requirements under the Solvent Emissions Directive or the IPPC or both. All solvent-using processes will be required to comply fully with the Solvent Emissions Directive by 31st October 2007.

As the impact of this legislative change takes effect, pharmaceutical businesses – like other solvent-using process industries – are advised to keep their environmental management systems under review and invest in the best available technology where appropriate.

TOWARDS SUSTAINABILITY

Amid this focus on emissions control, pharmaceutical processors are increasingly looking for technological solutions that are not only efficient and reliable, but also easier to manage, with reduced overheads, enhancing the overall sustainability of their plant.

As well as operating to the highest standards of efficiency, cryogenic emissions control systems can bring potential benefits which – if realised – could help to offset overall running costs. This makes cryogenic systems a more sustainable solution than many other forms of emissions control.

High performance cryogenic condensation systems are capable of recovering solvents in a pure form, which means that they can be recovered and re-used. To date these sustainability benefits have not been fully realised and they present an opportunity for forward-looking processing plants in the future. The author can be contacted at cryoeur@airproducts.com

Focus On Solvent Recovery

When it comes to weighing up the most efficient and effective abatement technologies, manufacturers should consider the following factors:

- **Flexibility** – Cryogenic technology is capable of recovering VOCs from low flow rates up to 2,000Nm³/h. These systems are highly flexible and operating temperatures can be easily changed to allow for recovery of VOCs with lower freezing temperatures.
- **Size** – Cryogenic freezing systems are more compact, operating with a single heat exchanger and are suitable for low gas flow rates.
- **Efficiency** – Cryogenic solvent recovery systems are highly efficient, using liquid nitrogen to freeze and recover the VOCs while ensuring that the process itself remains inert. The nitrogen used during the process may in some cases also be available for re-use.
- **Opportunities** – Cryogenic condensation and freezing systems recover solvents in a pure, uncontaminated form, which means that they can be recovered and re-used.
- **Compliance** – Cryogenic solvent recovery systems are capable of exceeding the required emissions limits applied in Europe and set a new benchmark for emissions control in the future.