Zero discharge: a catalyst for a new chemistry

David Santillo, Paul Johnston and Ruth Stringer reflect on the legal obligations forcing the process industries to observe their environmental responsibilities

THERE is little doubt that, in the latter part of the twentieth century, chemical engineers came under increasing pressure to observe regulatory moves designed to protect the environment. National administrations have varied significantly in the degree of control exercised on production processes and emissions and in the scope of their vision of the future for the chemical industry, but the trend towards reduced environmental impact, at least in the industrialised nations, is undeniable.

The inclusion of environmental protection as a tenet of the Treaty of Rome set the agenda for further developments within Europe, placing consideration of the environment (theoretically, at least) at the heart of decision-making processes, alongside economic and social concerns. The European Commission has developed legislation designed ostensibly to protect human health and the environment in many fields and has attempted to harmonise such controls across Europe.

Of particular relevance to the chemical engineer, perhaps, is the ongoing work under the EC Directive on Integrated Pollution Prevention and Control (IPPC), work aimed at defining appropriate practice and technological solutions for a wide range of chemical and product manufacturing sectors. Ultimately the 1996 IPPC Directive will cover sectors from iron and steel production to textiles, from refineries to polymer production. In each case, the outcome of the process is a technical reference document describing Best Available Techniques (BAT) for the variety of specific processes involved, the so-called BREF documents. To date, BREFs have been finalised for eight sectors and are scheduled for completion soon on a further 15 or so.

Initial scepticism from industry has apparently gradually been replaced by a greater trust in the process and willingness to contribute to the development and identification of BAT. Undoubtedly the IPPC Directive promises substantial challenges for the chemical industry as a whole and to the chemical engineer who in turn has to respond to demands for cleaner processes which meet the conditions of the BREF. Undoubtedly also, the work towards BAT in any one case will lead to better environmental performance, measured as an overall reduction in emissions of chemicals to the environment, as well as greater efficiency in terms of resource, water and energy use. Nevertheless, it must be remembered that the BREFs, however progressive, provide non-binding guidance only.

Moreover, the process of identifying BAT will always be permissive in nature, based fundamentally on what level of performance is achievable taking into account economic constraints rather than what might ultimately be desirable in terms of minimising impact. Although the concept of BAT incorporates the necessity to remain aware of and adapt to changes in technological capabilities, this evolution is often a slow process, constrained as it is by the medium to longer-term investment cycles followed by industry. All too often the focus remains on pollution control through 'end-of-pipe' waste treatment processes, rather than on the products and production processes themselves. So, despite the obvious improvements that IPPC will deliver, what is lacking is more strategic direction for the chemical industry – a longer-term vision of the principles and practices it will be required to operate under in its service of generations to come; a vision which will allow the chemical engineer to look beyond BAT towards the true sustainability of processes and products.

Such far-reaching developments clearly demand more than technological progress; rather they require changes in the way we both think and act. There are a number of barriers to such changes, not least of which is the unfamiliarity and apparent uncertainty of a market founded on principles other than short to medium-term economic returns. There is clearly an increasing interest among the public in more sustainable products, products for which the environmental as well as the ethical consequences are explicit. At the same time, however, there remains a degree of separation between the chemicals and other products we use in our daily lives and the production processes employed in their manufacture. Consumer products are generally priced largely independently of the true costs of production and disposal. For the interested consumer, or even retailer, the chain of responsibility is made yet more difficult to link by the sheer complexity of chemical production and trade, a web which commonly leaves chemical manufacturers far from fully apprised of all the end uses of their products. All to often, this lack of knowledge leads to a denial of responsibility for chemical products once they have left the plant.

The newly formulated *White Paper* on chemicals policy for Europe, developed in recognition of the failure of existing controls to adequately address the magnitude and diversity of chemical production and usage, contains commitments to make the market fate of chemicals more explicit, including the imposition of reporting and monitoring responsibilities on downstream users. Also contained within the proposals, due to be finalised in June this year, are stricter data requirements to support the marketing of chemicals, authorisation of specific uses only for chemicals with particularly hazardous properties and transfer of much of the responsibility for chemical assessments to the manufacturers themselves. Though undeniably far-reaching if it can be properly implemented, the policy again lacks a broader strategic goal, a roadmap which will stimulate the move beyond a 'business as usual, but with cleaner discharges' approach towards more sustainable practice.

Within Europe, this strategic direction is provided by a number of international, intergovernmental agreements, as well as in the developing approaches of certain progressive national administrations. Central to the evolution of these policies and measures has been the desire to protect, or at least reverse current degradation of, the marine environment. In turn, these policies are underpinned by recognition of the inherent limitations to analytical determination or prediction of the fate and effects of chemicals, coupled with the unavoidable reality that, once released to the marine environment, hazardous chemicals cannot be recalled. History has furnished us with numerous unforeseen examples of what can go wrong, examples which continue to surface year on year both within and beyond the marine environment. At the same time as scientific research has equipped us with ever better descriptions of ecosystem function and chemical pathways, it has also highlighted how much we still do not understand and the necessity, therefore, for a more fundamental paradigm shift in the manner in which we manufacture and use chemicals.

The periodic conferences of ministers from North Sea States, most recently in Esbjerg in 1995, have been particularly instrumental in setting the agenda for such a shift. The forward-looking declaration which arose from the 1995 conference formed the basis for the more detailed and binding agreements forged under the auspices of the OSPAR Convention for the protection of the North East Atlantic region at its meeting in 1998. Central to the OSPAR strategy is the concept that chemicals presenting certain intrinsic hazards (toxicity, persistence and capacity to bioaccumulate, or properties of similar concern) simply cannot be tolerated as contaminants of the marine environment. In turn, the only way in which to ensure that such chemicals do not reach the marine environment is to prevent their release in the first place. Hence the commitment signed by all parties to the OSPAR Convention (15 North East Atlantic states plus the European Commission) to make every endeavour to move towards the target of cessation of discharges, emissions and losses of hazardous substances by the year 2020.

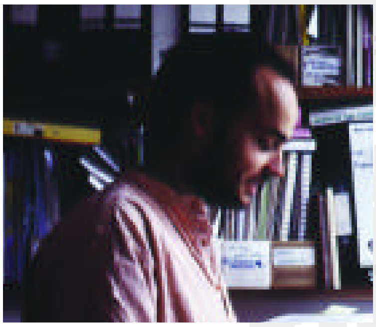
This 'one generation target', and the strategy which will implement it, marks an acceptance of the goal of 'zero discharge' for hazardous substances. The partial translation of this timeframe into European law, in the form of the provisions for the small subset of 'priority hazardous substances' identified within the new Water Framework Directive, will undoubtedly contribute to the enforcement of measures. Nevertheless, it is a wider change in philosophy, in will and responsibility, that the cessation target demands and on which its true success will ultimately depend.

This paradigm shift clearly strikes at the heart of chemical engineering. Meeting the 'one generation goal' will necessitate process designs and configurations geared not merely to maximising product recovery and minimising raw material and energy costs, nor simply to the meeting of emission limit values (ELVs) for specific substances. Rather it will demand more radical departures, the minimisation and prevention of waste streams, recirculation of material and more efficient energy flows. Ultimately, process and/or product substitutions which render manufacturing inherently less hazardous and facilitate the pursuit of zero discharge will be required. In some sectors, such progressive developments have been underway for some time. The conversion of some paper pulp bleach lines to totally chlorine free (TCF) technology, for example, has not only eliminated the secondary production of persistent organochlorine chemicals but has also paved the way for the recycling and recovery of effluents previously discharged.

In short, just as retailers and the user community will need to take more responsibility in the way they use and dispose of chemicals, so manufacturers will need to take responsibility for what chemicals they produce, and chemical engineers for how they produce them. Responsibilities must be seen to be integrated throughout the lifecycle, not isolated to how chemicals are used post-manufacture, and must extend beyond the current generation and beyond human society, in order to protect the fundamental bases of ecological sustainability.

The chemical industry of the future must be one which is not afraid to evolve, nor to recognise and act swiftly upon its mistakes. It must temper its simple focus on maximum profit with a recognition that it must serve the wider interests and aspirations of society, including the desire to avoid the use of chemicals which will systematically accumulate in the environment, appear in remote areas of the globe or contaminate our own bodies. The decision by 3M Corporation to cease production of the water- and oil-proofing agent perfluorooctenyl sulphonate (PFOS) in May 2000, based on recognition of its persistence and widespread distribution but before any proof of harm, may provide a *de facto* standard for industry to follow in the future.

Without doubt, the demand for a more sustainable chemical industry will entail, in turn, a new chemistry and hence, far-reaching challenges for the chemical engineer. Process solutions will need not only to be operationally and economically viable but also result in progressively lower environmental burdens. This means going beyond BAT and ELVs to the smarter solutions vital to our future utilisation of chemicals. It is not an abandonment of economics. Nor does it mark an end to the chemical industry. It is simply a longer-term and more integral approach to exploitation of chemistry. Far from economic suicide, those with the engineering expertise and a high degree of commitment to R&D will be the best equipped to attain the goal of zero discharge. Undoubtedly, too, they will find a responsive market developing in the current climate of growing environmental responsibility. ■



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