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THE UNITED KINGDOM OF GREAT BRITAIN AND NORTHERN IRELAND

THE CHANGING FACE OF THE CHEMICAL INDUSTRY: IMPLICATIONS FOR THE CHEMICAL WEAPONS CONVENTION

1. Executive Summary

- 1.1. At the First Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention (hereinafter, “the first Review Conference”), the States Parties have an obligation to review comprehensively the provisions of the verification regime for the chemical industry (paragraph 26 of Part IX of the Verification Annex to the Chemical Weapons Convention, hereinafter the “Verification Annex”), and especially the part of the verification regime concerned with the production of unscheduled discrete organic chemicals.
- 1.2. States Parties are thus mandated to use this opportunity to ensure the continuing viability and relevance of the verification measures of the Chemical Weapons Convention (hereinafter, “the Convention”), in light of the experience of the OPCW verification measures since entry into force of the Convention, and of the progressive evolution of the chemical industry.
- 1.3. This paper outlines key changes and developments within the industry since the Convention was negotiated in the 1980s, and demonstrates how these developments could render particular sections of the routine verification measures ineffective - unless action is taken to redress the balance - and hence threaten the object and purpose of the Convention.
- 1.4. Using information from various sources, including recent background papers from the Technical Secretariat (hereinafter, “the Secretariat”) and the OPCW Scientific Advisory Board (hereinafter, “SAB”), this paper concludes by proposing that several items be considered in detail by the States Parties. These proposals are intended to pave the way for increased focus on particular areas of the chemical industry that have evolved in the current commercial environment, and for which there is inadequate transparency under the current verification regime.



2. Background

- 2.1. Negotiations on the Convention began formally in 1984, but had been preceded by many years of discussions in Geneva. The Convention was opened for signature in 1993 and entered into force in 1997. The design of the Convention was therefore based on a chemical industry that has since had 20 years to evolve. During this period the chemical industry has undergone significant changes, which in turn have had an impact on the provisions of the Verification Annex.

3. The changing chemical industry: 1984 - 2003

- 3.1. **The decline of the multinationals.** In the late 1980s, the global chemical industry consisted mostly of a number of large multinational companies with major plant sites that produced a range of diverse products on a large scale. The majority of such plants were each dedicated to producing a small number of chemicals. Western countries dominated the industry, in terms both of research and development and of the manufacturing processes that produced complex chemicals in a number of stages, from raw materials through to the final product. By the end of the 1980s a transformation in the structure of the chemical industry had begun, and the 1990s witnessed major changes in the ownership and types of plant associated with the industry. These changes were brought about by several factors, including environmental and safety regulations and liability concerns, and were also driven by market forces. Multinational companies have divested significant parts of their portfolios, and large plant sites have been broken up into smaller units, with separate operations and owners now existing within the former site boundary. Although there are still major players on the world stage, they now tend to operate on specialised sites, with flexible production facilities located in several countries. The larger companies now concentrate on ‘core’ activities such as specialised synthesis or final formulation of products (see Annex A – Case Study 1 on Imperial Chemical Industries). They purchase specific chemicals from external suppliers, instead of owning facilities to produce intermediates themselves.
- 3.2. **The rise of the ‘chemical contractor’.** The gap in the market created by multinational divestments is being filled in part by a rapid rise in the number of facilities and plants specialising in the production of chemicals on a contract basis. Major companies can significantly reduce product introduction times by “outsourcing” (contracting out) the production of intermediates.
- 3.3. Such contract manufacturing companies may only have limited production runs of a particular chemical and, in order to maintain financial viability, they are required to produce a wide range of chemicals within their plants. They are driven towards flexibility in production, which means that they are able to respond quickly and efficiently to meet new customer requirements and orders. A greater focus on health and safety and on environmental standards has also led to improved equipment specifications, and thus to an increase in plant capabilities to produce and handle a wider range of toxic chemicals. As a result, the design of new chemical production facilities often differs significantly from that of older plants.

- 3.4. **Globalisation of the chemical industry.** The growth of chemical contracting has inevitably brought about a world-wide increase in the number of small, flexible batch-production facilities. Indeed, chemical production has already moved from the ‘traditional’, mainly western, manufacturing countries to other nations. This is due, in part, to emerging markets in Eastern Europe, Asia and Latin America. Indigenous chemical production capabilities are being built up for the first time in a number of countries, which are producing mainly starting materials and simple intermediate compounds at competitive prices, often taking advantage of lower operating costs. Parts of Asia have recently emerged as leading sources of fine chemicals. Most of the small and medium-sized plants operate on batch processes, whereas some of the larger producers have highly automated continuous process plants (see annex B – Case Study 2 on the growth and globalisation of contract manufacture and custom synthesis facilities).
- 3.5. **Advances in process technology and techniques.** Modern production equipment and synthesis techniques are also helping to reduce the size and increase the capability and versatility of standard chemical plant configurations. Technological developments in the use of automated ‘micro-reactors’ allow the production of substantial quantities of chemicals in relatively small plants. Advances such as combinatorial chemical techniques, catalysis, and other methods to enable commercially viable synthesis have the potential to change the nature of the chemical industry. As a result of these developments it is now practical to produce in bulk many chemicals which were previously difficult to synthesise. Knowledge of these advances is spreading globally, and could make it easier for non-State actors to engage in chemical terrorism. At the same time, certain traditional features associated with the handling or manufacturing of hazardous and/or volatile compounds may no longer be evident. New and evolving production techniques, such as solid state reactions that eliminate the need for costly bulk solvent use and storage, more efficient heat transfer methods, and the use of catalysts, are changing the size and traditional “signatures” of chemical production plants. The implementation of modern production ideologies and techniques reduces chemical inventories and makes it more difficult to detect and determine whether a plant has been used for purposes prohibited by the Convention.

4. Implications for the Convention

- 4.1. The Convention comprehensively prohibits the misuse of **all** toxic chemicals, regardless of their origin or method of synthesis, as described in recent papers by the Secretariat¹ and the United Kingdom². Although the Verification Annex addresses the chemicals listed in the Schedules, it also includes a number of measures that encompass other chemicals. These include sub-sections relating to chemical weapons (hereinafter, “CW”) declarations and destruction (Verification Annex, Part IV), CW production facilities (Verification Annex, Part V), challenge inspections (Verification Annex, Part X) and investigations of alleged use (Verification Annex, Part XI). The importance to the Convention of transparency with regard to the industrial production of non-scheduled chemicals is reflected in Part IX of the Verification Annex, which

¹ Attachment to the Chairman’s Notes from the 15th Meeting of the Open-ended Working Group for the Preparation of the First Review Conference, dated 15 November 2002

² The Comprehensive Nature of the Chemical Weapons Convention with Respect to Verification and National Implementation Measures, Delegation of the United Kingdom, Jan 2003.

relates to the declaration and verification of plant sites producing Discrete Organic Chemicals (hereinafter, “DOC”), with further focus on those DOC containing phosphorus, sulphur and fluorine.

- 4.2. As a result of the changes in the chemical industry outlined earlier, the United Kingdom believes that there are a number of issues which must be considered during the review of the industrial verification regime at the first Review Conference. This is essential if we are to ensure continuing confidence in the effectiveness of verification measures. These issues are detailed below.

Risk Factors

- 4.3. As stated clearly in the SAB report³, the current emphasis of verification activities under Article VI of the Convention is still heavily biased towards Schedule 1 and Schedule 2 production facilities. As elaborated by the Secretariat⁴, Schedule 1 and Schedule 2 facilities were deemed to pose the greatest risk to the Convention during its negotiation. Planning of inspections currently takes account not only of the Schedule in which the declared chemicals produced are included, but also of the features of the plant. The experience acquired during inspections carried out to date proves that production, processing, or consumption of Schedule 1 and Schedule 2 chemicals are not the only – or even the key – indications of the potential threat which a given facility poses to the Convention.
- 4.4. Under certain circumstances, a Schedule 1 facility may pose less of a potential threat to the Convention than an “other chemical production facility” (hereinafter, “OCPF”) plant site. For example, a single small-scale facility (hereinafter, “SSSF”) may consist of only a small laboratory containing a single fume cupboard, having the capability to produce a few kilograms, but more likely actually producing a few grams of chemicals per year. Conversely, a pharmaceutical plant producing a highly active ingredient that has corrosive and toxic properties could be declared as an OCPF. Production capability – and probably actual production in this instance - would be measured in hundreds of tonnes per year. Both facilities have the capability to produce Schedule 1 chemicals, but production at the SSSF is of the order of 100,000 to 1 million times lower than at the OCPF.
- 4.5. A limited number of inspections have been carried out at OCPF, considering the size of the sector and the number of declarable plant sites. Between the initiation of discrete organic chemical/phosphorus, sulphur and fluorine (hereinafter, “DOC/PSF”) inspections in May 2000 and the end of 2002 only 2% of the total number of declared DOC/PSF plant sites had received an inspection (Information on the Nature of the Facilities Declared and Inspected Under Article VI, Background Paper by the Secretariat dated 27 January 2003).

Organisational changes in the chemical industry

- 4.6. Some large chemical complexes have now become effectively ‘technology parks’, with multiple owners and/or operators. This change in organisational structure has

³ Report of the Fifth Session of the Scientific Advisory Board, SAB-V/1, dated 1 Nov 2002.

⁴ Information on the Nature of the Facilities Declared and Inspected Under Article VI, Informal Background Paper Prepared by the Secretariat dated 27 January 2003

changed the nature of OPCW inspections at some plant sites, with the result of reduced transparency of the site operations. Some Schedule 3 and OCPF facilities which were formerly part of larger sites now have very small plant site boundaries. Some operate with shared central resources, such as medical, engineering, waste handling and distribution facilities. Access to these shared activity areas is vital when it comes to providing a complete picture of the activities carried out at the site, which is required in order to validate declaration information. Care must be taken that the definition of Plant site (paragraph 6 (a) of Part I of the Verification Annex), is not interpreted so as to artificially limit access afforded to OPCW inspectors during the course of routine verification.

- 4.7. The growth in the global trade in chemical materials has led to increased transfers of chemicals through large distribution facilities. For verification purposes, this may result in increasingly complicated audit trails, with the identity of the initial manufacturer becoming obscured.

New production technologies

- 4.8. A potential threat to the Convention is posed by the growth in the number of OCPF currently capable of producing Schedule 1 chemicals with little or no physical conversion. The success of new custom and contract manufacturing facilities often depends on their ability to perform a wide range of chemical processes, anticipating the changing needs of both established and newly-found customers. As the boundaries of chemical manufacturing technology expand to allow the manufacture of ever more sophisticated products, the handling and use of toxic, corrosive and biologically active chemicals becomes a frequent occurrence. When considering the construction of any new facility, a company will forecast the needs of the plant for the ensuing 10 to 15 years. For those interested in manufacturing hazardous chemicals, installing the latest technology available to handle an unpredictable range of toxic and/or corrosive chemicals will be a paramount consideration when it comes to ensuring the long-term viability of a plant. To this end, production facilities need some, if not all, of the specific characteristics of Schedule 1 production facilities, such as chemically resistant equipment, specialised air handling and filtration equipment, and extensive health and safety measures.
- 4.9. The increased use of new technologies and equipment for the industrial-scale production of chemicals is helping to reduce the size and increase the capability of standard configurations within facilities.
- 4.10. New chemical production facilities can appear to be very different from older-style plants. Therefore, certain traditional signatures associated with the handling or manufacturing of hazardous and/or volatile compounds are no longer evident, and inspection teams need to be aware of these changes.
- 4.11. Capabilities for “just-in-time” production, and the use of supply ‘hubs’ (specialist stock holding and distribution centres), will reduce the need to store large quantities of raw materials and products at plant sites. Storage features could be one indicator of the existence of CW-related activities at a particular site (e.g. the storage of large quantities of precursors and products related to chemical weapons). Reduced storage features could challenge the effectiveness of plant verification if other verification measures cannot compensate for this type of change.

4.12. There has been an increase in the number of medium- and small-scale manufacturing facilities which carry out batch processing. These plants are designed for rapid switching between products to allow production of a wide range of chemicals in response to commercial demand. This increase highlights the need for the capacity to sample and analyse for trace quantities, in order to be able to confirm the absence of scheduled compounds.

5. Conclusions

- 5.1 The growth of contract manufacturing, coupled with advances in equipment and processing techniques, increases the potential for chemical manufacturing facilities to be misused in order to manufacture both scheduled and other toxic chemicals, as well as precursors and intermediates, in a covert manner. Advances in production technology used at industrial plants in many countries are also resulting in the increasing possibility for large-scale manufacture of those toxic chemicals for which large-scale synthesis was previously impractical, thus increasing the potential for their misuse as chemical weapons.
- 5.2 The changes to the chemical industry detailed in this paper, and the experience of the OPCW over more than five years of verification activities since entry into force of the Convention, are indicative of the need to reassess the emphasis of the declaration and verification activities of the Convention, especially in relation to OCPF. In fact, the Convention mandates (in paragraph 26 of Part IX of the Verification Annex) that such a review be undertaken at the first Review Conference.
- 5.3 Recent reports, notably the report to the OPCW by the International Union of Pure and Applied Chemistry (IUPAC)⁵, and the report of the Fifth Session of the SAB⁶, have made several proposals to address issues generated by changes to the chemical industry, which States Parties are urged to consider. The United Kingdom endorses the following proposals indicated in these two papers:
- Increasing the number of OCPF inspections will provide a much-needed increase in transparency of the growing capability of these sites. However, it will be essential to maintain as a parallel measure an effective and prioritised regime of inspections of facilities involved in scheduled-chemical activities.
 - Increasing inspectors' awareness of new production routes, processes and technologies through relevant training and workshops will allow them to recognise the nature of activities at inspected plant sites, and draw accurate conclusions accordingly.
 - Formal procedures for technology watch by the Secretariat to review implications for the Convention of advances in chemical processing and technologies should be instituted.

⁵ Impact of Scientific Developments on the Chemical Weapons Convention. Report by the International Union of Pure and Applied Chemistry to the OPCW and its States Parties, dated Nov 2002.

⁶ Report of the Fifth Session of the Scientific Advisory Board (SAB-V/1, dated 1 November 2002).

- It is necessary to reinforce education and outreach activities targeted to the worldwide scientific and technical community, with a view to increasing its awareness of the Convention and its benefits.

5.4 In addition, the United Kingdom urges that:

- The thresholds for declaration, and the information to be included in OCPF declarations, be reviewed in relation to the types of plant site which pose the greatest threat to the object and purpose of the Convention, in terms of their potential to produce not only Schedule 1 chemicals, but also toxic chemicals in general. This would provide better visibility of the current status of those aspects of the chemical industry which are relevant to the Convention.
- The Secretariat produce a complementary paper to ‘Changes in the Chemical Industry Relevant to the Implementation of the Convention’, detailing features of OCPF which it considers to be associated with a capability to produce Schedule 1 chemicals, in light of inspection experiences since 2000, and indicating whether these features can be used to identify potential ‘high risk’ facilities for inspection. The number of such facilities is likely to be small, and thus there is the possibility that a more focused use of limited inspection resources could be achieved.
- States Parties redouble their efforts to reach a swift conclusion to the ongoing discussions in the chemical industry Cluster with respect to the selection method for plant sites to be inspected under Part IX of the Verification Annex.

ANNEX A – CASE STUDY 1
IMPERIAL CHEMICAL INDUSTRIES

1. In order to retain profitability in the 1980s, Imperial Chemical Industries (hereinafter, “ICI”) sought to increase its portfolio in the areas of speciality chemicals and pharmaceuticals, which typically had high profit margins. In an agreement with British Petroleum, ICI expanded its activities in polyvinyl chloride and gave up the manufacture of polyethylene. It also expanded into the United States of America market by acquiring Glidden, a major paints producer, and Stauffer Chemicals. It then sold all Stauffers product lines except agricultural chemicals. During the period from 1982 to 1987, ICI reduced its personnel by 50,000. These changes, however, did not solve the profitability “problem”, and the international competitiveness of parts of the portfolio remained weak.
2. In contrast to its heavy chemicals divisions, ICI’s pharmaceutical division had become an international enterprise with manufacturing and processing plants in the United States of America, Europe, Latin America, Asia and Africa. ICI pioneered penicillin manufacture, and prospered in the 1950s in the large domestic market opened up by the formation of the National Health Service. This was possible mainly because its major competitors, Beecham and Glaxo, were behind ICI in terms of creating prescription-drug production and marketing operations. The success of the pharmaceuticals division led to a dramatic restructuring of the company in 1992, when ICI spun off its pharmaceutical and smaller biomedical units into a separate company called Zeneca. ICI did this to discourage any threat of a take-over (Hanson, the United Kingdom conglomerate, had bought 2.8% of ICI stock in 1991).
3. In 1997, ICI initiated its transformation from bulk chemical producer to global speciality products and paints leader by purchasing four businesses from Unilever. These were National Starch and Chemical Company (adhesives, sealants, speciality foods, industrial starches, speciality polymers, electronic and engineering materials); Quest International (fragrance, flavours and food ingredients); Unichema (personal care ingredients, natural and synthetic lubricants, and polymers) and Crosfield.
4. Since the Unilever acquisition, ICI has continued to diversify away from the less profitable heavy-chemicals product lines, and has sought opportunities for expansion into North America and Asia. Since mid-1997, ICI has made more than 50 deals worth more than £7 billion, broken down into 40 divestments, 10 acquisitions and two joint ventures. Its Regional and Industrial Businesses are located mainly in Pakistan, India and Argentina and are operated through non-wholly owned subsidiary companies. In Pakistan, ICI’s products range across a number of different market sectors that include agrochemicals, pharmaceuticals and speciality chemical products. ICI India’s regional business comprises rubber chemicals, nitrocellulose, pharmaceuticals and explosives, while in Argentina wine, chemicals and sulphur-related products are the most important. Major manufacturing locations for ICI Paints are in the United States of America, the United Kingdom, Brazil, Argentina, Germany, the Netherlands, France, China, India and Malaysia. This diversification and expansion has created opportunities for feeder companies to supply raw materials and intermediate products.

5. **Conclusions.** Although not always successful, the restructuring and diversification of ICI illustrates many of the changes in the chemical industry since the 1980s. It has divested non-profitable heavy-chemical manufacture, and has acquired new businesses to concentrate on its core activities (paint manufacture and speciality products). The spin-off of their life sciences business to create Zeneca has almost universally been reflected in other large companies (e.g., Monsanto, Ciba Geigy, Sandoz, Rhone Poulenc and Hoechst). It has become a significant global enterprise with a range of more than 50,000 products, over 38,000 employees world-wide and total sales amounting to £6,425 million in 2001.

ANNEX B – CASE STUDY 2

CONTRACT MANUFACTURE AND CUSTOM SYNTHESIS

1. During the last two decades, there has been a global expansion in the numbers of small- and medium-scale enterprises offering to the larger chemical companies contract and custom synthesis of starting materials, active ingredients and intermediates. Many of these new companies have been set up since the late 1980s to benefit from business opportunities created by the outsourcing policies (where production of starting materials and intermediates is contracted out to other suppliers) in market sectors such as pharmaceuticals and agrochemicals.
2. A number of organisations supply databases and search engines to assist companies in outsourcing chemicals. One example accessed through the Internet offers 26,475 sites covering 64 categories of supply chemicals⁷. Another database contains 15,000 companies offering custom synthesis facilities⁸. Yet another site advertises 200,000 substances from 7,000 suppliers in 130 countries⁹. The majority of databases also give chemical suppliers the facility to display their capabilities to a world-wide audience, and the opportunity to increase their customer bases and ranges of products to meet customer requirements. The ability to advertise products and locate end-users in this way has led to an expanding market, where lower operating costs can give contract suppliers a competitive edge. Emerging markets in Latin America, Eastern Europe and Asia, coupled with lower operating costs, have led to an increase in the number of indigenous chemical suppliers in these regions.
3. An Internet search under the terms “contract manufacture” and “custom synthesis” yields thousands of entries corresponding to companies offering these services. To illustrate this point, the home pages of several companies in various geographical locations (Europe, Latin America, North America, and Asia) were looked at to obtain information on market segments, product ranges and quantities supplied. Although some companies specialised in specific products, e.g. sulphur-containing chemicals, materials for the petrochemical and dye industries, etc, others offered more wide-ranging product lists. Analysis of their corporate profiles, histories and mission statements showed a number of common trends:
 - Many were founded since the late 1980s.
 - Most claim rapidly-expanding customer bases and increasing numbers and ranges of products (one company offers 17,000 fine organic compounds and claims to have added over 4,000 compounds in the last two years).
 - The majority offer client confidentiality.
 - Many accept order volumes from milligrams/millilitres up to tens of tonnes.
 - Many offer small quantity laboratory synthesis and testing, and small-scale batch synthesis followed by scale-up to continuous manufacturing on tonne scales.
 - Many advertise multi-purpose plant facilities capable of a wide range of reactions and techniques (e.g., general organic reactions, pyrolysis, autoclave reactions,

⁷ www.neis.com/db/category/cat154.asp

⁸ www.powersourcing.com/se/chemicalcustomsynthesis.htm

⁹ www.chemsources.com

distillation, electrolysis, extraction, chiral synthesis, hydrogenation, and many more).

- Many claim to have the flexibility to broaden current technologies and process capabilities to manufacture new compounds and attempt challenging syntheses.
 - Most are willing to translate customer ideas into actual products through customer-driven research and development.
 - The majority advertise competitive prices.
 - Many quote adherence to International Quality Standards.
4. A few companies in the sample selected also claim to concentrate on nuisance and difficult or hazardous chemicals.
 5. In an attempt to show the global nature of producers of intermediates, the number of companies producing three Schedule 3 compounds was determined (as listed in ‘Database of World Chemical Producers’ version 7). The results are shown in Table 1, and have been split into the number of countries producing the chemicals in each of the world regions.

Chemical	Total no. of countries producing	Europe	North America	South America	Australasia	Asia	Africa
Triethanolamine	18	7	2	2	1	6	-
Thionyl Chloride	8	3	1	-	-	4	-
Phosphorus Trichloride	13	7	1	1	-	3	1

Table 1: Number of countries producing selected Schedule 3 chemicals by region

6. Using the same sample chemicals and data source (DWCP v. 7), Table 2 shows the number of individual manufacturers for each Schedule 3 chemical, and their regional locations.

Chemical	Total No of manufacturers	Europe	North America	South America	Australasia	Asia	Africa
Triethanolamine	64	12	5	9	1	37	-
Thionyl Chloride	28	4	3	-	-	21	-
Phosphorus Trichloride	83	11	5	1	-	65	1

Table 2: Number of individual manufacturers of selected Schedule 3 chemicals by region

7. The details in Table 1 show that the dominance of the historic chemical producing countries no longer applies, as the manufacturing of the selected Schedule 3 chemicals is now spread across the world. Table 2 further highlights that the actual number of facilities producing the selected chemicals is now concentrated outside of Europe and North America. These two regions now represent less than one-quarter of manufacturers of the chemicals cited (27% for Triethanolamine, 25% for Thionyl Chloride, and 19% for Phosphorous Trichloride).
8. Further searches on the web revealed that many of the companies covered in this study also produce fine and speciality chemicals, with a large catalogue of products, and that several offer custom syntheses and contract manufacturing facilities. Should

any of these companies produce less than 30 tonnes per year of any of the Schedule 3 chemicals they have in their portfolio, then they would not be declared as Schedule 3 producers. Should they produce less than 200 tonnes per year of a Schedule 3 chemical, then they would not be subject to verification under that regime. However, the fact that the companies in question can produce these chemicals indicates their ability to produce toxic and corrosive chemicals (in the cases of Thionyl Chloride and Phosphorous Trichloride), and, depending upon the plant capacity, they would be declared as a DOC or PSF producer.

9. **Conclusions.** Production of fine and speciality chemicals has become very much a global business, with many producers offering custom synthesis and contract manufacture. Verification of these companies' activities will present particular challenges to the OPCW inspectors, in terms both of the growth in the numbers of such facilities and of the expanding numbers of products and variety of processes present within flexible batch-production facilities. As major companies continue to outsource intermediates to drive down the costs of bringing new products to the market, the number of chemical transfers between producers, suppliers and shipping agents will increase, and consequently the associated audit trails will become more complex.

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