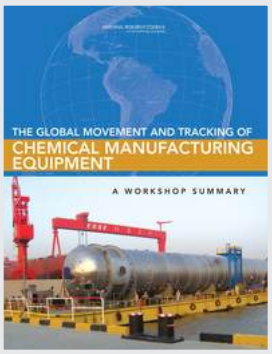

The Global Movement and Tracking of Chemical Manufacturing Equipment: A Workshop Summary

DETAILS

54 pages | 8.5 x 11 | PAPERBACK
ISBN 978-0-309-30651-5 | DOI 10.17226/18820

CONTRIBUTORS

Kathryn Hughes and Joe Alper, Rapporteurs; Board on Chemical Sciences and Technology; Division on Earth and Life Studies; National Research Council

THE GLOBAL MOVEMENT AND TRACKING OF CHEMICAL MANUFACTURING EQUIPMENT

A WORKSHOP SUMMARY

Kathryn Hughes and Joe Alper, *Rapporteurs*

Board on Chemical Sciences and Technology

Division on Earth and Life Studies

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS **500 Fifth Street, NW** **Washington, DC 20001**

NOTICE: The project that is the subject of this report was approved by the Governing Board of the National Research Council, whose members are drawn from the councils of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine. The members of the committee responsible for the report were chosen for their special competences and with regard for appropriate balance.

This publication results from research supported by the Naval Postgraduate School's Project on Advanced Systems and Concepts for Countering Weapons of Mass Destruction (PASCC) via Assistance Grant/Agreement No. N00244-13-1-0028 awarded by the NAVSUP Fleet Logistics Center San Diego (NAVSUP FLC San Diego). The views expressed in written materials or publications, and/or made by speakers, moderators, and presenters, do not necessarily reflect the official policies of the Naval Postgraduate School nor does mention of trade names, commercial practices, or organizations imply endorsement by the U.S. Government.

International Standard Book Number-13: 978-0-309-30651-5
International Standard Book Number-10: 0-309-30651-5

Additional copies of this report are available from the National Academies Press, 500 Fifth Street, NW, Keck 360, Washington, DC 20001; (800) 624-6242 or (202) 334-3313; http://www.nap.edu.

Printed in the United States of America

Cover image (bottom): Courtesy of the Morimatsu Group

Suggested citation: NRC (National Research Council). 2014. *The Global Movement and Tracking of Chemical Manufacturing Equipment (A Workshop Summary).* Washington, DC: The National Academies Press.

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. C. D. Mote, Jr., is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Victor J. Dzau is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. C. D. Mote, Jr., are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

BOARD ON CHEMICAL SCIENCES AND TECHNOLOGY

ORGANIZING COMMITTEE ON THE GLOBAL MOVEMENT AND TRACKING OF CHEMICAL MANUFACTURING EQUIPMENT

NANCY B. JACKSON, Franklin Fellow, U.S. Department of State
ROBERT E. ROBERTS, Senior Scientist, Institute of Defense Analyses
USHA WRIGHT, Senior Vice President and Co-General Counsel, O'Brien & Gere
CLARA J. ZAHRADNIK, Export Control Leader, E. I. du Pont de Nemours & Company

NATIONAL RESEARCH COUNCIL STAFF

TERESA FRYBERGER, Director
KATHRYN HUGHES, Senior Program Officer
DOUGLAS FRIEDMAN, Senior Program Officer
CARL GUSTAV-ANDERSON, Research Associate
ELIZABETH FINKELMAN, Program Coordinator
NAWINA MATSHONA, Senior Program Assistant
COTILYA BROWN, Senior Program Assistant
CAMLY TRAN, Postdoctoral Fellow
JOE ALPER, Consulting Writer

Acknowledgment of Reviewers

This workshop summary has been reviewed in draft form by persons chosen for their diverse perspectives and technical expertise in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making the published workshop summary as sound as possible and to ensure that it meets institutional standards of objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this summary:

Paul Amyotte, Dalhousie University
Richard T. Cupitt, U.S. Department of State
Charles T. Mooney, Xylem, Inc.
Donald Prosnitz, Independent Consultant

Although the reviewers listed above provided many constructive comments and suggestions, they did not see the final draft of the workshop summary before its release. The review of this summary was overseen by the National Research Council, which is responsible for making certain that an independent examination of this workshop summary was carried out in accordance with institutional procedures and that all review comments were carefully considered.

Contents

Acronyms and Abbreviations

ASME	American Society of Mechanical Engineers
BCST	Board on Chemical Sciences and Technology
CEFIC	European Chemical Industry Council (Conseil Européen des Fédérations de l'Industrie Chimique)
CWC	Chemical Weapons Convention
DOC	discrete organic chemical
EAR	Export Administration Regulations
eLVIS	eBay Listing Violation Identification System
ISO	International Organization for Standardization
ITAR	International Traffic in Arms Regulations
NCIS	Naval Criminal Investigative Service
NRC	National Research Council
OCPF	Other Chemical Production Facilities
OPCW	Organisation for the Prohibition of Chemical Weapons
PASCC	Project on Advanced Systems and Concepts for Countering Weapons of Mass Destruction
UNSCR	United Nations Security Council Resolution
WCO	World Customs Organization
WMD	Weapons of Mass Destruction
WTO	World Trade Organization

1

Introduction and Overview[1]

In the years before Saddam Hussein co-opted pesticide production facilities in Iraq to produce chemical weapons, the world's inspection and verification regimes were designed to govern large-scale chemical manufacturing facilities, which were primarily located in a few regions of the globe. Globalization has reduced the efficacy of the current inspection regimes and opened verification gaps through the proliferation of chemical manufacturing equipment and infrastructure. To better understand the movement and tracking of chemical manufacturing equipment of dual-use[2] concern, the Project on Advanced Systems and Concepts for Countering Weapons of Mass Destruction (PASCC) at the Naval Postgraduate School contracted with the Board on Chemical Sciences and Technology (BCST) of the National Research Council (NRC) to hold a day-and-a-half workshop on the global movement and tracking of chemical manufacturing equipment. The workshop, held May 12-13, 2014, in Washington, DC, looked at key concerns regarding the availability and movement of equipment for chemical manufacturing, particularly used and decommissioned equipment that is of potential dual-use concern. Though the original statement of task called for an examination of future technology, discussions among the planning committee (see Appendix C for planning committee biographies) along with input received from the stakeholder community during the planning phase made it clear that there were some fundamental questions regarding current technology and controls that required more discussion than originally anticipated. Thus, the focus of the workshop shifted slightly, primarily to address current rather than emerging concerns. In addressing these concerns, the workshop examined today's industrial, security, and political contexts in which these materials are being produced, regulated, and transferred. The workshop also facilitated discussions about current practices, including consideration of their congruence with current technologies and security threats in the global chemical industrial system. The full statement of task can be found in Appendix A.

CONTEXT FOR THE WORKSHOP

Dual-use applications for chemical manufacturing equipment have been recognized as a concern for many years, and export-control regulations worldwide are in place as a result. These regulations, in conjunction with the verification and inspection requirements of Article VI of the Chemical Weapons Convention (CWC), are designed to support nonproliferation of manufacturing equipment suitable for production of chemical warfare agents. In recent years, globalization has changed the distribution of chemical manufacturing facilities around the world. This has increased the burden on current inspection regimes, and increased the amount of manufacturing equipment available around the world. Movement of that equipment, both domestically and as part of international trade, has increased to accommodate these market shifts.

Challenges for Direct Inspection of Production

Since World War I, when industrial dye manufacturing facilities were adapted to produce many of the chemical warfare agents released on the battlefields of Europe, poten-

[1]The planning committee's role was limited to planning the workshop, and the workshop summary has been prepared by the workshop rapporteur as a factual summary of what occurred at the workshop. Statements, recommendations, and opinions expressed are those of individual presenters and participants, and are not necessarily endorsed or verified by the NRC, and they should not be construed as reflecting any group consensus.

[2]Dual-use items are generally defined as those that have both civilian and military applications.

tial dual-use applications for chemical equipment have been recognized. Reactors, piping, pressure vessels, and other such basic manufacturing equipment, though requiring some specialization for the production of reactive chemical agents, can be adapted and used in processes for the manufacture of chemicals of concern by state or non-state actors. It is this concern that supports the inspection and verification requirements called for under Article VI of the CWC and that underlies some of the policies restricting the movement of manufacturing materials and equipment, such as U.S. export control regulations on manufacturing equipment, and more broadly, the agreements of the Australia Group.[3]

Many of the current inspection and verification regimes were developed during a time when large-scale chemical manufacturing facilities, including those for specialty chemicals, were largely located within developed countries, which is also where the companies responsible for manufacturing the equipment were based. Initially, the CWC inspection and verification regime covered facilities known to produce chemicals listed in the treaty's schedules, but this changed in the early 1990s in the wake of the revelation that Saddam Hussein had co-opted pesticide production facilities in Iraq to produce chemical weapons agents. After that "verification gap" was identified, a requirement was developed that instructs signatories to the treaty to declare the presence of Other Chemical Production Facilities[4] (OCPFs) within their countries and states that these facilities may be subject to inspection. However, to provide a sense of scale to the challenges faced by the organization, in late 2008 it was reported that approximately 500 OCPFs had undergone inspection. (Matthews, 2008) That same year, the Director-General of the Organization for the Prohibition of Chemical Weapons (OPCW, 2008) stated:

> The layout, design, and characteristics of plant sites are under continued review by industry. Very importantly, globalization is bringing about a massive redistribution and regional migration of chemical production and trade in the world.
>
> In parallel with these movements, there has been an exponential growth in the number of declared OCPFs. Today, the figure is rising in the order of 4,500 to 5,000, depending on the year. Due to their technological features (such as multi-purpose process equipment and flexible piping), a number of OCPFs could easily and quickly be re-configured for the production of chemical weapons and are thus highly relevant to the object and purpose of the Convention. This is all the more pertinent in view of the evolving threat posed by terrorism.

In light of these numbers, it becomes clear that direct monitoring of a significant portion of worldwide production facilities for potential production of chemical weapons agents is challenging.

With the limitations of direct inspection and verification of facilities, indirect controls in support of non-proliferation, such as export controls, play a critical role in reducing available production capacity. The restriction and monitoring of the flow of the chemical manufacturing equipment is intended to support non-proliferation by preventing specialized equipment, such as reactors and piping with specific corrosion-resistant coatings, from entering countries where concerns about either state or non-state actors exist.

Monitoring for Movement of Equipment

Monitoring of equipment movement, stockpiling, and acquisition has been used for decades to monitor production of enriched nuclear materials, such as highly enriched uranium, that can be used for the production of nuclear weapons. Aluminum fuel rods used in uranium enrichment centrifuges, for example, have been a long-used, tell-tale sign of production of weapons-grade uranium by state actors. In the United States, utilization of the information derived from these types of movements in countries from Pakistan and North Korea to Iraq and Iran has allowed the government to make critical policy decisions, most notably around counter-proliferation policy. In many ways, production of weapons-grade nuclear materials requires a relatively well known set of procedures and equipment that can be identified as potential threats.

Within the chemical manufacturing world, however, regulators act to place controls and restrictions on access to bulk-scale equipment without inhibiting the availability of this equipment to individuals pursuing legitimate commercial products. In the nuclear arena, the equipment being tracked or controlled is often highly specialized, which is not the case for chemical manufacturing. Within the United States and globally, equipment with features such as specialized coatings to resist corrosion or dual-walled piping—both of which are needed to produce chemical weapons on a large scale—are subject to export controls with the goal of restricting sale and ownership of such equipment to legitimate, verified buyers. As noted in the introduction to this section, however, many of these requirements were initially developed when chemical manufacturing was largely based in the developed world, and globalization has resulted in a significant change in the distribution of manufacturing facilities worldwide.

[3]The Australia Group is an informal forum of countries which, through the harmonization of export controls, seeks to ensure that exports do not contribute to the development of chemical or biological weapons. Coordination of national export control measures assists Australia Group participants to fulfill their obligations under the Chemical Weapons Convention and the Biological and Toxin Weapons Convention to the fullest extent possible.

[4]Under the CWC, OCPFs are defined as facilities that "(a) produced by synthesis during the previous calendar year more than 200 tonnes of unscheduled discrete organic chemicals (DOCs); or (b) comprise one or more plants which produced by synthesis during the previous calendar year more than 30 tonnes of a DOC containing the elements phosphorus, sulfur or fluorine (PSF chemicals)" (OPCW, 2005).

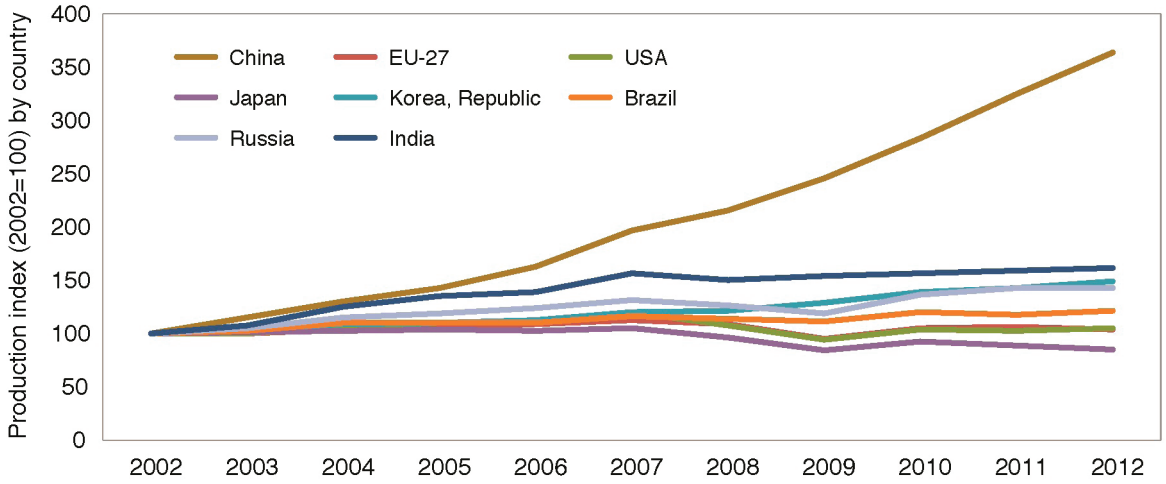

FIGURE 1-1 International comparison of chemical production growth.
SOURCE: CEFIC Chemdata International, 2013, and CEFIC analysis.

This equipment is easiest to control when it is first manufactured. Pristine reactors, for example, can be built and shipped to a specific facility or company owner for its first use. Changes in production may require equipment to be modified, however, and in such cases, when a facility or unit is being decommissioned, companies have four common methods for handling the manufacturing equipment:

- Movement to another production facility or unit within the company,
- Sale of the equipment to another company with a similar product or production line,
- Sending the equipment to auction, or
- Scrapping the equipment.

At these times, though companies are governed by international law and the laws of their home countries, local capacity and regulation for managing decommissioned equipment vary. A large, experienced auction company specializing in manufacturing equipment in Europe, for example, will likely have a greater ability to adhere to requirements for verification of final ownership than a local auction house in a developing country.

The Impact of Globalization

Adding to the challenge of monitoring equipment, chemical manufacturing has become a global endeavor over the past two decades, with the fastest growth occurring in Asia. Figure 1-1 illustrates the rapid change in production growth in the chemical industry since 2002. As a result of these changes, a number of specific challenges to equipment tracking can be identified, examples of which include:

- Increased local capacity for production of manufacturing equipment worldwide;
- Increased movement of equipment within any given country;
- Rapid economic growth leading to rapid changes in the status of facilities, both in terms of company ownership and in the needs of the facilities; and
- Decommissioning of facilities in areas where production has become less profitable.

Taken together, these changes are likely to increase the availability and movement of both general and specialized chemical manufacturing equipment globally, especially in economically emerging regions, and adapting to these changes will be necessary to ensure that such equipment remains out of the hands of individuals wishing to cause harm.

Addressing these challenges will require a multidisciplinary approach, requiring input from individuals with knowledge of chemistry and chemical engineering, experts in policy and non-proliferation, and input from the chemical industry. Such changes are likely to continue as the world economy grows, especially with expected advances in chemical production processes.[5] Identifying potential future gaps or areas of concern in the tracking and monitoring processes and possible methods for addressing them would be beneficial.

[5]Examples of anticipated changes in the coming years include increased use of biological materials to produce chemicals and increased availability and functionality of microreactors.

ORGANIZATION OF THE SUMMARY

This publication summarizes the presentations and discussions that occurred at the workshop (see Appendix B for the workshop agenda), highlighting the key lessons presented and the resulting discussions among the workshop participants (see Appendix D for a list of attendees). Chapter 2 discusses the global landscape for chemical manufacturing equipment and Chapter 3 examines issues related to the lifetime of chemical manufacturing equipment. Chapter 4 recounts the presentations and discussions on security matters and Chapter 5 looks at the challenges associated with the Internet as a secondary market for used chemical manufacturing equipment. A recurring sentiment from the presentations and resulting discussions was the sense that many companies in the United States and Europe have strong corporate cultures that understand the need for export prohibitions and that promote adherence to existing regulations. The main challenge to non-proliferation comes from the globalization of the chemical industry and the need to help those countries that have only recently built chemical production capabilities develop the knowledge of and expertise to meet the obligations spelled out in these treaties and national regulations.

Chapter 6 summarizes the group discussion that examined a set of questions that were provided to the workshop participants prior to the meeting. This discussion stressed the importance of developing strong partnerships both among companies in the chemical industry and between industry and government.

In accordance with the policies of the NRC, the workshop did not attempt to establish any conclusions or recommendations about needs and future directions, focusing instead on issues identified by the speakers and workshop participants. In addition, the organizing committee's role was limited to planning the workshop. The workshop summary has been prepared by workshop rapporteurs Kathryn Hughes and Joe Alper as a factual summary of what occurred at the workshop.

REFERENCES

CEFIC. 2014. *The European Chemical Industry: Facts and Figures 2013*. Brussels: European Chemical Industry Council. Available at http://asp.zone-secure.net/v2/index.jsp?id=598/765/42548 (accessed 6/25/2014).

Matthews, R. 2008. Other Chemical Production Facilities Inspections. Presentation at CWC 2nd Review Conference Open Forum, 9 April 2008. Available at http://www.opcw.org/index.php?eID=dam_frontend_push&docID=12368 (accessed 6/25/2014).

OPCW. 2005. *Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction.* Available at http://www.opcw.org/chemical-weapons-convention/verification-annex/part-ix/ (accessed 8/12/2014).

OPCW. 2008. Opening Statement by the Director General to the Second Review Conference. Available at http://www.opcw.org/index.php?eID=dam_frontend_push&docID=1874 (accessed 6/25/2014).

2

The Changing Global Landscape

KEY POINTS

- The globalization of the chemical industry, and particularly its growth in Asia and Latin America, combined with changes in the technologies used to produce chemicals represent major challenges for tracking chemical manufacturing equipment. (Maennig)
- The number of math, science, and technology graduates produced by China and other countries outside of the United States and Europe portends a future in which the knowledge needed to produce and utilize chemical manufacturing equipment will be more broadly distributed globally. (Maennig)
- Increasing automation of chemical manufacturing, a trend of building smaller chemical production facilities, and the use of biotechnology in chemical manufacturing create challenges and opportunities for chemical weapons inspectors. (Maenning)
- The worldwide proliferation of regulations and international agreements pertaining to chemicals and chemical manufacturing equipment makes it difficult for even well-meaning companies to be in full compliance. (Maennig)

In the workshop's opening session, Detlef Maennig, an industrial chemist with Evonik Industries representing the European Chemical Industry Council (CEFIC), noted that the chemical industry has changed dramatically over the past 20 years in a way that has gone largely unnoticed by the general public. These changes include a shift in the regions where the chemical industry is active and in its product mix as well as the development of new regulations, international cooperative groups and trade alliances, information technologies that more rapidly disseminate technological know-how, and new chemical production technologies, such as biological reactors and microreactors.

The globalization of the chemical industry, and in particular the rapid growth of the industry outside of the United States and Europe, increases the challenges of monitoring the movement and use of chemical manufacturing equipment. One example of this challenge is that locally owned chemical companies in new chemical producing regions may not be aware of the responsibilities under the CWC. They may also lack the internal compliance programs and standards that are applied in regions with an established chemical industry. In addition, the globalization of the chemical industry has created a large pool of people with expertise in the production of dual-use chemical manufacturing equipment who may not be aware of the provisions of the CWC.

Before addressing these changes, Maennig provided some background information on CEFIC, which represents some 29,000 chemical companies spread across Europe. About 600 of these companies are direct members of CEFIC with the rest being represented via their membership in one of the 28 member national chemical federations. In addition, there are 30 companies with associate membership that have operations in Europe but have headquarters elsewhere. CEFIC operates 104 different sector groups with about 4,500 industry experts participating in these groups.

Returning to the subject of change, Maennig noted that the number of state parties that have declared that they have chemical manufacturing facilities rose dramatically between 2001 and 2010, with the largest increase in company numbers occurring in Asia and Latin America. At the same time, global output of chemicals more than doubled (Figure 2-1) and China and the rest of Asia have both surpassed Europe as the leading manufacturers of chemicals. "It used to be that 30 percent of the world's chemicals came from Europe and 27.7 percent came from North America," said

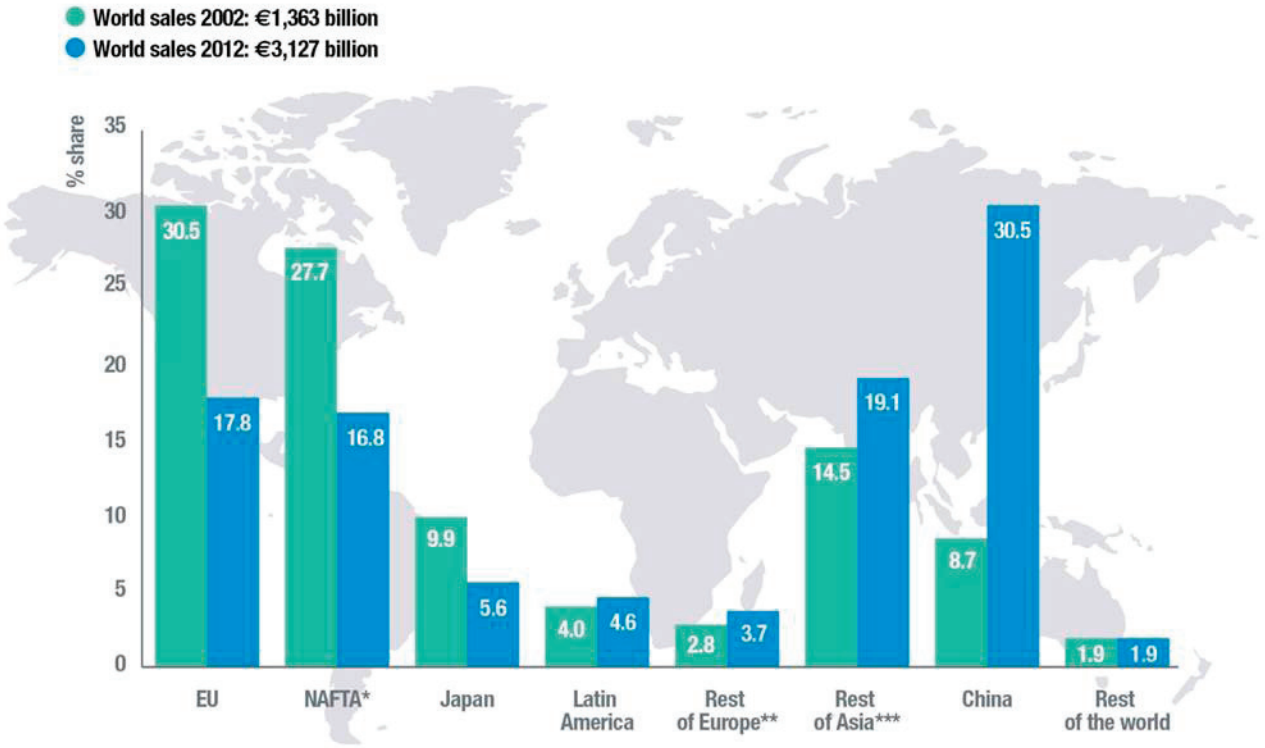

FIGURE 2-1 World chemicals output more than doubles as emerging market sales surge.
SOURCE: CEFIC Chemdata International, 2013.

Maennig. Today, he noted, the European Union accounts for only 17.8 percent of chemical sales and North America's market share has dropped to 16.8 percent (CEFIC, 2014). According to 2012 sales figures, Asian chemical production is now higher than that of Europe plus North America. In fact, China's sales alone, which total €952 billion in 2012, are almost equal to those of Europe plus North America, at €558 billion and €526 billion respectively. To put these figures in context, Maennig said that Europe's chemical sales have almost doubled since 1992 while its market share is half of what it was 20 years ago. Yet despite losing market share, Europe is still the world's leading regions in terms of chemical exports, accounting for 41.6 percent of the world total. Seven member states, led by Germany, France, and The Netherlands, account for 85 percent of the European Union's chemical sales.

One change that Maennig noted as important for the future of the chemical industry was that the number of math, science, and technology graduates produced by China has soared since 2000 and now surpasses those from Europe and the United States combined. "So we need to be aware that China will not only be what we like to refer to as the world's chemical workbench, but it will also be a significant contributor to worldwide intellectual property," Maennig predicted. China also dominates today in terms of capital spending in the chemical industry, with €133.8 billion in capital investments compared to €24.7 billion in North America and €19 billion in Europe.

Another substantial change, said Maennig, has been the growth in the number of medium- and small-scale plants that specialize in producing high-value, high-profitability specialty chemicals, in contrast to the world-scale facilities that produce bulk petrochemicals, chlorine-based chemicals, and fertilizers. "You see this with all of the big players. They are all trying to move more into higher value, value-added products, and away from bulk chemicals," said Maennig.

An important technological change that is sweeping the chemical industry involves an increasing level of information technology integration. "You don't see chemical plants anymore that do not run without a distributed control system that is state of the art," said Maennig. The acts of adding chemicals to reactors by hand or manually turning valves are largely relics of an earlier time, he added. For chemical weapons inspectors, this change means that they have to be aware that they cannot measure inputs and outputs by buckets and valves. On the other hand, production data should all be available from the distributed control systems.

Biotechnology is another significant development for the chemical industry. Maennig said current estimates suggest that by 2020, some 10 percent of global chemical output will be the result of biotechnological processes rather than traditional petrochemical-based processes. He said that he expects that this development will have a significant impact on chemical weapons inspections.

The regulatory landscape for the chemical industry has changed significantly over the past several decades, particularly with regard to export controls for chemicals and chemical manufacturing equipment. There are now regulations governing persistent organic pollutants, ozone depletion, narcotics production, psychotropic substances, money laundering, and terror financing in addition to the Chemical Weapons Convention (CWC) that is most germane to this workshop. There are also other international agreements, such as the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies, the Missile Technology Control Regime, the Nuclear Suppliers Group, and the Australia Group, and a wide landscape of voluntary warning lists, sanctions, and embargoes that individual governments issue. The United States, explained Maennig, has special re-export regulations that companies need to consider as well. "It is very easy to overlook a regulation," said Maennig. "You need to be very careful and try to follow the regulations as best you can." He suggested, in fact, that the subject of regulation would make a good future topic of discussion.

The chemical industry's focus over the past decade has also shifted from one of products to one of developing solutions to challenges, said Maennig. The result of this change in focus is that chemical companies are getting more involved with equipment manufacturers and forging new alliances with energy companies. This move, he explained, is related to sustainability. "When we look into the future, there will be nine billion people on the planet by 2050, so the chemical industry is looking at how it can guarantee that there will be enough food, enough water," said Maennig. In addition, the world is urbanizing rapidly, and he estimated that 67 percent of the world's population will live in cities, creating a tremendous demand on infrastructure, water, energy, and traffic. In terms of energy, the chemical industry has been aggressive about developing chemical production technologies that use less energy and is working with other interested partners to provide solutions to these problems.

The final change that Maennig highlighted was the reduction in the time that companies have to bring products to the market than they did in past decades. Joint development of products now seems to be a critical part of the chemical industry. So, too, is life-cycle analysis. Maennig highlighted this change by noting that chemists are creating some 12,000 new substances each day.[1]

Turning to the subject of the CWC, which has been in force since 1997, Maennig said that what has been happening in Syria argues that the Convention will not stop all production of chemical weapons. One sign of that reality is that the Organization for the Prohibition of Chemical Weapons (OPCW) has built up its capacity to handle and destroy chemical weapons. What is needed going forward, said Maennig, is better communication between OPCW and the chemical industry. "In the beginning phases of the Chemical Weapons Convention, there was an intense interaction between the chemical industry and the OPCW. But since it has worked so well, there has been less momentum to maintain that part of the dialogue. Now that we see how the international framework is changing, how the security framework is changing, there should be enhanced interaction between the chemical industry and the OPCW," Maennig said in closing his comments.

DISCUSSION

In response to a question from Charles Mooney of Xylem, Inc., about the rise of China as a chemical producer, Maennig explained that China got into the field mostly as a producer of bulk drugs and commodities but that bulk production continues in other parts of the world because local production reduces transportation costs and concerns. He noted that China's chemical industry initially benefited from lower production costs arising from fewer safety and environmental controls compared to those in place in Europe and North America. China, however, is using more sophisticated production techniques to address pollution and safety issues. Maennig estimated that within 5-10 years that there will not be much of a difference in the type of chemistry being done in China in comparison to Europe and North America.

Nancy Jackson, from the Department of State, asked about shifts in worldwide investment in chemical research, in contrast to capital investment. Maennig said that investment in research in China and some of the other rapidly developing countries is still relatively low, particularly in terms of foreign investment.

REFERENCE

CEFIC. 2014. *The European Chemical Industry: Facts and Figures 2013*. Brussels: European Chemical Industry Council. Available at http://asp.zone-secure.net/v2/index.jsp?id=598/765/42548.

[1] The Chemical Abstracts Service estimates approximately 15,000 new substances are added to the registry every day (http://www.cas.org/content/chemical-substances/faqs, accessed July 17, 2014).

3

The Lifetime of Manufacturing Equipment

The workshop's second session featured four speakers who discussed examples of how different companies deal with their chemical manufacturing equipment in the context of a changing industry and the restrictions of what can be done with it after its initial owner has no further use for it. Charles Mooney, Director of Global Trade Compliance at Xylem, spoke about his experience in exporting chemical equipment export. Ye Shao, Manager of International Relations for the Morimatsu Group, discussed China's perspective on international trade of chemical manufacturing equipment. Ana Prieto, an independent consultant on global environmental, health, and safety functions, gave her perspective on how chemical manufacturing equipment is managed in the field and how that relates to an important limitation of current controls. J. Craig Desrosiers, Senior Buyer at E.I. du Pont Canada, described some of the different types of equipment used in chemical manufacturing. A discussion moderated by Clara Zahradnik, Export Control Leader for DuPont Chemicals & Fluoroproducts and a member of the workshop organizing committee, followed the presentations.

KEY POINTS

- There is tremendous variation in the way individual countries implement the many international provisions dealing with chemical processing equipment. (Mooney)
- A combination of durable materials (Desrosiers) and the ingenuity of chemists and chemical engineers mean that chemical manufacturing equipment rarely dies, but rather is reconditioned or repurposed for other uses. This is particularly true for equipment used in the biotechnology and fermentation industries, where process conditions are generally mild and non-abrasive, and for equipment that has no moving parts. (Mooney)
- There is a low barrier to entry into the chemical equipment manufacturing industry, with China being one example, where there are now some 3,000 companies capable of building chemical production equipment. The only barriers to entry are access to capital and labor. (Shao) When coupled with the lack of regulations in many developing countries governing the sale and disposal of equipment within national borders, this expansion of equipment manufacturers increases the opportunities for the diversion of chemical manufacturing equipment. (Prieto)
- As the market for chemicals grows in the developing world, so too will the number of small- to mid-sized chemical equipment manufacturing companies. These companies will need to have a certain level of technical sophistication to make equipment for the U.S. and European export markets. (Shao)
- Three trends—industry consolidation, globalization, and an increasing focus on core competencies and the accompanying shift to contract manufacturing in the closely related pharmaceutical industry means that there is surplus chemical manufacturing equipment available and a developing global market seeking to purchase this equipment. (Prieto)
- The advent of online commercial marketplaces, such as eBay and others, increases the chances that surplus equipment will move across borders and become challenging to track. (Prieto)
- The increase in mergers and acquisitions in the pharmaceutical industry can create gaps in inventory control and tracking of surplus equipment. (Prieto)
- Today's export controls are linked to an expectation of practice that does not necessarily align with rapid changes that are taking place in the industrial landscape. As a result, export regulations were crafted

during a time when the concern was over nations using equipment for nefarious purposes may not be up to the task of controlling proliferation of chemical weapons capabilities in today's world in which groups rather than counties are the main threat. (Prieto)

- Current regulatory schemes take a backward-looking approach to technology. Regulators could instead look ahead and try to devise approaches to respond to emerging technology. (Prieto)
- In addition to an expansion in the number of companies globally that can produce chemical manufacturing equipment, there has been a concomitant growth in the number of firms that can produce the corrosion-resistant materials that are required to build long-lasting equipment. (Desrosiers)
- The time required for regulators to respond to requests for licenses and the need for speed and flexibility in industry can lead to tension as manufacturers endeavor to comply with global export and nonproliferation regulations. However, strong corporate culture among established chemical companies makes it possible to maintain profitability alongside compliance with regulatory requirements and "doing the right thing." (Desrosiers, Mooney, Shao)

EXPERIENCES IN EXPORTING CHEMICAL MANUFACTURING EQUIPMENT

There are four pillars to export controls, said Charles Mooney. The first pillar concerns products and it requires knowing what the product is, what it will be used for, and what it is capable of being used for beyond its intended application. The second pillar deals with the end use of an item, that is, how the equipment is going to be used. "As chemical producers and manufacturers of equipment, one of our concerns is that our equipment is always used the way it is intended to be used or designed," said Mooney. For example, his company makes heat exchangers that are subject to controls of the International Traffic in Arms Regulations (ITAR) because of their intended use. Others are subject to controls of the Export Administration Regulations (EAR) because the materials used to make the equipment, which are specialized and enable its use in harsh chemical environments, are controlled.

The third and fourth pillars refer to the destination for the item and the end user at that destination. "The country is a concern, but this is more about who is using it in the country since countries don't use equipment or chemicals—end users do," explained Mooney. In the end, these four pillars all come down to a matter of trust, capability, and capacity, he said. "If your exporter does not have a program that is grounded in these elements…chances are there is going to be no control and there is going to be an issue," Mooney stated.

Regarding international standards, Mooney said that the provisions for dealing with most chemical processing equipment, particularly dual-use items, are found in the CWC, the Australia Group's Common Control Lists, the Missile Technology Control Regime, and to a lesser extent in the Wassenaar Agreement and guidelines of the Nuclear Suppliers Group. In particular, there is tremendous variation in the way individual countries implement these standards. Each country has its own control lists, even though they originate from the same multinational agreements. Japan's list, for example, fills a thin book, while the U.S. Department of Commerce's list takes up a very thick book, according to Mooney. Countries also differ in how they interpret these agreements and how often they update their control lists. For example, when his former company wanted to move mixers to new plant in China, it used a Japanese company to source the equipment because Japan, unlike the United States, did not require any licensing to move the mixers to China, enabling the mixers to be moved in 10 months. He noted that during a subsequent move of the same size and type of mixers from the U.S. to China, simply acquiring the licenses from the U.S. Bureau of Industry and Security took approximately the same amount of time to obtain. "That doesn't make it right, that doesn't make it wrong," said Mooney. "It is a business reality, though."

Often, said Mooney, there are more than one set of controls for the same transaction, and this can create difficulties, particularly when working in more than once country. "To comply with global standards, the exporter must consider the regulations of the local exporting company, and any extra-territorial controls," he said. In Europe, for example, Germany and the United Kingdom have very rigorous export-control regimes, but other countries, such as Italy and Spain, have, as Mooney put it, "a different perception of what the regulations mean."

Mooney said that it is important to plan for the time that it takes to get all of the necessary licenses when planning to export equipment covered by any of the multinational agreements. In some cases, licenses can take just a few days or weeks to procure, but in other cases it can take many months of back and forth with regulators. One problem he sees with all of the regulations is that they largely depend on self-policing and honesty. While the United States may issue an export license with various provisos and logging requirements, keeping track of what happens to equipment after it has moved or been sold to others can be difficult at best. His advice to those individuals responsible for export controls is to err on the side of caution when seeking authorization to export equipment or materials that could have dual-use applications.

Turning to the subject of chemical equipment lifetime, Mooney quipped that chemical manufacturing equipment never dies, but rather it comes back to life in some other form with some other use because of the significant initial

investment that is made in these items. Multiple factors determine the lifetime of a piece of equipment, he explained, including the materials from which it is made, what it can be used to make, and if it was designed to be maintained over many years. He noted that he has seen mixers in use that were at least 50 years old, and added that much of this type of equipment, including reactors, have no moving parts to wear out. This is particularly true of equipment used in the biotechnology or fermentation industries, where process conditions are generally mild and certainly not caustic or abrasive. Mooney also credited the chemical industry overall for its skill in creating new uses for old equipment.

INDUSTRIAL REGULATIONS AND EQUIPMENT FABRICATION

From his perspective as a manufacturing representative for a company in China that builds chemical production equipment, Ye Shao said this business is not very sophisticated and that it is easy to establish a new company to compete in this market—China alone has some 3,000 companies capable of building chemical production equipment, and they are largely interchangeable in terms of their capabilities. Given that the competition is stiff, it should not be surprising that this is a difficult business to sustain. He noted that for his company, there are five major parts: raw materials, engineering, labor—the welders, inspectors, and engineers involved in building a piece of equipment—and infrastructure, which includes the large facilities at which equipment is put together. He also said that the equipment manufacturing business is become less rather than more integrated, with many companies now outsourcing engineering, inspection, and sometimes even assembly to outside shops in order to reduce costs and remain competitive.

The global market for mechanical fabrication equipment, said Shao, began in the United States and Europe in the 1950s and it largely remained in those two markets until the 1970s. The industry then moved to Japan and Singapore in the 1970s and remained there for the remainder of the last century. Today, Korea, China, and the Middle East are major players in this industry, and Shao predicted that the industry will move to other developing countries, particularly within Africa, in the years ahead as the need for energy and chemicals grows in those markets.

Though it does not take much beyond capital to establish a manufacturing company, there are a number of standards that anyone competing in this field must meet in order to sell the equipment they produce. The oldest standard is the American Society of Mechanical Engineers (ASME) Code, which was developed more than 100 years ago. Originally a national standard, the ASME Code has been adopted as a global standard followed by engineers worldwide. "ASME certificates are entry tickets for doing something in the global markets," explained Shao. In May 2002, a new standard—the European Union's Pressure Equipment Directive—was enacted and made it legally compulsory for all fabricator shops to follow this directive if they want to sell their products in the European markets. China recently enacted its own standard, known as GB 150, that is equivalent to the ASME Section VII, Division 1 standard that provides requirements applicable to the design, fabrication, inspection, testing, and certification of pressure vessels operating at either internal or external pressures. Shao said that newly industrialized companies have to be certified according to these standards to do business in the United States, Europe, and China.

One of the drivers for the development of standards is that standards make life simpler with regard to national regulations, said Shao, and both the World Trade Organization (WTO) and the International Organization for Standardization (ISO) are trying to develop standards to guide this industry, such as a standard for fabricating pressure vessels and boilers. He noted, though, that during his 10 years in the industry he has yet to see a WTO or ISO standard being compulsory for any specific project.

Before discussing China's perspective on this industry, Shao spoke briefly about the economics of chemical equipment manufacturing. Using a $1 million stainless steel pressure vessel as his example, he explained that 60 percent of that $1 million goes to purchase the raw materials, about 35 percent is spent on labor costs, and the remaining 5 percent pays for engineering. One unusual feature of chemical manufacturing equipment is that labor costs rise with the size of the equipment, giving countries with low labor costs a competitive advantage when it comes to building large pieces of equipment. However, some contracts specify that the bidder must obtain written approval of the buyer to use any materials or labor not originating in the United States, Canada, Japan, the United Kingdom, France, Germany, Spain, and Italy. Shao noted that companies in developed countries are competitive because they have a better understanding and application of the regulations germane to them, they tend to be more efficient, and because they have an accumulated knowledge base that lends itself to better efficiency.

In China, the growth of ASME certified manufacturing companies has soared since 2003. In 2003, 115 out of a global total of 4,492 companies (2.5%) held ASME certificates. By 2013, that number had risen to 747 certificate holders out of 6,894 (10.8%) worldwide. Shao noted that there are no more than 300 certificate holders in the United States. He also said that while the perception is that China is a low-cost solution for manufacturing, this is increasingly not true. What has helped China expand its equipment manufacturing industry has been the rapid expansion of the market that has accompanied internationalization, China's focus on large value-added projects that require sophistication but come with high rates of return, and recognition by global industries that China has the resources and skills to compete in this market. As global markets expand, he added,

there is an increasing demand for what he called "universal products" that meet the specifications spelled out in global, technology-driven regulations.

OBSERVATIONS FROM THE FIELD

As an introduction to her talk, Ana Prieto explained that she would be speaking from her perspective as an environmental health and safety professional who spent much of her career in the pharmaceutical industry. She noted that in 2010, the world's chemical industry realized an estimated turnover of roughly $3.12 trillion dollars, of which the United States accounted for approximately 21 percent. By segment, basic chemicals accounted for $250 billion of the U.S. chemical industry revenue, specialty chemicals totaled $126 billion, agricultural chemicals totaled $30.7 billion, and consumer products accounted for $71.5 billion of the total. Pharmaceuticals represented the largest category, totaling $186 billion.

In brief review of the pharmaceutical sector, Prieto explained that there are two major components to the process of making a finished drug product, whether it is a tablet, ointment, cream, or injectable. The first is the production of the active pharmaceutical agent itself and the second is formulation, which is when the active pharmaceutical agent is mixed with other ingredients to produce the finished product. The major difference between the pharmaceutical industry and other segments of the chemical industry is scale, she said, but the equipment used to make pharmaceuticals—reactors, centrifuges, distillation columns, and others—is similar if not the same as that used in chemical manufacturing. Most pharmaceuticals, for example, are made in batch processes. Another aspect of the pharmaceutical industry is that there are three subsectors: original or "branded" pharmaceuticals, the products of "big pharma;" generics, which are copies of drugs whose patents have expired; and over-the-counter agents that have been deemed safe for self-medication and for which no prescription is required.

What all of this has to do with the topic of this workshop, said Prieto, is that the pharmaceutical industry is experiencing some of the same trends as the overall chemical industry. The first trend is consolidation, which reflects the growth potential for emerging markets, the expiration of patents, and the development of desirable new technologies. These technologies may be more lucrative to own and control by purchasing the company that developed them rather than merely licensing it from the developer. The second trend is globalization driven by cost efficiency, market opportunities, and economic development, and the third trend—the one that Prieto said is most germane to the issue of chemical manufacturing equipment—is a focus on core processes. Companies, she said, are trying to focus on what they do best, whether that be research and development, marketing, or manufacturing, and are turning more to contract organizations and partnerships to reduce costs of drug production. When undergoing these shifts in business models, companies may decommission or sell their chemical manufacturing facilities.

The impact of these three trends, said Prieto, is that there is both surplus manufacturing equipment available and a developing global market looking to purchase this equipment. The advent of online marketplaces, such as eBay and others, makes it more likely that this surplus equipment will move across borders and become challenging to track. At the same time, the increase in mergers and acquisitions comes with the potential that the buyer of a company may not know what equipment it is purchasing as it may not be inventoried accurately. "There really are some potential gaps in the knowledge as to the equipment owned," said Prieto.

As an example, she described the time she went to visit a site in Croatia for a first-time visit to a company her firm had purchased. While touring the rather large facility, she and her hosts came across a building filled with chemical manufacturing equipment that had been dismantled, put into storage, and forgotten. "There was no inventory control or tracking of what was in place," said Prieto. She noted that the gaps in this particular purchased company's organization capacity that allowed this equipment to go uncatalogued is not that uncommon, particularly in smaller companies. With limited resources and systems, these smaller firms are placing increased reliance on service providers such as equipment dealers, freight forwarders, and auctioneers, to manage their transactions. "If you are not careful how you choose that partner, you may unintentionally, with all the best ideas and thoughts, wind up not being able to track what you have and where," said Prieto.

Another issue that she discussed briefly was that while there are a great many export regulations in place, there are few controls over the sale and disposition of equipment that does not cross national borders. "Other than hazardous waste regulations that tell me what I can and cannot do if a material is a hazardous waste, I don't believe in my experience that there have been any regulations around in-country movement of equipment," said Prieto. She added that this is also true in some of the less developed nations that are building their own equipment manufacturing infrastructure for internal use.

In closing, Prieto said that from her perspective, "manufacturing equipment is used in a broad variety of sectors and is easily available through a variety of ways. In reality, there are no or few mechanisms in place to identify and manage that equipment in an in-country transaction." She added that the focus on core capabilities and economic drivers has increased the number of companies with access to chemical manufacturing equipment. "The complexity and the number of players who are now in this field and may not have the necessary knowledge are extensive," said Prieto. She noted, too, that the export controls that are in place are linked to an expectation of practice that does not necessarily align with rapid changes that are taking place in the industrial landscape. As a result, she worries that while export regula-

tions were crafted during a time when the concern was over nations using equipment for nefarious purposes, the reality of today's world is that groups rather than counties are the main threat.

MATERIALS FOR EQUIPMENT MANUFACTURING

In this session's final presentation, J. Craig Desrosiers used DuPont's equipment needs as a means of describing the specialized materials used to construct chemical manufacturing equipment and their respective applications and durability over time. He noted that DuPont's seven major market segments uses a variety of items, such as heat exchangers, reactors, distillation columns, and pressure vessels, and that these items can be constructed using many different materials that include glass linings, fluoropolymer linings, hi-nickel alloys, and exotic metallurgies such as titanium and tantalum.

Glass-lined equipment is valued for its corrosion resistance to all but a few chemical environments; its inert nature that does not contaminate products and protects their color and purity; its smoothness that minimizes friction and reduces demands on agitation equipment, and its superior performance under vacuum arise from the tight bond that forms between glass and steel. French company De Dietrich began making glass-lined equipment in 1870, and U.S. company Pfaudler launched its first glass-lined product in 1884. The two companies together still dominate the market and now have factories around the world. China, he said, now has as many as 30 factories making glass-lined equipment, though only a few can meet global quality requirements, and there are some smaller companies that specialize in re-glassing used equipment. In the United States, surplus equipment brokers are major supplies of glass-lined equipment.

Typically, he explained, glass-lined equipment has a lifetime of longer than 20 years, but mechanical damage from maintenance or operations can lead to expensive repairs or re-glassing in 2 to 5 years. Accessories, such as agitators, baffles, and other internal components, are replaced frequently—usually after 2 to 5 years. A National Board Number in the United States and a CE Number in Europe is associated with each piece of equipment on an attached nameplate and can be used for tracking purposes.

Fluoropolymer-lined equipment such as distillation columns, reactor vessels, scrubbers, tanks, and piping, is used in highly corrosive environments. There are several major players in this market sector and the market for fluoropolymer-lined equipment has grown substantially over the past 20 years. Because of the need for the highest level of quality and inspection, the supply chain for fluoropolymer-lined equipment often still starts in the United States. Desrosiers noted that the life cycle of this equipment has improved significantly over the past 20 years and tracking of this equipment can be handled easily using its National Board Number.

Equipment made with hi-nickel alloys and other exotic metals are used for their outstanding corrosion resistance under highly acidic, highly chlorinated, and high-temperature conditions. Many of the materials used in this type of equipment are related to austenitic stainless steel but are more highly alloyed with nickel, chromium, and molybdenum to increase corrosion resistance. Long life cycles are associated with equipment made with these materials. Unlike with fluoropolymer-lined equipment, the supply chain for this type of equipment has expanded globally over the past 20 years. Today, companies in China, Japan, Korea, Taiwan, and India are significant players in this market, Desrosiers said in closing.

DISCUSSION

Elizabeth Scott Sangine of the U.S. Department of Commerce began the discussion by asking the presenters if they had any perspective on how the business models of their respective companies viewed proliferation risks. Desrosiers replied that DuPont is concerned about where its technologies will go in certain countries, particularly those in which the government makes no secret of the fact that it will take whatever technology it wants regardless of contracts and regulations. "I am extremely concerned about how we manage that risk," said Desrosiers. He did comment that while export controls are absolutely necessary, they sometimes are cumbersome and very costly to follow. Clara Zahradnik, the session moderator, added that a key consideration is to have trust in one's trading partners, and given that many of the chemical weapons that are appealing to terrorist groups can be "made in washtubs," it is equally as important to control chemicals as well as equipment.

Detlef Maennig asked if there was a tracking technology in place for dual-use equipment and was reminded by Zahradnik of the National Board number or CE number that is affixed to each piece of equipment. Zahradnik did note, though, that often an export license is applied for and granted before a piece of equipment is produced and given an identifier number. Prieto wondered if it would be feasible to go back and assign tracking numbers to legacy equipment. This prompted Nancy Jackson, of the U.S. Department of State, to ask the panelists if they had any ideas on who would set up an international tracking system. Prieto replied that it may be possible to add provisions to existing regulations and treaties, but that she didn't see a direct pathway. "I think the challenge will be keeping it somewhat simple," said Prieto, especially given the multitude of regulations that exist outside of the United States and Europe.

Kathryn Hughes of the NRC asked if there was an intersection among international regulations, export controls, voluntary standards, and corporate culture where it would be possible to create a system of protection that goes beyond compliance. Mooney said that one of the biggest drivers of

protection is corporate culture and most of the companies in the chemical industry have strong corporate cultures that have found ways to balance regulatory requirements and doing the right thing with profitability. He added that this is not a U.S. initiative, but rather a worldwide initiative that is following in the footsteps of U.S. companies that are already doing the right thing.

Shao agreed that corporate culture is critical and added that from his perspective as a manufacturer, controlling technology is more important than controlling the actual equipment. Prieto suggested that trade associations and professional organizations might be able to play a role in developing voluntary programs and disseminating the knowledge needed to understand and follow controls and regulations. Zahradnik said that large companies, which have the necessary corporate cultures, can be ambassadors for following standards and adhering to best practices in their dealings with smaller companies and vendors. Usha Wright, of O'Brien & Gere and a member of the workshop organizing committee, asked if the transportation industry could play a role in terms of compliance and tracking, and Desrosiers thought it could act as a cross-checker but not as a primary enforcer.

Astrid Lewis from the U.S. Department of State asked Shao if China had an equivalent to the National Institute of Standards and Technology that develops the standards for various regulatory codes. Shao replied that China does have such an organization that does help set national standards and codes. He added that China largely models its standards after those of the United States, Europe, and Japan, and most often uses the ASME standards even when exporting to Europe. "If you want to do global sourcing, it is mandatory to have an understanding of the ASME standards," said Shao.

Hughes asked what was being missed given the rate of change globally. Desrosiers replied that there is a significant skill gap between the European Union, North America, and the rest of the world. "While I know the gap is trying to be closed, one of the things that I find when I procure equipment outside of those regions, I have to spend significantly more in inspection to make sure the quality of the work is there, the quality of the material is there. While I think these countries are coming along nicely, there is still a significant gap between the experienced countries and the emerging countries," said Desrosiers. Prieto thought that regulatory schemes are somewhat backward-focused given the rate of change. "We should be looking to what it is going to look like in another 10 years and try to devise regulations for that," she said. Mooney said that the regulatory system needs to be more responsive in terms of time to approval. "We've got to find the right velocity," he said.

Mooney made two additional observations. One was that while the world of new equipment is well controlled, the Internet is changing the landscape with regard to used equipment. The second observation was that none of this is taught in schools and perhaps that needs to change, too. Richard Cupitt of the U.S. Department of State said that there are efforts ongoing to teach "responsible science" at the university level and that various educational organizations, both in the United States and Europe, are developing courses in that area.

4

The Security Dimension

The workshop's third session focused on various aspects of security and chemical weapons production and featured presentations by four speakers. Jonathan Forman, Science Policy Advisor for the Organisation for the Prohibition of Chemical Weapons (OPCW), spoke on the topic of preventing chemical weapons proliferation. Matthew Moakler, Foreign Affairs Officer in the U.S. Department of State's Office of Missile, Biological, and Chemical Nonproliferation and Chair of the interagency Shield Licensing Group, presented a policy perspective on dual-use chemical equipment non-proliferation. Richard Cupitt, the U.S. Coordinator for United Nations Security Council Resolution (UNSCR) 1540 in the Office of Counterproliferation Initiatives at the U.S. Department of State, then discussed implementation of UNSCR 1540, which addresses proliferation of nuclear, chemical, and biological weapons and illegal trafficking in these weapons of mass destruction (WMD). The final presentation by Elizabeth Scott Sangine, Director of the Chemical and Biological Controls Division at the U.S. Department of Commerce, described the U.S. approach to chemical equipment export controls. A discussion moderated by Nancy Jackson, Franklin Fellow at the U.S. Department of State and a member of the workshop organizing committee, followed the presentations.

KEY POINTS

- The role of non-state actors is a major challenge for non-proliferation activities, particularly since the control of those actors depends on individual nations enforcing international agreements and developing sufficient national-level controls to govern the use and transfer of chemical manufacturing equipment within their own borders. Additional challenges arise from non-state actors using less sophisticated technologies to make chemical weapons. (Forman)
- Treaties are important as matters of principle, but they are only implemented to the degree that national-level laws that address criminal legislation, trade controls, and the reporting and monitoring of industry within the national boundaries are both developed to conform with treaty obligations and enforced. (Forman) As of 2011, fewer than half of the member nations of the United Nations had created a legal framework to account for the production, use, storage, or transport of chemical weapons-related materials, and even fewer countries had enforcement measures in place. (Cupitt)
- Chemicals can be listed under the CWC, but there is a concern that new methods that avoid listed compounds can be developed to create toxic chemicals or that novel delivery technologies, such as nanotechnology, can be used to turn an unlisted compound into a chemical weapon. (Forman)
- Changing technology can create difficulties for inspectors trying to differentiate between a legitimate chemical plant and one making chemical weapons (Forman).
- The ability to transfer information, DNA sequences for example, without the additional need to transfer material may present a future challenge for controlling dual-use materials. (Forman)
- The non-physical transfer of technology thanks to avenues such as the Internet is a major concern and can only be addressed through a combination of activities, such as promoting global norms and developing non-proliferation regimes that can link like-minded countries in a concerted effort to stop such proliferation. (Moakler)

- Sound export licensing decisions by suppliers and nations have had a tangible impact on proliferators by denying them access to the world's best sources of technology and corrosion-resistant equipment. (Moakler)
- The trend for chemicals production to move to lower-cost countries creates a challenge for the effective use of export controls because fewer chemical-producing nations are now part of the Australia Group. (Moakler)
- Information exchange between industry and regulators is critical for making regulations work and reducing the overall burden on industry. Applications for an export license should include information on the specific intended end use, as well as other potential uses; the intended destination; and what kind of relationship and for how long has the licensee had with the intended recipient company and its background. Volunteering such information takes a strong corporate culture that encourages this degree of sharing. (Sangine)
- Education, training, and outreach efforts have lagged behind other approaches to non-proliferation but are needed to help create a culture of support for non-proliferation activities. (Sangine, Cupitt)
- There is little political will at the national level to increase the number of chemicals on control schedules. (Cupitt, Maennig)

CHEMICAL WEAPONS NON-PROLIFERATION

The OPCW is the implementing body for the CWC, the multilateral disarmament treaty for chemical weapons, explained Jonathan Forman. The OPCW is located in The Hague and has a staff of about 500 people—120 of which are chemical weapons inspectors—from 80 nations with an annual operating budget of about $101 million excluding the cost of the current disarmament activities in Syria, which are funded by voluntary contributions from the member states. There are 190 member states, all signatories to the CWC; all but Israel and Myanmar have also ratified the treaty. Four countries—Angola, North Korea, Egypt, and South Sudan—have not signed the treaty.

There are four core activities for OPCW: chemical disarmament, which includes the destruction of military chemical weapons stockpiles; non-proliferation, which includes verification; assistance with and protection against chemical weapons; and fostering international cooperation. Verification, Forman explained, is a process by which the State's Parties declare the chemicals and chemical activities that they have going on in their territories, including industrial activities that meet certain criteria and that are subject to random inspection by a team of international inspectors. At military sites, verification entails having inspectors confirm that every chemical weapon and all related munitions are accounted for and destroyed. In some cases, the verification process involves sampling and analysis, while in other instances it involves just looking around and checking records, said Forman. At a higher level, verification includes looking at the national-level controls that the member states put into place. The goal of this process is to build confidence among nations that each signatory to the CWC is following through with its obligations to comply with the treaty's provisions.

Treaties are great in principle, said Forman. "They say that this is what we believe in and this is what we are committed to," he said. "But how do you actually implement the laws and regulations that make a treaty effective? That is what is done at the national level." He explained that each nation is responsible for enacting the laws and regulations needed to meet the responsibilities obligated by the treaty. One limitation of this approach is that in today's world, non-state actors are a major worry and non-state actors are not covered directly by the treaty. "How non-state actors get dealt with in terms of the treaty is really through the implementation of national laws," said Forman. "National laws take care of criminal legislation, trade controls, and the reporting and monitoring of industry within the national boundaries. That is complicated in a way because if all of the different states are allowed to have their own laws that create a lot of interesting situations when you are trying to import and export across international boundaries."

Forman presented a brief history of chemical weapons, starting with World War I. The first attempt at stopping the use of chemical weapons occurred in 1952 when countries signed the Geneva Protocol and pledged not to use chemical weapons in war except in response to a chemical weapons attack. Under the Geneva Protocol, countries continued to maintain stockpiles of chemical weapons and agents that were far more potent than the mustard gas used in the First World War.

The verification process, said Forman, starts with a country declaring the chemical weapons it has in its possession. The verification division at OPCW evaluates these declarations, monitors data for the production of specific chemicals, and sends inspectors into the field for on-site inspections. The chemicals fall into three schedules: warfare agents, chemical weapons precursors and breakdown products, and industrial dual-use chemicals, which include substances such as hydrogen cyanide and phosphorous trichloride that have important uses but that could be turned into chemical weapons. Also included are chemical production facilities producing more than 200 metric tons per year of discrete organic chemicals, or greater than 30 metric tons if the discrete organic chemicals contain phosphorous, sulfur, or fluorine. There are exemptions for chemical plants that make fuels, explosives, and oligomers. For those plants, verification involves ensuring that there is an absence of chemicals identified in the CWC Schedules. Forman noted that between 30,000 and 35,000 chemicals are scheduled, a

small percentage of the 140 million unique chemicals that have been synthesized.

There are a number of concerns about chemicals listed under the CWC, Forman said. "We are always concerned if there are new routes to make toxic chemicals," he said, citing the advent of biotechnological process as one example. "There are concerns that you might be able to take a chemical that wouldn't have been considered as something weaponizable and through some new technology, perhaps drug delivery strategies that people use with nanoparticles, to turn it into something that could be used as a weapon. This is really less about chemical production and more about the formulation of chemicals," Forman noted. Another concern is that banned activities can be disguised and not subject to the verification regime.

One challenge for inspectors is telling the difference between a chemical weapons production facility and a commercial chemical production plant. This challenge has been exacerbated by the continued development of new ways to make chemicals, such as through fermentation. "If you are looking for specific types of equipment that are being sold or imported or exported, it is not always obvious that the traditional equipment is the only thing you have to look at," Forman said. Even more vexing are differences in national level regulations concerning what types of plants are declared. "Declarations are not always consistent from state party to state party," said Forman. "One of the States Parties actually declares breweries just to make the point that fermentation is a chemical process."

The ability to transfer information easily is another confounding issue today for weapons inspectors. As an example, Forman said that it is possible to send a DNA sequence to a DNA synthesizing machine located anywhere in the world. "The people on the other end don't actually have to know what I am making. They just have to be able to load up the machines with the right precursor materials," said Forman. He added that his thinking on how to account for this type of information exchange is still in flux.

Chemical weapons programs carried out by nations are fairly easy to spot because they are usually technologically sophisticated, but this is not the case with non-state actors, where simple, cheap, obtainable technology is more valuable than sophistication. While such operations are supposed to be covered by national laws, it is possible for a non-state actor to cobble together simple technologies at a scale small enough to avoid being declared or detected. Forman noted that weaponization requires more than just chemicals and facilities that are creating weaponizable materials have a certain look to them that can serve as a telltale sign for inspectors.

The biggest challenge with chemical weapons is being ready to react. "For the OPCW, that means keeping a well-maintained and well-skilled inspectorate, being up to date on analytical capabilities, knowledge of chemical weapons issues and how to handle them, and also having trained responders," explained Forman. One way forward, he said, is to take a holistic view that looks at the big picture of what a facility looks like, the kinds of materials at the plant, the regulatory environment in which it exists, and the possible motivations of the people who are acquiring chemical manufacturing equipment. Taking a holistic view requires engaging experts with a broad range of skill sets. "You need people that can recognize when technologies might be of concern," said Forman. "You need people that can recognize when new technologies could also be used to help you do better non-proliferation or better verification." Finally, it is important to maintain a dialog and share information. "You need to teach people what is important and to understand the changes that are taking place in the world and how they fit into this bigger security picture," Forman said in closing.

Kathryn Hughes from the NRC asked if inspectors check the tracking numbers on equipment. Forman replied that the inspectors will do visual inspections in some plants and sampling and analysis in other plants. "They are not looking for tracking numbers of individual equipment. They are looking to see that this plant has been declared as a discrete organic chemicals plant," said Forman. He noted that if the inspectors are doing sampling or analysis, which is based on gas chromatography/mass spectrometry readings, they check to see if the analytical results are in the database of scheduled compounds.

A POLICY PERSPECTIVE ON DUAL-USE CHEMICAL EQUIPMENT NON-PROLIFERATION

The reason that the United States opposes chemicals weapons, said Matthew Moakler, is that they are weapons of mass destruction that can only be used indiscriminately and that have a disproportionate impact on civilians. Since the 1980s, the key to U.S. strategy regarding non-proliferation in this area has been to impede the flow of the items needed to make chemical weapons. He noted that the chemical weapons programs of rogue states such as Iraq, Libya, and Syria were based almost entirely on items purchased from abroad. He also said that the real threat today is not from nation states as much as from so-called lone actors, such as the five Iraqis arrested in 2013 who were creating Sarin using small-scale production equipment or the American who pled guilty to producing ricin in his home and sending ricin-laced letters to various public officials, including President Obama and Senator John Wicker.

Addressing the impact of controlling the export of dual-use equipment, Moakler said that export controls help prevent proliferators from acquiring the items that they need to make chemical weapons. "Sound export licensing decisions by supplier and transshipment countries, time and again, have had a tangible impact on proliferators by denying them access to the world's best sources of technology and

equipment," said Moakler. He noted that since the 1980s, particularly after the chemical weapons attacks during the Iran/Iraq war, individual countries cannot employ effective national export controls individually but have to do so in concert with one another. "The more states that adopt and effectively administer similar controls, the more effectively this objective can be achieved," said Moakler.

To that end, the United States coordinates its national export controls with the Australia Group, which includes 41 countries and represents roughly 80 percent of the global trade in chemicals and chemical equipment. Over the past 30 years, the Australia Group has focused on harmonizing and updating export controls of dual-use chemical and biological manufacturing items to ensure they do not contribute to weapons programs. The Australia Group has also shared information and lessons learned pertaining to the threat of chemical and biological weapons and regarding technology, enforcement, and interdiction in order to harmonize export controls across nations. It also reaches out to nonmembers to foster a better understanding of what this group is trying to accomplish and to encourage adoption of comparable export controls. That effort, said Moakler, has led many key exporters outside of the Australia Group, including China, India, Russia, South Africa, and the United Arab Emirates, to implement export controls.

The reason for controlling the materials that are exported, Moakler explained, is that manufacturing chemical warfare agents is not unlike manufacturing other chemicals. It involves assembling a plant out of component parts that perform the basic unit operations of chemical engineering—transportation, combination, separation, and reaction. These component parts are similar to those in any chemical plant around the world, with a few caveats. First, most chemical warfare agents are acids and many of their precursors are highly corrosive. Therefore, any surface that comes in contact with them must be made of corrosion-resistant materials. It is possible to use regular stainless steel equipment, which is what Iraq was using at the end of its chemical weapons program, but these items must be replaced regularly because of corrosion, significantly increasing the cost of production and the time needed to realize a weapons program. The second caveat is that there is an extreme safety risk inherent in chemical warfare agent production, so there is a premium placed on preventing leaks through the use of equipment made of robust, corrosion-resistant materials, and then detecting those leaks with toxic gas monitors.

Moakler explained that deciding on a list of items to include in an export control program requires balancing the non-proliferation benefit with the commercial impact of licensing, a point made earlier by Charles Mooney in his presentation. "Finding that sweet spot is a challenge, especially at the policy level," said Moakler, which is why export control lists are supplemented by what is known as the "catch-all" rule. The overriding goal, he said, is to capture items such as reactors, storage vessels, distillation columns, heat exchangers, pumps, valves, piping, filling equipment, and toxic gas monitors made of corrosion-resistant materials including glass, high-nickel steel, graphite, ceramics, fluoropolymers, titanium, zirconium, and other corrosion-resistant exotic alloys.

Looking forward, there are several challenges for the use of effective export controls. One challenge is that the trend for chemical production to move to lower-cost countries means that fewer chemical producers will be part of the Australia Group, which is why that group has been reaching out to new supplier countries to encourage them to adopt export controls. Another challenge arises from unlisted items, primarily those that are not corrosion resistant, which is the reason for the catch-all control lists that allow the United States and other Australia Group members to intervene and require export licenses for unlisted items when they believe that the exports will contribute to chemical weapons proliferation. Moakler added that there is a great opportunity for industry to approach U.S. regulators if they have any suspicions that export of a given piece of equipment might lead to chemical weapons production.

The transfer of technology, either tangible or intangible, from one entity to another via non-physical means such as the Internet, was identified by Moakler as a major concern. He noted that controlling proliferation of this type of information requires a combination of activities, such as promoting global norms via treaties and developing non-proliferation regimes in addition to the Australia Group that can marshal like-minded countries to work together to curb the spread of chemical weapons. Other tools for impeding the flow of technology includes unilateral interdiction of suspect shipments, the threat of sanctions, providing technical and financial assistance to help countries put into place more effective export controls and destroy any chemical weapons stockpiles or production facilities, and visa screening that aims to identify individuals that are coming to the United States solely, incidentally, or principally to violate or evade any law prohibiting the exports of goods, technology, or sensitive information.

CHEMICAL SECURITY AND UNSCR 1540

Richard Cupitt began by providing an overview of UNSCR 1540, noting that it was unanimously adopted by the United Nations Security Council in 2004. The resolution was the first formal decision taken by the Security Council to address the proliferation of nuclear, chemical, and biological weapons as well as their means of delivery as a threat to international peace and security. To that end, UNSCR 1540 identifies illicit trafficking in these weapons of mass destruction and their means of delivery, as well as related materials such as manufacturing equipment, as a new area of concern. In addition, this resolution focuses on

proliferation to and by non-state actors, another new emphasis for the Security Council. Within its text are more than 200 specific obligations, and because it was adopted under Chapter 7 of the United Nations Charter, these obligations are legally binding on all states. The resolution explicitly embraces various international legal instruments, including the CWC, while implicitly endorsing the lists from other multilateral agreements on export controls, such as those of the Australia Group.

The specific points listed in UNSCR 1540 include the requirement to account for and secure "related materials," which includes equipment as well as technologies and materials in production, use, storage, and transportation. UNSCR 1540 also obliges member states to restrict trafficking and brokering of such items by, among other means, controlling their export, transit, transshipment, and re-export. The resolution specifically requires states to have end-user controls to help assure that non-state (and state) actors cannot use these methods to acquire indirectly the materials they need to produce weapons of mass destruction.

Cupitt explained that UNSCR 1540 also created a committee, with a current mandate that runs until 2021, to oversee enforcement. This committee, a subsidiary body of the Security Council, is advised by a group of experts, and its primary role is to monitor and report on implementation. The committee's other tasks include data collection regarding the status of each nation state in terms of the measures they have taken to plan or implement each of the 200-plus obligations in the resolution. The committee creates a matrix[1] for each of the 193 U.N. member states and each matrix has 382 fields that account for some aspect of implementation. "There is a lot of information in these matrices on legal measures and the legal framework," explained Cupitt. Additional information on enforcement actions is also included in the matrix. The committee last reported to the Security Council in 2011 and is currently in the process of updating these matrices.

The 2011 report showed that fewer than half of the member nations had created a legal framework to account for the production, use, storage, or transport of chemical weapons-related materials, and even fewer countries had enforcement measures in place. For those countries with laws on the books, very few had rules relating to accounting for equipment or technology and fewer than half had measures in place to secure equipment, technologies, and related materials. Out of the approximately 80 countries that have declared chemical weapons production facilities, 20 or so do not have any measures in place to secure production, use, storage, and transport of equipment, materials, and technologies at those facilities. One conclusion that Cupitt said can be drawn from the 2011 report is that very few of the measures taken by countries are designed to address terrorism or proliferation. Most measures addressed other objectives, particularly environmental concerns, worker safety, and public health. This is not true, however, for those nations in the Australia Group.

One of the committee's activities involves identifying the effective practices that nations are taking and to share those findings. "On the security side, most of the effective practices that the committee was able to identify would come from unconventional chemical sources," said Cupitt, from organizations such as the International Marine Organization, the International Civil Aviation Organization, the U.N. Environmental Program, the Food and Agriculture Organization, and the World Health Organization. He noted, too, that the committee has worked with the OPCW on ways of securing materials based on the OPCW's work on accounting, verification, and destruction.

The committee has also surveyed nations for their effective national practices and received submissions from 42 states so far. "Unfortunately, only five of those even referenced chemical security in any way," said Cupitt. He added that the U.S. Chemical Facility Anti-Terrorism Standards appear to be unique and the committee has been sharing these with the other nations. Several states, including the United States, are preparing new submissions on effective national practices.

Cupitt concluded his remarks by stating that while many members of the committee will say that nuclear or biological weapons are more important because the mortality and morbidity associated with the use of those weapons is likely to be higher than for a chemical weapon attack, he takes the perspective that the risk of a successful chemical attack is much higher. "These things are easier to get and easier to produce. There is a real risk," said Cupitt. On a positive note, he added that there is an opportunity for action because there are many ways of fitting chemical weapons non-proliferation activities into existing environmental compliance programs.

CHEMICAL EQUIPMENT EXPORT CONTROLS

To start the session's final presentation, Elizabeth Scott Sangine reminded the workshop that the authority for the federal government to require industry to take the appropriate steps to control the export of equipment that could be used to make chemical weapons comes from the Export Administration Act of 1970, when the primary worry was over the Soviet Union's chemical weapons program. "There was not a comprehensive chemical weapons treaty at the time, but many of the supplier states did get together," said Sangine. Export controls for chemical equipment were first added unilaterally to the U.S. Commerce Control List and then by the Australia Group in 1991. At the time, equipment was available from 20 non-Australia Group countries, including Russia, China, India, South Africa, and Taiwan. Until 2005, she added, a U.S. export license was required only for so-called countries of concern. Today, an export license is required for all non-Australia Group member countries.

[1] http://www.un.org/en/sc/1540/national-implementation/matrix.shtml.

Sangine said that though the number of applications for chemical equipment export licenses has soared since 1999 to close to 3,000 in 2013, the number of those applications that get rejected has stayed small, around three to four a year. "That just shows that most of the equipment is used for legitimate business," said Sangine. The requirement for a license, she said, is to enable the federal government to keep track of end-users and to provide information about end-users that a potential licensee might not be able to access. She added that there are export control lists for both chemicals and chemical equipment and that there are license exceptions available for industry to use for certain situations, such as in the case where there is a plant shutdown and a customer needs a replacement part. Temporary exemptions are granted so that companies can take equipment to international trade shows, and government-to-government exceptions are granted for emergency responses to disease outbreaks, for example.

When it receives an application for an export license, Sangine's office first reviews the construction materials and the performance capabilities for a given piece of equipment. She provided some advice for those who do need to apply for a license. "The reasons your export licenses might take longer than you would like is if we don't really understand what you are shipping or why," she told the workshop. "We really need this information when you apply." Applications for an export license should include information on the specific intended end use, as well as other potential uses; the intended destination; and a description of the relationship the licensee has with the intended recipient company, including information such as how long they have worked with the company and any other relevant background information.

When a license is issued, it comes with a set of standard conditions that include a statement of end use; that there should be no resale, retransfer, or re-export without prior U.S. government authorization; that the equipment not be used to make chemical or biological weapons; and that the applicant must inform the consignee of these license conditions. She explained that from the standpoint of the U.S. government, control continues to exist over an item for its entire lifetime, even if gets incorporated into some other piece of equipment. The reality, though, is that the U.S. government is incapable of knowing if an item is resold. There are Department of Commerce export control officers with law enforcement responsibilities stationed in Singapore, Hong Kong, Russia, India, China, and the United Arab Emirates who conduct pre-license checks and post-shipment verifications. In addition, the Office of Export Enforcement collaborates with all of the U.S. law enforcement agencies to develop leads and monitor proliferation activities. She noted that most of the indicators of a proliferation network's activities are financial in nature.

Sangine said that export controls are applicable when technology takes the form of technical data or technical assistance and whether that technology is tangible or intangible. This provision becomes particularly germane for academics and universities who may not be aware that having a foreign national come to a laboratory to learn a new technology does fall under the export control regulations. The exceptions are if the foreign national is a green card holder, permanent resident, or protected individual as defined under U.S. Code. The applicable regulations are spelled out in Export Administration Regulations 734.2(b)(3), she added.

One of the big changes that have taken place since the 1980s is that companies no longer store parts on site and now expect replacement parts to be delivered within hours, not days. However, issuing export licenses takes longer than that, explained Sangine. The Department of Commerce has adjusted to this new reality by allowing in-country storage, enacting internal procedures to shorten review times, and granting 4-year licenses. Another significant change has been the shift in concern from state chemical weapons programs to those run by terrorist organizations. As a result, the Commerce Department now works closely with the Department of State on sanction and embargo lists, and it issues regime denial notifications within the context of the Australia Group. She also said, "If you have a gut feeling that something is not right, apply for a license and let us be the ones to judge."

Sangine ended her comments by stating, "We know chemical equipment and chemical production is global and we have these controls to make it harder for proliferators. We know there are other things they can use, but this is just to hopefully slow it down a little bit. We do licensing as rapidly as possible, but we are always open to new ideas that help us. As I said, these are pretty old methods of doing export controls, so any and all new ideas are welcome."

DISCUSSION

To open the discussion, Clara Zahradnik asked Sangine if the federal government would consider revising the CB3 regulations in light of the migration of production and technology for chemical equipment. Sangine replied that the Department of Commerce is always open to taking suggestions from industry and will take that idea under consideration. Zahradnik replied, "I think maybe some creativity would help industry a lot."

In response to a question from Nancy Jackson about enforcement, Cupitt acknowledged that enforcement is a difficult problem for the U.N. committee. "To some extent the committee is focused on the legal aspects and whether a law exists. If there is no legal measure, it is unlikely there will be any enforcement that will take place," he said. What the committee has done is work closely with the United States and the World Customs Organization (WCO) to develop a strategic trade control enforcement project that the WCO will conduct. These activities will be similar to those the WCO has conducted for other illicit trafficking areas such as endangered species and human trafficking. He added that

Interpol has an effort underway to identify potential chemical, biological, radiological, and nuclear facilities that nonstate actors could use for nefarious purposes. Cupitt noted that the European Union is training prosecutors, investigators, and judges to deal with these cases.

Kathryn Hughes asked if there are any efforts underway to educate and train chemical engineers so that they can identify things that might be questionable when they go visit other facilities. Sangine replied that the Commerce Department does a great deal of outreach with industry and with major domestic trade groups. Academia, however, has been tougher to reach, she added. Cupitt said that outreach is not required under the U.N. resolution, but it is recommended and the committee does collect data on outreach efforts. "I would say there are a fair number of government outreach programs on the chemical side compared to the nuclear and biological sides," said Cupitt. He added that the committee is engaging industry to develop codes of conduct at the facility level. Jonathan Forman acknowledged that OPCW's efforts to "work with chemical engineers, particularly in the academic sector, have been fairly lax." He also noted that OPCW often has difficulty hiring chemical engineers as inspectors, which he said creates a "compelling reason to recommend to our management that we go out and try to talk to the chemical engineering community in order to keep our inspectorate well informed and well trained going into the future."

Jackson asked the speakers if they thought there should be additional chemicals added to the schedules list. Forman replied that there does not seem to be the political will from the member states to do that, and Cupitt said that this is really up to the individual states to define what goes on its control lists. Detlef Maennig added that the chemical industry's position on this matter is that it is against increasing the number of chemicals on the schedules at the moment unless there is a demonstrated case or there is a risk identified or there is a loophole in the convention. Cupitt also commented that when the U.S. Chemical Facility Anti-Terrorism Standards were released, which included a list of chemicals of interest that included the scheduled compounds, the result was that several thousand chemical facilities changed their processes to get rid of the chemicals that were on the chemicals of interest list. "In essence, they became more proliferation resistant," said Cupitt.

5

The Internet as a Secondary Market

KEY POINTS

- Online marketplaces need comprehensive user policies that detail the types of items sold through their sites and a combination of software filters and human review to ensure that listed equipment is not shipped inappropriately. (Carson)
- Regulators need to provide key word lists and regularly communicate with online marketplaces in order for screening and filters to be effective. (Carson)

Previous discussions at the workshop had identified the Internet and online marketplaces as an avenue for transnational movement of used chemical manufacturing equipment and therefore as a new challenge to non-proliferation activities. At the start of the second day of the workshop, Michael Carson, Senior Manager for Global Regulatory and Policy Management at eBay, spoke about the steps that eBay takes to prevent regulated or illegal equipment from being sold and exported through its online auction site without the proper licenses.

The eBay brand comprises three major businesses: eBay Marketplaces, its online auction site; PayPal, an online electronic payment system; and eBay enterprise, an e-commerce provider for large businesses. eBay Marketplaces, Carson said, has 145 million active users and 650 million live listings at any one time. "From my perspective, we are always trying to find the proverbial needle in a haystack because 99.9 percent of those listings are completely legitimate," said Carson. "There are a small percentage of items that my group and a group within eBay concentrate on and are looking at for violating listings. We also educate users about what potential hazards may be out there with different listings."

For those at the workshop who were not familiar with eBay, Carson explained that it acts as a marketplace that brings together buyers and sellers and it never handles the goods itself. Sellers list items on the Marketplace and buyers from around the world can look at these items, bid on them, buy them, and receive them directly from the seller. All that eBay does is facilitate the auction and collect and disburse the purchase price of the items. eBay earns revenue from an item listing fee and a small percentage of the final sale value. Other online marketplaces compete with eBay, said Carson, including Amazon, Craigslist, uBid, and eCrate.

eBay has policies set forth in a user agreement that details the type of items that cannot be sold through its Website. These policies, of which there are 54 that relate specifically to prohibited and restricted items, are enforced by monitoring users with a variety of tools, including filters created from information about export controls. The goal, said Carson, is to prevent listings that violate these policies from getting on the site and then educating those who try to list a prohibited item so that they do not try again. If a prohibited item does get listed on its site, eBay works with investigators around the world to deal with that after the fact. "Whether it is working with law enforcement on an investigation of a fraudulent transaction or potentially illegal transaction, we have a whole team of people around the world that work with law enforcement to provide them with information to help with that investigation and if appropriate, prosecute those sellers that may be violating our policies," explained Carson.

Aside from the user base complying with the provisions of the user agreement, eBay employs teams of customer support agents around the world to examine thousands of listings per day that are identified by filters as potential problem listings. In some cases, this review results in eBay contacting the seller and providing them with information so that they can list the item, such as listing it only on eBay's domestic site and not on its international sites, which would create the chance that the prohibited item would be exported. In other

cases, the items are permanently blocked with no referral to customer service agents.

To illustrate how eBay enforces its listing prohibitions, Carson gave three examples that took place within one week, earlier in 2014. In the first example, a small Canadian town tried to auction a 40 foot sperm whale that had washed up on its shores after the Canadian government rejected the town's call for help. Unfortunately for the town, eBay has a policy that prohibits the sale of endangered species—even dead ones—and the company notified the town that they could not list the carcass. "When we were developing our animal parts policy, we certainly didn't have this in mind," said Carson. "As you can see, we need to be able to expect anything."

In the second example, eBay was approached by the Australian Consumer Protection Agency about people selling inflatable pools that violated a new enacted safety standard. In response to the Australian government's request, eBay created a message to inform users of this new provision of Australia's law. Using filters, eBay's system automatically targets and notifies relevant individuals "This is a very targeted effort. We are not messaging anybody who is listing an item on eBay's Australia site about swimming pools," Carson explained.

The third example involved a visit from a special agent from the Naval Criminal Investigative Service (NCIS) who talked to the company about goods whose export is controlled by ITAR and Export Administration Regulations (EAR). From eBay's perspective, the company prohibits these items from being exported outside of the United States altogether. NCIS wanted to know how eBay dealt with these items and understand how its filters work, while eBay was interested in improving its filters with keywords that NCIS could provide. "It is a collaborative situation when we work with these regulatory agencies," Carson explained.

eBay's prohibitions related to ITAR and EAR-regulated goods, detailed in one of its 54 policies, starts from a policy position of first trying to educate its user community about the regulations. For ITAR-listed items, eBay's policy states that both buyer and seller have to be located within the United States. The policy provides a Web link to the relevant regulations. eBay's guiding philosophy is that the majority of its users are not trying to abuse the system and that they comply with these policies once they are educated about the prohibitions for specific items.

The eBay Listing Violation Identification System (eLVIS)—the filters that screen every potential eBay listing before it is posted to the Web—is a rules-based engine built using keywords from a variety of sources. Among these sources are member reports—every eBay member can report an item as a potential violation—internal input, regulatory agencies, law enforcement agencies, and industry. eBay works closely with the Food and Drug Administration and Drug Enforcement Agency, for example, in the area of drugs and supplements, both legal and illegal. It also works with the Consumer Products Safety Commission to identify recalled items, with the Fish and Wildlife Service on prohibited items such as ivory carvings, and with the U.S. Agriculture Department on the important export of seeds, plants, and animal products. The company works with a similar set of regulators in the European Union, Australia, and the Asia-Pacific region, though Carson added that these international agencies have not been as interactive with eBay as have U.S. agencies in terms of providing keywords or language for the filters.

In some cases, law enforcement agencies will act as a buyer on the site for undercover investigations. To create export control filters, eBay looks at several listing attributes, including the keywords used to describe the product, the category in which it is listed, the shipping destinations and the location of the eBay site where the item is posted, and the buyer's location. Carson noted that improving the filters to reduce false positives and still catch prohibited items, all while keeping the filters up to date, is a never-ending process. "We are always trying to fine tune the filters and looking at different circumvention techniques," said Carson.

He described an example of the type of blocking message that gets sent to a user. In this case, the user was selling night vision goggles, which are legal to sell but not to export from the United States under ITAR regulations. The message informs the seller that the item cannot be exported, but that it can be listed if the seller restricts shipping options to exclude shipping outside of the United States. It also provides links to the relevant regulations and eBay's policies concerning items that violate those regulations so that the seller can learn from the experience. Similarly, if a buyer tries to purchase an item that requires an export license from another country, the system notifies the buyer of that requirement and again provides links to relevant information.

While eBay is dedicated to being a good corporate citizen, it is also concerned about the eBay brand. "We don't want to be associated with illegal items or brand-damaging items. We don't want the headline to be that users saw a drone on eBay that was exported to Syria or something like that. Even though eBay may not be directly liable for that—it may be the seller who is prosecuted for it—it is brand damaging for us from an eBay perspective and also it impacts whether other people are going to use eBay," said Carson. "It is in our own self-interest, separate from the legal and regulatory interest, to make sure that we have a safe and well-lit marketplace that is actively policed."

DISCUSSION

When asked how long it takes from the time a flag occurs to when a person reviews the flagged listing, Carson replied that the goal is 6 hours, though sometimes it can take as long as 24 hours. Richard Cupitt then asked if eBay refers blocked items to law enforcement agencies. Carson replied that the

listings for any flagged item are delayed automatically from posting for 6 hours. He added that blocked items—those that are immediately spotted by eLVIS, blocked, and never referred to customer service—are never posted so there is nothing to refer to law enforcement. "If there is an item that does get onto our site and then is exported, we will work with the law enforcement agency, either proactively if we find it or reactively if they come to us, to provide them with information for this seller. In that scenario, we have a whole team that works with law enforcement on that," said Carson.

Cupitt also asked if eBay works with the Department of Commerce on items regulated by EAR. Carson explained that with EAR, since it can cover such a wide variety of goods, the company looks at large categories of items and broader-based keywords so that it can send an educational message to both buyers and sellers. "We are not actually blocking the item," said Carson, "because at the end of the day, we don't know whether it is actually export controlled or not or if it is to which countries. The approach we try to take is we cast a broader net for EAR, but from an education standpoint as opposed to blocking and taking down."

Astrid Lewis asked how eBay employees are trained to use eLVIS. Carson explained that it brings representatives of regulatory and law enforcement agencies to its Salt Lake City service center, which is where its North America eLVIS team is located. eBay and the agencies see these training sessions as two-way streets, Carson said, because both parties end up learning through these interactions. The agencies, for example, learn what eBay is seeing in terms of new trends, while eBay learns about any gray areas that need particular attention. He noted, too, that the eLVIS database has upwards of 20,000 different rules, each of which can contain from five to a thousand keywords, and that the company tries to focus on areas where historically it has seen violations. "We are trying not to boil the ocean," he said. "We are always iterating, always going back and looking at how did this item get through."

Kathryn Hughes asked Carson if he knows of other companies that go through similar lengths to screen the items it sells or lists. He replied that the situation is mixed, with some companies taking the same intensive approach that eBay takes and others that are completely reactive—letting anything on the site and then taking it down only when someone outside the company, such as user or law enforcement, points out a problem. "As much as our stockholders wished that everything you could buy and sell is only on eBay, unfortunately, that is not the case. There is a whole big Internet out there with different ways they can bring buyers and sellers together," said Carson. "Even if we solved the problem on eBay in a particular area, that is not going to solve the problem on the Internet by a long shot." He said eBay does share its best practices through various industry groups and it benefits from what other companies are doing in this area, too.

Clara Zahradnik asked Carson if chemical manufacturing equipment ever appears on eBay. He replied that such equipment is listed under the business and industrial category, which can also include items such as medical devices and farm machinery. He also noted in response to a question from Prieto that eBay tracks the type of blocked items that users try to list and how frequently they do so in order to spot trends that could be useful both for internal screening efforts and law enforcement agencies.

In response to a question from Cupitt as to whether eBay screens for names on specifically designated terrorist lists, Carson responded that eBay Marketplace does not, but PayPal and other financial institutions do that. "Ultimately, there is no way to use eBay without a financial instrument, so we rely on PayPal's screening for that," he explained. He added that eBay does look for items from embargoed countries, such as Cuban cigars and Iranian rugs, and for specific items by name and part number that are ITAR-listed. Carson explained that while some ITAR-listed items can be exported with the proper export license, eBay has no practical way of checking whether the sellers have the required licenses. "We made the decision to say if it is ITAR controlled, it can't be shipped outside the United States," said Carson.

Detlef Maennig asked if eBay can be sued for having prohibited items on its site. Carson said that generally speaking, the company has immunity in the United States as a marketplace because it does not control the items. "Ultimately, the legal responsibility falls on the buyer and/or seller in those areas," he explained. From a civil standpoint, eBay has been sued by a number of rights owners over counterfeit goods, but so far, the company has successfully defended itself in those cases. "We do have programs in place to address those concerns, but ultimately it is not eBay's legal responsibility." In Europe, he continued, the standards are somewhat different, and the company has an international legal team to deal with the legal responsibilities.

6

Final Group Discussion

As the workshop's final activity, the attendees gathered for a session of deliberations and discussion focused on a set of questions that the attendees received prior to the workshop. These questions were modified slightly from those in the Statement of Task (see Appendix A) to reflect the expertise of the final workshop program while remaining in accord with the intention of the task. The questions were:

1. How do the changes in the global chemical manufacturing landscape over the last 10 years affect the efficacy of current regulatory structures regarding the monitoring and movement of chemical manufacturing equipment around the globe?
2. Are there readily identifiable security gaps or mismatches that exist under the current system of controls and regulations? How might advances in manufacturing technologies, such as the increased use of microreactors, affect the ability to monitor for diversion or misuse of equipment?
3. What changes or steps might be necessary in the next 10 years to support robust tracking and monitoring of potential dual-use equipment to support U.S. and global non-proliferation goals?

In addressing these questions, the following key points were raised, reiterating those that were noted throughout the day's presentations and discussions:

- The rapid globalization of both the chemical industry and equipment manufacturing capabilities has created a situation where existing regulations and treaties are less capable of tracking and controlling the movement of chemical manufacturing equipment and where more emphasis is needed in education, training, and outreach efforts to create national and, even more importantly, corporate cultures that respect and support the goals of non-proliferation. (Mooney, Prieto, Souza)
- Regulations must balance the need to control the movement of chemical manufacturing equipment with the speed and flexibility that industry requires to operate profitably in an increasingly competitive marketplace. (Desrosiers, Wright, Cupitt) In general, U.S. companies' internal policies are more restrictive than existing treaties require. (Mooney, Zahradnik, Desrosiers, Moakler)

To start the discussion, Charles Mooney said the biggest change over the past 10 to 20 years has been the shift from a regional production emphasis to a truly global one. By this he meant that as production capabilities moved outside of the United States or Europe, those capabilities were developed to meet local and regional needs for specific chemicals and materials. Today, chemical plants are not only flexible in terms of what they produce but they also can be dissembled and moved to meet demand as it shifts region by region. The relevance of this change, he said, is that the regulations as they exist today are U.S.-centric and were developed on the premise that all of the expertise for making and using chemical manufacturing equipment was located here and perhaps Europe. Going forward, a useful approach may be to get the message out to all of the new centers of global expertise that responsible use must be part of the corporate culture and that it takes effort and focus to develop that kind of culture.

Craig Desrosiers proposed that regulators should consider creating an "elite user" policy that would apply to specific companies that have gone through a pre-selection process. This process would assess a given company's policies and its responsible uses of various types of equipment. Companies that met certain criteria would then be granted the ability

to move equipment around the globe to meet its production needs. Another approach would be for a company to provide a list of fabricators that it planned to use for some extended time period and that could be vetted ahead of time. "I understand the need for regulations, but it costs industry millions of dollars a year to fulfill these obligations. There has to be some way that you can get to the end goal that you need to get to, but we can be able to continue to operate," said Desrosiers. Matthew Moakler said that the Commerce Department has a validated end user program, but that to be pre-approved by this program companies have to release details of their business practices to the federal government for review, something that most companies are reluctant to do. "It might be worth looking at this validated end user program and figure out how it can work more effectively."

Richard Cupitt noted that there are provisions for what are called special comprehensive licenses that allow a company to export multiple times to the same end user or export certain commodities multiple times to different end users. He acknowledged that this program has not been used often because of the extensive set of requirements that companies have to meet to be granted this type of license, but he added that it may be worth looking more closely at this program to see if it can be improved and become more generally useful.

Ana Prieto asked if there might be a way of constructing tax breaks or other assistance so that smaller companies build the systems that will help foster a compliance mindset. She also noted that the pharmaceutical industry is developing technology that enables it to track individual bottles of drugs and wondered if that technology could be applicable to manufacturing equipment. Another participant asked if it would be possible to create one central source, perhaps a Web site, where a company could go to as a single source for information on export controls.

With regard to gaps that need to be addressed, Cupitt said that while all of the nations that have agreed to UNSCR 1540 have obligations to account for materials and equipment, many countries have not followed through on those obligations. He added that the United Nations committee that oversees UNSCR 1540 is in the process of collecting examples of how individual countries are working to meet these obligations. The chemical industry could play a role in addressing this gap by helping these countries better understand their obligations, an idea that Prieto, Astrid Lewis, and Maennig also suggested, with Maennig noting that outreach activities should be tried before creating new legal requirements. Lewis noted that the fertilizer industry, after the Oklahoma City federal building bombing, took it upon itself to educate the public and small business while Congress was trying to decide what kind of law to pass. Usha Wright, who moderated the discussion, said that it is important not to overburden industry with regulations that make it uncompetitive with companies based in countries with fewer regulations. She added, though, that industry has a vested interest in helping enforce the regulations that already exist because no company wants its name associated with some global terror event.

Andrew Souza, whose responsibilities at the Department of State include detailing cases of proliferation, noted that over the past 15 years the West has been closed to proliferators. Rather, proliferation has been tied to China, India, and other emerging countries. "We in the United States spend a lot of time and have spent a lot of time reaching out to these emerging chemical producing countries to get them more active and get their practices up to Western standards," said Souza. "It is really only in the last five years that it is starting to dawn on countries like India and China that this is important and they have to devote resources to it. My hope would be in the next 10 years of more arm twisting and cajoling that we will get India and China to where they need to be. That will hopefully lighten the burden on the industry side because maybe we can look at relaxing the licensing requirements for those countries."

Kathryn Hughes asked the industry representatives to comment on how their companies' practices intersect with regulations. Mooney said that Xylem's policies are based on the regulations but that they are often more extensive than regulations require. "Typically, our policies will go past the regulatory requirements," he said, explaining that the reason for doing this is to protect the company's name. Xylem also works with its employees to understand why these policies exist and why the company believes they are important. Zahradnik said that DuPont takes the same approach in at least some cases, believing that there can be more risk than embodied in the regulations and that company policies need to be more restrictive as a result in those cases. Desrosiers added that the vendors that DuPont uses globally go through an extensive qualification process, noting that he and his colleagues spend half of their time traveling to vendors to vet them. Maennig expressed a contrary view, stating that his company follows the regulations and goes no further, and he believes that the chemical industry is largely moving in that direction. "I am cautioning that you shouldn't have too much hope that industry is going beyond what is really required," he stated.

Prieto, who has had experience working with both large and mid-sized companies, said that large companies have the capabilities to engage in these types of self-regulating activities and outreach efforts. However, mid-sized and smaller companies often lack the necessary centralization, and in some cases, they do not even have the proper understanding of the regulations to enforce them with company policies.

Cupitt said that countries often react better when companies say that certain actions are taken for company policy rather than because it is U.S. policy. Along the same lines, Lewis said many countries say they agree to be part of international agreements because they hope to be eligible to compete for business in return. If companies are reinforcing

this idea through their own policies and stressing the fact that they will only do business with those that pass a vetting process that includes meeting treaty obligations, then that can act as a powerful incentive to these emerging economies to participate in these agreements.

Turning the discussion to the third question, Hughes asked the non-proliferation experts what capabilities they need going forward to keep track of what has become a highly complex, global chemical industry. "What are the networks, communities, and discussions that are going to allow you to be responsive, regardless of the regulations?" she asked. Moakler said that there are many processes within government that need to be improved to make the review process more efficient. He also said that much of what the Department of State has done so far is to engage international organizations such as the Australia Group and that these organizations are planning extensive outreach efforts that include compiling best practices that can be shared. He was curious as to whether there might be customer service type applications that industry uses today with its customers that might be duplicated elsewhere. For example, many consumer products today come with the opportunity to register the product online complete with serial number, establishing a communication channel between the buyer and seller. "A system like this might contribute to accounting later on," he suggested.

Zahradnik asked if it would be possible to have EAR translated into Chinese and Hindi to make it easier for companies from those countries to follow U.S. regulations. Cupitt said that this would be expensive and that it would be unlikely that any translations would be considered official for legal purposes.

Addressing Hughes's question, Cupitt said that it would be helpful to make it someone's job to do outreach to industry on a regular basis. That occurs in some countries, he said, but it is usually done on an ad hoc basis. He also noted that U.S. agencies are making use of social media to do outreach and he wondered if it would be possible to do so using more formal mechanisms. "If you have formal mechanisms, it is usually part of somebody's job and that somebody is then evaluated based on how well they do that job. Without that, it's luck of the draw," Cupitt said. He recommended, too, that licensing officers should be provided with regular training opportunities to learn about the latest technologies.

Lewis said that the U.S. government has several projects ongoing that may help track technologies. One project, known as FUSE, looks at all of the patents that have been filed using a number of databases and journals to identify new, emerging technologies and new code words being used with certain industries. Another program, called FORM-ST, goes out to the wider science and technology community to forecast potential breakthroughs in science and technology fields. Zahradnik added that the Department of Commerce does have technology advisory committees for each of the categories in EAR and that the agency is looking to broaden industry participation in these committees. Desrosiers asked if it would be possible to conduct a deeper analysis of the license applications that are not approved to serve as an educational component, and Moakler noted that his office is doing just that. In a final comment, Wright said that one resounding theme that came through in this discussion is that there is a role for partnerships within industry and between industry and government.

Appendix A

Statement of Task

An ad hoc committee will plan and conduct a public workshop to examine key concerns regarding availability and movement of equipment for chemical manufacture that is of potential dual-use concern. The workshop will examine topics such as:

- How well do current systems to track production, sale, transfer, and destruction of equipment of dual-use concern operate? What shortcomings exist nationally and globally?
- How are advances in manufacturing technologies, such as increased use of microreactors or fermentation techniques for chemical production, impacting the ability to monitor for diversion or misuse of equipment?
- What changes might be necessary in the next 10 years to assure sufficiently robust tracking and monitoring of potential dual-use equipment to support U.S. and global non-proliferation goals?

The committee will develop the agenda for the workshop, select and invite speakers and discussants and moderate the discussions. The 2-day event will include plenary talks, discussion, and break-out sessions as appropriate. Invitees will include technical experts in chemistry and chemical engineering, experts in the global chemical industry, and experts in policy and non-proliferation. Participants will include members of the scientific community from industry, academia, and non-profit organizations. Governmental technical personnel and experts in non-proliferation will also be invited to participate. International attendees, particularly those from developing countries of interest (Pakistan, Indonesia, or others) will help provide a global perspective.

Appendix B

Workshop Agenda

Workshop on the Global Movement and Tracking of Chemical Manufacturing Equipment
May 12-13, 2014
National Academy of Sciences Building
2101 Constitution Avenue, NW
Washington, DC
Room 120

DAY 1

8:00–8:30	*Room opens*
8:30–8:45	Welcome and Panel Introduction

Session 1: The Global Landscape

8:45–9:20	Detlef Maennig, CEFIC–The European Chemical Industry Council
9:20–10:00	Discussion
10:00–10:15	*Break*

Session 2: The Lifetime of Manufacturing Equipment

10:15–10:20	Panel Introductions
10:20–10:45	Charles Mooney, Xylem, Inc.
10:45–11:10	Ye Shao, Morimatsu Group
11:10–11:35	Ana Prieto, Independent Consultant
11:35–12:00	J. Craig Desrosiers, E.I. du Pont Canada Company
12:00–12:30	Discussion
12:30–1:30	*Lunch*

Session 3: The Security Dimension

1:30–1:35	Panel Introduction
1:35–2:00	Jonathan Forman, Organisation for the Prohibition of Chemical Weapons (OPCW)
2:00–2:25	Matthew J. Moakler, U.S. Department of State
2:25–2:50	Richard T. Cupitt, U.S. Department of State
2:50–3:15	Elizabeth Scott Sangine, Bureau of Industry and Security, U.S. Department of Commerce
3:15–3:45	Discussion
3:45–4:00	Closing Remarks from Day 1 and Adjournment

DAY 2

8:00–8:30	*Room opens*

Session 4: The Internet as a Secondary Market

8:30–8:35	Speaker Introduction
8:35–9:00	Michael Carson, eBay, Inc.
9:00–9:30	Discussion

Session 5: Breakout Groups and Discussion

9:30–10:45	Breakout Groups
10:45–11:15	Report Back and Discussion
11:15–11:30	Closing Thoughts and Adjournment

Appendix C

Biographical Sketches of Workshop Speakers and Organizing Committee Members

Speakers (in order of appearance)

Session 1: The Global Landscape

Detlef Maennig, CEFIC- The European Chemical Industry Council
Dr. Maennig studied chemistry at the University of Bonn, obtained his M.Sc. from Yale University and his Ph.D. from the University of Munich. He has been an industrial chemist for Evonik Industries for almost 30 years in various functions in Germany, the U.S. and in the Peoples Republic of China. For over 25 years, he has been involved in Chemical Weapons Convention (CWC)-related issues from negotiations in Geneva to practical implementation in Member States. He has written numerous articles and is a frequent speaker on this topic. Most recently, he was awarded the German Federal Cross of Merit for his contributions to the CWC.

Session 2: The Lifetime of Manufacturing Equipment

Charles Mooney, Xylem, Inc.
Mr. Mooney is a Trade Compliance and Business professional that has designed and implemented effective trade compliance programs in challenging business situations and industries. He is Director of Global Trade Compliance at Xylem, Inc. His experience includes Research, Operations and Marketing. He has combined this and applied it in the development and implementation of global trade compliance programs in diverse industries including materials for electronic assemblies and equipment for the transport and measurement of water. His expertise includes Customs, multinational trade agreements, their application to various global export regulations and the ITAR. He is a U.S. Licensed Customs Broker and has a Bachelor's Degree in Biology from Boston College, a Master's Degree in Chemical Engineering from the University of Massachusetts, Lowell, and an Executive MBA from Suffolk University.

Ye Shao, Morimatsu Group
Mr. Shao has worked with the Morimatsu Group since 2005, and has held several managerial positions within the company. Currently, Mr. Shao is Manager of International Relations, operating in both Texas and Shanghai. From 2009-2011, he served as Manager of International Business Development, and from 2005-2009, he was the Manager of Overseas Project Coordination. Mr. Shao holds a Bachelor of Arts degree and a Master's degree in International Political Economy. He specializes in strategic planning, international business planning, industrial analysis, and Chinese manufacturing consultation.

Ana Prieto, Environmental Health & Safety Professional
Ms. Prieto is an accomplished, results-driven executive, with close to 30 years of experience in leading global environment, health, and safety (EHS) functions, primarily in the pharmaceuticals industry. She has provided strategic and technical leadership in a variety of roles, most recently as Vice President, EHS, in the Americas region for Teva Pharmaceuticals. Ms. Prieto is a CIH and is admitted to the bar in both New York and New Jersey. She is member of numerous professional associations and has served as Chair and Vice-chair of the ABIH. Ms. Prieto holds a B.S. in Environmental Sciences from Cook College, Rutgers University in New Brunswick, NJ, earned an MSPH in Environmental Sciences and Engineering from the University of North Carolina at Chapel Hill, NC, and completed her J.D. at Pace University School of Law, with a focus on environmental law.

J. Craig Desrosiers, E.I. du Pont Canada Company
Mr. Desrosiers is a Senior Buyer at E.I. du Pont Canada Company. He has strategic sourcing responsibilities that include the strategic development and supply chain optimization for the process equipment needs for E.I. du Pont global operations. This includes the development of global sourcing strategies, supplier qualifications, and contract negotiations. His expertise includes global supply chain development, contract administration and engineering design. This expertise has allowed him to modify existing design paradigms, and supply chains, in collaboration with engineering colleagues, to meet current business needs in accordance with core values and business goals. He brings with him over 24 years of experience in mechanical engineering design, process piping design, strategic sourcing, and construction.

Session 3: The Security Dimension

Jonathan Forman, Organisation for the Prohibition of Chemical Weapons
Dr. Forman currently holds the post of science policy adviser at the Organisation for the Prohibition of Chemical Weapons (OPCW). Dr. Forman received a Ph.D. in chemistry from the California Institute of Technology in 1996, after which he worked for a series of biotechnology companies developing molecular diagnostic and bioanalytical assay technologies for genomic, immunoassay, and cell capture applications. He has been at OPCW (and away from Silicon Valley) since March of 2013.

Matthew J. Moakler, U.S. Department of State
Mr. Moakler is a Foreign Affairs Officer in the Office of Missile, Biological, and Chemical Nonproliferation, Bureau of International Security and Nonproliferation. He is the Chair of the SHIELD Licensing Group, an interagency group that reviews export license applications for chemical and biological proliferation concerns. Mr. Moakler has over 12 years of experience in the field of countering weapons of mass destruction; serving in various positions including as a hazardous materials response team leader, a strategic level planner, and the team leader for an emergency management building partnership capacity program. He earned his MS in Biodefense from George Mason University, BS in Biology from Siena College, and is currently pursuing a MS in Countering WMD Studies through the National Defense University and Missouri State University.

Richard T. Cupitt, U.S. Department of State
Dr. Cupitt serves as the U.S. UNSCR 1540 Coordinator in the Office of Counterproliferation Initiatives at the U.S. State Department, fostering the implementation of UNSCR 1540 nationally and globally. From 2005 to 2012, he worked as an Expert for the Committee established pursuant to UN Security Council resolution 1540 (2004). As such he helped monitor and facilitate implementation of resolution 1540 in all UN Member States, along with building relationships with more than forty international organizations, industry, and academia. Securing chemical weapons related materials in production, use, storage, and transport comprise an important element of the more than two hundred legally binding obligations of UNSCR 1540.

Dr. Cupitt held a position as Scholar-in-Residence at American University from 2004-2008, after serving as Special Adviser for International Cooperation for the U.S. Undersecretary of Commerce in the Bureau of Industry and Security from 2002-2004. From 1988-2002, Dr. Cupitt had various posts for the Center International Trade and Security (CITS) of the University of Georgia, including Associate Director, and also as a visiting scholar at the Center for Strategic and International Studies (CSIS). Dr. Cupitt also has held academic positions at Emory University and the University of North Texas. He has produced four books and more than 20 peer-reviewed articles on export controls, along with dozens of other non-proliferation, security or trade-oriented publications. In addition, he has served as a consultant on projects for the U.S. State Department, several U.S. national commissions and U.S. national nuclear laboratories, and several international organizations.

Elizabeth Scott Sangine, Bureau of Industry and Security, U.S. Department of Commerce
Ms. Sangine is the Director of the Chemical and Biological Controls Division, Bureau of Industry and Security, U.S. Department of Commerce. In her role as Director of the Chemical and Biological Controls Division, Ms. Sangine manages export licensing for dual-use items controlled for chemical and biological non-proliferation. She participates in the multilateral regime negotiations for the Australia Group, and formulates policy as it relates to biological security, dual-use research of concern, and chemical issues. She works extensively with the interagency and industry on the list of controlled items and the licensing of these items. Ms. Sangine started her career in the private sector in the Chemical Industry and the Telecommunications Industry where she was a product development specialist, quality specialist, and project manager. She has been with the Department of Commerce, Bureau of Industry and Security since 2003. Ms. Sangine has a Bachelor of Science Degree in Chemical Engineering (BSChE) from Virginia Tech, a Masters of Business Administration (MBA) Degree from the University of Houston, a Master's of Science in Natural Resource Strategy (MS) from the National Defense University, and a certified graduate of the Commerce Senior Executive Service Candidate Development Program.

Session 4: The Internet as a Secondary Market

Michael Carson, eBay, Inc.
Mr. Carson is the Senior Manager for Global Regulatory and Policy Management at eBay. In this role, Mr. Carson is responsible for developing and implementing policies to effectively manage eBay's regulatory, industry, and brand risks. Mr. Carson also spent 5 years at PayPal heading their North America Brand Risk Management Group. Prior to joining eBay and PayPal in 2005, Mr. Carson worked in the government relations field for an issues management group focusing on technology and privacy matters. In addition, he also spent 3 years in the public sector serving as Staff Director for the Senate Minority Leader's Office in the Massachusetts State House. Mr. Carson is a Boston College graduate with a B.A. in Political Science.

Organizing Committee Members

Nancy B. Jackson, U.S. Department of State
Dr. Jackson is a Franklin Fellow at the U.S. Department of State working in both the Science Advisor to the Secretary of State's office and in the International Security and Nonproliferation Bureau. Previously, she was manager of the International Chemical Threat Reduction Department in the Global Security Center at Sandia National Laboratories which assists the U.S. Department of State in solving problems related to international chemical security and chemical weapons non-proliferation. With the DOS Chemical Security Engagement Program (CSP), Dr. Jackson has worked with universities, small/medium chemical companies, and government regulators in Southeast Asia, South Asia, the Middle East, and North Africa. Before working in chemical security, Dr. Jackson was deputy director of Sandia's International Security Program where she assisted the director in fulfilling its mission to create technology-based solutions through international cooperation to reduce the threat of all weapons of mass destruction proliferation and terrorism. Prior to her positions in Global Security, Dr. Jackson was involved in alternative energy research and development at Sandia, as a principal investigator and a manager.

Dr. Jackson received the 2013 Award for Science and Diplomacy from the American Association for the Advancement of Science where she is also a Fellow. She was recipient of the 2005 American Indian Science and Engineering Society Professional of the Year Award. Dr. Jackson has a B.S. degree in chemistry from George Washington University from which she won a Distinguished Alumni Achievement Award in 2005 and has a Ph.D. in chemical engineering from the University of Texas at Austin. In 2009, she was elected to the Presidential succession of the American Chemical Society. She served as President-Elect for 2010, President for 2011, and Immediate Past President for 2012, and is a fellow of the American Chemical Society.

Robert E. Roberts, Institute for Defense Analyses
Dr. Roberts is the Senior Scientist at the Institute for Defense Analyses and former Director of the Science and Technology Policy Institute. He is also the former Vice President for Research and Director of IDA's Science and Technology Division. Before joining IDA, he spent several years with the Department of Energy, and prior to that, he was associate professor of chemistry at Indiana University. Dr. Roberts is founder, former director, and mentor for the IDA Defense Science Study Group, a program established to foster interest in national security issues among outstanding young professors of science and engineering. Dr. Roberts received his bachelor's degree in chemistry from the Carnegie Institute of Technology (now Carnegie Mellon), his Ph.D. in physical chemistry from the University of Wisconsin, and was a National Science Foundation postdoctoral research fellow at Massachusetts Institute of Technology.

Usha Wright, O'Brien & Gere
Ms. Wright is senior vice president and co-general counsel for O'Brien & Gere, an environmental engineering and consulting firm with offices throughout USA. She has extensive international industry experience in chemical safety. In 2008 she retired as senior vice president for global workforce strategy at ITT Corporation, a position she had held since 2005. From 1993 to 2005 Ms. Wright was vice president and associate general counsel for ITT, with global responsibility for environment, safety, and health (ES&H). Before joining ITT, she was executive director of environmental health and safety at Ciba Geigy Pharmaceuticals from 1977 to 1993. Ms. Wright has a B.S. in chemistry from Rutgers University, an M.S. from the University of North Carolina, and a J.D. from Rutgers University. She was an adjunct faculty of Rutgers Law School from 1999 to 2006. As a Certified Industrial Hygienist and a Certified Safety Professional, she has served on the boards of the American Industrial Hygiene Association and the Board of Certified Safety professionals. She also served on the board of the Environmental Law Institute for last 8 years, where she was involved in conducting training in ES&H compliance in various academic institutions in India. Currently, she is also president and chairperson of the board of SHARE (shareafrica.org), a nongovernmental organization working in western Kenya.

Clara J. Zahradnik, DuPont
Dr. Zahradnik joined DuPont 34 years ago after completing a Ph.D. at MIT in physical chemistry. She is currently the Export Control Leader for the DuPont Chemicals & Fluoroproducts (DC&F) division and has held that position since 2006. Her experience is in commodity and technology (chemical process and chemical equipment) export licensing. She has also developed strong expertise in the design and construction of chemical equipment utilized in sulfur acid recovery at oil refineries, titanates, fluorochemical

refrigerants, cyanides, dimethylamine, and other products. Dr. Zahradnik has an extensive background in R&D in the laboratory and industrial plant settings coupled with business management expertise. She has held positions in R&D research, R&D management, and in business leadership as Product Manager and Business Manager in established businesses and in commercialization of new products. Dr. Zahradnik also currently represents DuPont on the Materials Technical Advisory Committee at Commerce.

Appendix D

Workshop Attendees

Organizing Committee Members Present

Nancy B. Jackson, U.S. Department of State
Usha Wright, O'Brien & Gere
Clara J. Zahradnik, DuPont

Speakers

Michael Carson, eBay, Inc.
Richard Cupitt, U.S. Department of State
J. Craig Desrosiers, E.I. du Pont Canada Company
Jonathan Forman, Organisation for the Prohibition of Chemical Weapons (OPCW)
Detlef Maennig, CEFIC—The European Chemical Industry Council
Matthew J. Moakler, U.S. Department of State
Charles Mooney, Xylem, Inc.
Ana Prieto, Environmental Health & Safety Professional
Elizabeth Scott Sangine, Bureau of Industry and Security, U.S. Department of Commerce
Ye Shao, Morimatsu Group

Participants

David Abreu, The George Washington University
Dmitry Kaledin, Embassy of the Russian Federation, Washington DC
Yeva Krechetova, George Mason University
Astrid Lewis, U.S. Department of State
Nana Noi, British Embassy Washington
Lynsey Pinfield, British Embassy Washington
Greg Rohling, Kelley Drye & Warren LLP
Andrew Souza, U.S. Department of State

NRC Staff

Kathryn Hughes, Senior Program Officer, BCST
Elizabeth Finkelman, Program Coordinator, BCST
Teresa Fryberger, Director, BCST

Science Writer

Joseph Alper, Life Science and Nanotechnology Consulting, LLC

Appendix E

The Board on Chemical Sciences and Technology

The National Academies' BCST exists as the oversight group that ensures the highest quality scientific and technical advice is being provided to our Nation's decision makers from experts in chemistry and chemical engineering. BCST is a forum through which the chemistry and chemical engineering communities can give back to society, demonstrate the broader impact of their expertise, and help address critical societal problems. Its mission statement calls for BCST to assure that our Nation's decision makers receive the highest quality scientific and technical advice from experts in chemistry and chemical engineering.

BCST committees are currently active in four areas:

- *Chemical and Energy Industries*. This area is focused on issues that directly affect the chemical and energy industries, such as process safety, sustainable chemistry, and globalization of the chemical enterprise. Recent activities in this area include a study examining the design and evaluation of safer chemical substitutes and an upcoming study on the effects of diluted bitumen on the environment.
- *National and Homeland Security*. This area addresses safe and secure use of chemicals and responds to needs relating to homeland and national security. BCST committees have provided both the Department of Defense and the Department of Homeland Security with advice related to chemical and biological defense, sensor technology, and explosives detection. Recent work includes an examination of core capabilities for research and development in chemical and biological defense on behalf of the Department of Defense, as well as the workshop summarized here.
- *Education and Workforce*. This area of focus seeks to assure that the training and education of chemists and chemical engineers continues to prepare them for successful careers in the global chemical enterprise. It also addresses questions relating to current and emerging workforce needs and dynamics. Recent work includes a study on communicating chemistry in informal environments and another study examining the culture of safety in academic laboratories.
- *Basic Research*. This area focuses on questions related to technical developments in chemistry and chemical engineering, factors that support a strong chemical research infrastructure to support societal needs, and research-related road-mapping and program reviews. Recent work in this area includes a study on current and future research opportunities in the glycosciences and a current study on the industrialization of biology.