Report

The Pavlodar Chemical Weapons Plant in Kazakhstan: History and Legacy

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The former Soviet Union's chemical weapons (CW) program consisted of many production plants that created the world's largest stockpile of chemical weapons.[1] Most of the CW production and storage facilities were located in Russia, but a few facilities existed in other Soviet republics. In recent years, Western countries have provided significant financial assistance for dismantling former CW facilities in Russia and converting former CW production facilities for commercial use.[2] Although a fair amount has been written about Russian CW facilities, little is known about the CW programs in other former Soviet republics.

One such facility designed for the production of CW was built in the city of Pavlodar in northern Kazakhstan.[3] The Pavlodar Chemical Plant was a dual-purpose complex in which civilian chemical production served as a cover for military activities. This plant appears to have been the most recently constructed of the Soviet CW production centers and may have been designed for the production of new-generation binary nerve agents, which were developed by the Soviet Union in the 1980s.[4]

Although the Pavlodar plant manufactured precursor chemicals for CW agents, it never actually produced chemical weapons. The plant was not yet complete when Moscow halted construction in 1987 because of the Soviet Union's increasing involvement in the negotiation of the Chemical Weapons Convention (CWC). Nevertheless, manufacturing lines and equipment for primary and intermediate CW precursors and buildings for filling CW munitions were constructed at Pavlodar. The plant also acquired personnel with expertise in CW production.[5]

This report is devoted to the role of the Pavlodar Chemical Plant in the former Soviet CW program and its current status. The first part of the report describes the history of the Pavlodar plant and its military and civilian infrastructures. The second part deals with the CW capability of the plant and the nature of the chemical agents that were produced there. The third part focuses on conversion problems facing the Pavlodar plant in the new market environment following the breakup of the Soviet Union.

A DUAL-PURPOSE CHEMICAL COMPLEX

Construction of the Pavlodar Chemical Plant began in 1965 on the banks of the Irtysh River in northern Kazakhstan.[6] As was typical of Soviet CW production facilities, the plant was designed to be a dual-purpose production complex, capable of manufacturing both civilian chemicals and military CW agents. The civilian part of the plant served as a cover for the military-related production and supplied the latter part with energy and basic chemicals.[7] The first nitrogen and oxygen production plant at the Pavlodar plant, called the "heart of the plant" due to the importance of nitrogen screening in dealing with flammable chemicals, began operating in 1973. The construction of new buildings and the introduction of new production lines, particularly the military ones, continued until 1992. In 1991, the Pavlodar plant was a huge complex occupying a territory of 2,500 hectares and employing some 6,500 people, including 500 engineers. In addition to chemical production, the plant had a farm and an extensive social infrastructure that served its employees.[8]

The Pavlodar plant was under the authority of the Soyuzorgsintez Directorate of the Soviet Ministry of Chemical Industry, which supervised the production of all military-related chemicals in the Soviet Union. The plant consisted of Site Number One, designated for civilian production, and Site Number Two, designated for the production and weaponization of CW agents. Site Number Two had a strict security system and was headed by a chief engineer who reported directly to the central Moscow authorities. The authorities at Pavlodar usually did not have military ranks, although military representatives would arrive during the launch of CW production lines.

Sapyrbek Sultanovich Berketov served as the director of the entire Pavlodar plant were from 1977 to 1986, and Boris Aleksandrovich Sharov did so from 1986 to 1997.[9] However, in accordance with the separate management security system, these officials may not have had clearance to know in detail about the CW activities at Site Number Two. The first secretary of the regional committee of the Communist Party, the highest authority in the region, had no control over the Pavlodar plant. However, specialists from Site Number Two had clearances to visit other CW production facilities in Novocheboksarsk and Volgograd and learn from these plants' expertise.[10]

MILITARY PRODUCTION AT PAVLODAR

Site Number Two consisted of about five plants designated for the production of CW agents, including basic chemicals manufacturing, laboratory testing, and filling of agents into military munitions. The site occupied a territory of 550 hectares, with most of the production buildings located in two parallel rows (see Figures 1-4).[11] The site was designed to manufacture nerve agents, but construction of military lines had not been completed when Soviet authorities halted the CW program in 1987.[12] At the order of Soviet leader Mikhail Gorbachev, the Pavlodar plant stopped building new CW production lines and began the dismantlement and conversion of the existing infrastructure for the production of civilian chemicals.[13] Were it not for Gorbachev's order, construction of the CW plant would have been completed three years later.[14]

The production process at Site Number Two started with a plant for manufacturing phosphorus trichloride ($PC1_3$), the basic starting material for the synthesis of nerve agents (see Table 1 listing Site Number Two facilities).[15] Yellow phosphorus extracted from deposits in southern Kazakhstan, together with chlorine produced at Site Number One, were used as initial components for the synthesis of phosphorus trichloride. The chlorine was obtained using mercury electrolysis from sodium chloride taken from a deposit near Pavlodar.

A plant designated for manufacturing intermediate CW chemicals was situated next to the $PC1_3$ production building. This building was equipped with corrosion-resistant chemical reactors lined with silver or made of high-nickel steel (Hastalloy). Such equipment is needed for the synthesis of nerve agent components, which require the use of highly corrosive chemicals such as hydrochloric acid and hydrogen fluoride.[16] The nickel alloy, designated XH65MB, used in the Site Number Two reactors contained 65 percent nickel, 18 percent molybdenum, 11 percent wolfram, and chromium. Due to the high cost of Hastalloy equipment, it is usually not widely available at civilian plants.[17]

The next buildings in line were the main plant for manufacturing the final CW agents and laboratory buildings for testing them on laboratory animals. Construction of these facilities was never competed. The last building in line, which was destroyed in 1987, was designed for operations with supertoxic CW agent products.[18] Located across from and parallel to the main production building was a building for filling chemical munitions; it had four-meter thick walls reinforced with 16 internal columns to contain accidents with high explosives.[19] The plan was to build special tunnels connecting this building with the final CW agent production building nearby.

Other buildings at the site included warehouses for storage of chlorine, support facilities, and an incinerator for the elimination of chemical wastes.[20] Several railroad lines and vehicle roads crossed the site, including one railroad line departing directly from the munitions

Table 1: Production Facilities at Site Number Two

Buildings and their CW production purposes	Buildings' status after the 1987 conversion until 1992	Status as of June 1999
Phosphorus trichloride ($PC1_3$) production building	Civilian-use PCl_3 production	Civilian-use PCl_3 production
Intermediate CW precursor production building	Production of civilian-use Folitol, Gidrel, and Acrylates in silver-lined reactors	Production of civilian IOMS mineral-salt inhibitors in Hastalloy reactors
Final CW agent production building	Not completed	Not in use
Laboratory buildings	Not completed	Sold to a Kazakhstani leather processing company
Munitions filling building	No military equipment installed; used for civilian chemical production, including PVC pipes	Sold to Kazenergokabel, a wire production company
Building for operations with final CW products	Completely destroyed in 1987	
Support infrastructure building	Motor oil production	Sold to Lyubol, a Kazakhstani-Swiss joint venture
Incinerator for the elimination of chemical wastes	In use	In use

filling building. Facilities for supplying heat, electricity, and water, and other support infrastructure serving Site Number Two, were located at Site Number One.[21]

In 1987, at Gorbachev's orders, the building for operations with final CW products was razed to the ground. Also, one smoke stack connected to the underground ventilation system next to this building was destroyed. Other facilities and equipment at Site Number Two were converted for the production of civilian chemicals. From 1988 to 1992, the equipment formerly designated for producing intermediate CW precursors was converted to the manufacture of organophosphorus compounds (including phosphorus trichloride) for commercial purposes.[22]

Third-Generation Nerve Agents

The Pavlodar plant was the most modern Soviet CW production facility, where advanced Soviet CW technologies were to have been introduced. It began operations about 15 years after the nerve agent production plant in Novocheboksarsk, Russia.[23] Pavlodar was intended to substitute for some production lines at Novocheboksarsk and at the older nerve agent production plant in Volgograd, which had been constructed after World War II. For example, production of phosphorous trichloride was to be transferred from Volgograd to Pavlodar.[24]

Pavlodar officials believe that the plant was intended to manufacture "six types of the latest, 1980s-generation, binary chemical weapons."[25] Although no details are available, these agents may have been the so-called *novichok* ("newcomer") CW that, according to Western news sources, were developed by the Soviet Union in the 1980s. A novel family of binary nerve agents, *novichok* compounds were derived from new unitary agents called Substance 33, A-230, and A-232, which had been created earlier. The *novichok* agents were re-

Figure 1: *Pavlodar Chemical Plant, Site Number Two, phosphorous trichloride production building*

Figure 2: *Pavlodar Chemical Plant, Site Number Two, intermediate precursor production building*

Figure 3: *Pavlodar Chemical Plant, Site Number Two,intermediate precursor production building (left), final production building (right), and railroad from the munitions filling building*

Figure 4: *Pavlodar Chemical Plant, Site Number Two, laboratory buildings*

portedly five to eight times more potent than the most toxic V-type agents. Various *novichok* agents were at different stages of production and development. Some were reportedly produced in pilot-scale quantities at Novocheboksarsk and Volgograd and field-tested from 1989 to 1993 at Shikhany in Russia and at the Ust-Yurt Plateau, near Nukus in Uzbekistan.[26]

THE CW PRECURSOR CHEMICAL PRODUCTION LINE

The intermediate CW precursor lines at Pavlodar utilized sophisticated alkylation reactions, the central step in the synthesis of nerve agents. Corrosion-resistant equipment, such as silver-lined reactors that are not widely found in commercial plants because of their high cost, was required because of the evolution of hydrochloric acid and hydrogen fluoride during the synthesis.[27] Phosphorous trichloride was the basic material employed in this process. Because the $PC1_3$ plant at Site Number Two did not become operational until 1989, PCl_3 was initially delivered to Pavlodar from Russian enterprises.[28]

Civilian Items Manufactured in These Production Lines

From 1988 to 1992, the Pavlodar plant used these same reactors to manufacture civilian compounds called Folitol-163, Gidrel, and Acrylates.[29] Folitol-163, or 1,1,3 -trihydroperfluoropropyl perfluorononylen ether, had the following molecular structure:[30] $CF_2{=}CF{-}(CF_2)_7{-}O{-}CH_2{-}CF_2{-}CHF_2$. It was used as a fluid to protect the submerged engines of electric pumping equipment when those engines come in contact with oils and ground water at high temperatures.

Gidrel was a 40-percent water solution of hydrazinium bis 2-chloroethyl phosphonic acid with the following molecular structure.

$$[CH_2Cl{-}CH_2{-}\overset{\overset{\displaystyle O}{||}}{\underset{\underset{\displaystyle OH}{|}}{P}}{-}O^-]_2\ \ NH_3^+{-}NH_3^+$$

It was used for plant growth regulation, in particular as a stimulant for ripening fruits and vegetable species; as an agent for inhibiting potato sprouting during storage and increasing the yield of cucumbers; and as a cotton defoliant.

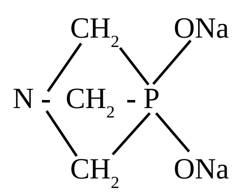
A representative of a series of Acrylates compounds, 1,1-dihydroperfluoroheptyl acrylate had the following molecular structure.

$$H_2C{=}CH{-}\overset{\overset{\displaystyle O}{||}}{C}{-}O{-}CH_2{-}(CF_2)_5{-}CF_3$$

Pavlodar's Acrylates were used in the production of fluoride-containing rubber and for coating textiles and leather to provide them with acid-, oil-, and water-resistant properties.

Based on its molecular formula, Gidrel could be classified as a Schedule 2 chemical under the CWC. It has a phosphorus atom to which one ethyl group is bonded (with one H-atom replaced by a Cl-atom), and thus by definition could fall under the CWC list of Schedule 2 chemicals.[31] However, production of these compounds stopped in 1992, when on the order of the Moscow authorities, the Pavlodar plant removed the silver linings from the reactors and shipped them to Russia.[32]

From 1987 to the present, the Pavlodar plant has manufactured another civilian organophosphorus chemical called IOMS, a mineral-salt inhibitor, using Hastalloy reactors that have remained at the former intermediate precursor production building at Site Number Two. IOMS is nitrilo trimethylene phosphonic acid, a disodium salt with the following molecular structure.



Because IOMS has more than one carbon atom bonded to the central phosphorus atom, it is not covered under the CWC list of Schedule 2 chemicals.[33] This chemical is widely used at energy and metallurgical enterprises in Russia and the other former Soviet Union (FSU) states to inhibit the formation of mineral salts in water-delivery and heat-exchange pipes. The synthetic process uses phosphorous trichloride as a basic material, involves alkylation reactions, and requires corrosion-resistant equipment because of the release of hydrochloric acid.[34]

CIVILIAN PRODUCTION AT PAVLODAR

Site Number One at the Pavlodar plant consisted of 30 plants and produced a variety of civilian chemicals, such as caustic soda, chlorine, sodium hypochlorite, ammonium chloride, lubricating oil additives, flotation agents, antifreezes, phenol-formaldehyde resins, and plasticizers for PVC resins. These products were sold to industrial enterprises all over the Soviet Union, including Kazakhstan, Russia, Belarus, Uzbekistan, and Kyrgyzstan. In addition to the civilian chemical plants, a closed plant at Site Number One produced high-purity aluminum trichloride from 1977 to 1990. This compound was used to manufacture propellant for SS-20 missiles[35] and to make tiles for the Soviet space shuttle Buran. The aluminum trichloride plant was equipped with Hastalloy reactors. The Hastalloy alloy, designated XH78T, used in these reactors contained 78 percent nickel, one percent iron, one percent titanium, and chromium.[36]

CONVERSION EFFORTS AT PAVLODAR

After the breakup of the USSR, the newly independent Republic of Kazakhstan inherited the Pavlodar Chemical Plant. In 1994, the plant became a joint-stock company, with 90 percent of the shares owned by the state and 10 percent of the shares owned by plant employees. The plant is under the authority of the Kazakhstani Ministry of Energy, Industry, and Trade, which is managing the state's shares of the plant.[37]

Most of the former authorities and specialists remained at the plant after its transfer to Kazakhstan. Director Sharov continued heading the entire plant until 1997.[38] In April 1998, Aleksandr Siryk, who has worked at Pavlodar since 1976, was named director. From 1991 to 1994, he headed the $PC1_3$ production plant at Site Number Two. The plant's chief engineer is Lev Shchetinin, who has worked at the plant since 1973 and headed Site Number Two from 1991 to 1994.[39] About 10 people on the current staff had clearances to access classified military chemical production information at Site Number Two. Currently, the plant employs 1,500 people, about 10 percent of whom are engineers.[40]

Under the Kazakhstani authorities, the Pavlodar plant continued developing civilian production at the former military facilities, although some of the chemicals could fall under international dual-use control lists. The plant continued manufacturing $PC1_3$ for civilian use at Site Number Two.[41] From 1992 to 1994, $PC1_3$ was sold to Hungary and Germany. The plant also continued to manufacture PVC pipes, hydrochloric acid, and chlorine-paraffins at Site Number Two and has started to produce motor oils there. Civilian production at Site Number Two, in part due to its newer equipment, has increased to 40 percent of the entire plant output after its transfer to civilian uses. In 1993, 1,300 metric tons of the IOMS mineral-salt inhibitors were sold to firms in Kazakhstan, Russia, and other NIS countries.[42]

The production of high-purity aluminum trichloride for military use at Site Number One was halted in 1990 due to the end of production of SS-20 missiles and the suspension of the Buran space shuttle program. In 1994, the Kazakhstani government allocated some funds for the conversion of this plant to manufacturing plasticizer components. From 1993 to 1994, several buildings at Site Number Two were sold to private companies. The motor oil production plant, together with 30 employees, was sold to the Kazakhstani-Swiss joint venture Lyubol; the munitions filling building was sold to the Kazakhstani wire manufacturing company Kazenergokabel; and laboratory buildings were sold to a local leather processing company. These buildings either were not completed or did not contain military equipment (see Table 1).[43]

Economic Difficulties

The revenues of the Pavlodar plant have declined drastically since 1991, when government resources for conversion were cut back and the plant began a difficult process of adjustment to a new market environment. Since 1996, the Pavlodar plant has twice been close to bankruptcy. In 1992, conversion funding from Moscow ceased, after which the Kazakhstani government provided little support to the plant. The plant had to close the antiquated, environmentally harmful chlorine production line (which used mercury electrolysis) in 1993 because it lacked funds to invest in a modern chlorine production line.[44] Now, due to the need to purchase chlorine from Russia, the costs of a number of Pavlodar chemicals have increased significantly and production of some items has been discontinued, for example caustic soda and civilian-use aluminum trichloride. While some German and Japanese companies expressed interest in establishing a new, environmentally benign chlorine production line at Pavlodar (using membrane technology), the Kazakhstani government was not able to provide the state guarantees for investment required by these companies.[45]

Since 1995, other former Russian CW plants have increased the production of civilian chemicals similar to those manufactured at Pavlodar, displacing Pavlodar from its traditional markets in Russia, Kazakhstan, and other FSU countries. The situation became even worse after August 1998, when the sharp devaluation of the Russian ruble raised the cost of Pavlodar's goods by 150 to 200 percent in comparison with Russian chemicals. For example, the former CW plant at Novocheboksarsk has displaced Pavlodar from the FSU market for IOMS mineral-salt inhibitors.[46] According to Pavlodar plant representatives, most Kazakhstani energy-generating stations, including those owned by foreign companies, currently use IOMS-type mineral-salt inhibitors. These include the Belgian Tractabel company, which operates power generation facilities in Almaty, and the US AES company, which operates a number of power plants in eastern Kazakhstan. In 1999, the Pavlodar plant estimated that demand for mineral-salt inhibitors in Kazakhstan amounts to about 500 tons per year. However, Pavlodar's product is not competitive with Russian products. The cost of Pavlodar's IOMS in 1999 was $3,000 per metric ton, while the cost of the similar Novocheboksarsk product was $2,100 per metric ton.[47]

The Pavlodar plant has also encountered tough competition from Russian firms in selling flotation agents used in the processing of ores. Former Pavlodar plant customers at the Norilsk Nickel, Pechenga Nickel, and Yakutalmaz enterprises in Siberia, Russia, now purchase flotation agents manufactured at former CW plants in Russia. In recent years, because the plant no longer produces basic materials, it has been mostly involved in sporadic custom chemical production deals with private civilian Kazakhstani companies. While the Pavlodar plant is managing a water pumping and delivery system from the Irtysh River to a number of industrial facilities in Pavlodar, it has suffered from non-payment for its services by these enterprises, which are experiencing their own economic problems.[48]

Due to economic difficulties, some expensive dual-use equipment appears to have been sold by cash-strapped management to private buyers. Around 1997, Hastalloy reactors located at the aluminum trichloride production building at Site Number One were sold to unknown private parties. The dual-use equipment at Site Number Two remains at the plant.[49]

Under recent reorganizations, the Pavlodar plant has cut its oversized infrastructure and labor force. In 1996, the Kazakhstani Rehabilitation Bank[50] required the plant to fire 3,200 employees and transfer its huge housing and employee support infrastructure to the city authorities. The majority of these people reportedly have found jobs at a nearby oil refinery, aluminum plant, and construction companies. Information on whether some of these people might possess sensitive knowledge was not available.[51]

As of April 1999, the plant retained only a few essential facilities at both Site Number One and Site Number Two, occupying only 120 hectares of its former territory. The rest of the facilities, mostly designated for sale, were inherited by the Khimprom Joint Venture that had been detached from the Pavlodar Chemical Plant. Khimprom assumed responsibilities for the plant's debts, and its main role appears to be selling excess equipment and facilities. The Pavlodar Chemical Plant retains dual-use equipment at Site Number Two. In June 1999, new managers at the Pavlodar plant paid long-delayed salaries to workers from previously saved funds and were hoping to revive the plant.[52]

CONCLUSION

In comparison with former CW production facilities in Russia, the Pavlodar Chemical Plant in Kazakhstan has attracted little international assistance for its conversion and civilian market development.[53] This might be related to the fact that the plant was not fully constructed and never produced chemical weapons.[54] The plant was not declared by the Soviet Union during data exchanges with the United States under the Wyoming Memorandum of Understanding of September 23, 1989. Kazakhstan, which ratified the CWC on June 24, 1999, likewise did not declare the Pavlodar plant before joining the convention.[55]

The Pavlodar plant deserves more attention from nonproliferation specialists because it retains personnel with CW knowledge and dual-use equipment. While the plant never produced final CW agents, it possesses the capability to produce primary and intermediate CW precursors. In the late 1980s, the military CW production at the Pavlodar plant was halted, some military facilities and equipment destroyed, and production switched into manufacturing civilian-use chemicals. However, the plant has retained personnel with sophisticated training in manufacturing advanced CW agents and some dual-use equipment. The plant also continues to manufacture dual-use chemicals, which have military applications in addition to civilian uses.

The most important international support would help the former military Pavlodar plant develop civilian production and retain its personnel in civilian activities.[56] In recent years, lacking its own resources or support from the cash-strapped Kazakhstani government for conversion and equipment upgrades, the plant has experienced a significant decline in civilian production revenues. Hopefully, Kazakhstan's recent ratification of the CWC will open the way for international support of civilian activities at the Pavlodar plant.

[1] During the CW data exchange with the United States in December 1989, the Soviet Union declared its stockpile of chemical weapons to be 40,000 metric tons, including 30,000 metric tons of nerve agents (sarin, soman, and VX) and 10,000 metric tons of older generation blister agents (lewisite and mustard gas). Under the September 23, 1989, Wyoming Memorandum of Understanding (MOU) between the United States and the Soviet Union, the Soviet Union declared about 20 former CW production and filling plants that had been operational since January 1, 1946. Most of the Soviet CW production plants were located in the Russian Volga River basin. The plants at Volgograd, Novocheboksarsk, and Volsk-17 at Shikhany were involved in producing nerve agents such as sarin, soman, and VX. Older CW plants at Dzerzhinsk, Chapayevsk, and Kineshma produced blister agents such as lewisite, mustard gas, and adamsite. The main CW development center was the State Union Scientific Research Institute of Organic Chemistry and Technology in Moscow (GosNIIOKhT), which had an affiliate at Volsk-17. Other known development centers were the Military Chemical Defense Academy and the Scientific Research Institute for Chemical Machinery in the Moscow region. CW agents were tested at the Shikhany test site in Russia and Ust-Yurt test site in Uzbekistan. More detailed information on Russian CW facilities can be found in the following literature: Alexander Pikayev and Jonathan B. Tucker, eds., Monterey-Moscow Study Group Report, *Eliminating a Deadly Legacy of the Cold War: Overcoming Obstacles to Russian Chemical Disarmament,* (Moscow: Committee on Critical Technologies and Nonproliferation, January 1998), pp. 5, 89-92; Jonathan B. Tucker, "Converting Former Soviet Chemical Weapons Plants," *The Nonproliferation Review* 4 (Fall 1996), p. 78; Douglas L. Clarke, "Chemical Weapons in Russia," *RFE/RL Research Report* 2 (January 8, 1993), pp. 4-7.

[2] The Russian Federation signed the Chemical Weapons Convention (CWC) on January 13, 1993, and ratified it on November 5, 1997. The United States allocated $2.2 million for the destruction and dismantlement of the nerve agent facility in Volgograd, under the Department of Defense's Cooperative Threat Reduction (CTR) Program. European countries provided assistance for the dismantlement of blister agent facilities. Western governments also encouraged their chemical companies to establish civilian production at former CW facilities. For example, the US DuPont corporation planned to invest $10 million in herbicide production at the Russian former CW production company, Khimprom State Joint Stock Company at Novocheboksarsk. Pikayev and Tucker, eds., *Eliminating a Deadly Legacy of the Cold War*, pp. 11 and 19. For more on Khimprom, see Sonia Ben Ouagrham, "Conversion of Russian Chemical Weapons Production Facilities: Conflicts with the CWC," *The Nonproliferation Review* 7 (Summer 2000).

[3] One 1997 publication of the US Office of the Secretary of Defense mentioned a chemical warfare-related facility in Kazakhstan that "is being demilitarized and converted to peaceful purposes," evidently referring to the Pavlodar plant. Other former CW-related facilities in Kazakhstan include a production plant at the city of Zhambul and storage barracks on the Ili River. No further information on these facilities is known to the author. Office of the Secretary of Defense, *Proliferation: Threat and Response* (November 1997), p. 46; US government official, interview by author, January 2000.

[4] Pavlodar plant representatives, who worked at its military and civilian sites, interview by author, June 1999; Tucker, "Converting Former Soviet Chemical Weapons Plants," pp. 78-79.

[5] Pavlodar plant representatives, interviews by author, June 1999.

[6] Pavlodar, having 360,000 citizens in 1991, is one of the largest Kazakhstani industrial cities built during the development of "virgin lands" in northern Kazakhstan in the 1960s. In addition to the Pavlodar Chemical Plant, large industrial enterprises for such activities as oil refining, aluminum production, machine-building, radiotechnical work, and construction are located in Pavlodar. Several powerful energy-generation facilities, such as the Ekibastuz coal-fired stations I and II, Yermakovskaya coal-fired station, and city coal-fired stations I, II, and III, are concentrated near the city. About 15 percent of Pavlodar citizens in 1991 were ethnic Germans who had been expelled from Russia to Kazakhstan by Stalin. Pavlodar plant representatives, interviews by author, June 1999.

[7] In comparison with the Soviet CW plants, American CW production plants were usually single-purpose, solely military facilities. Tucker, "Converting Former Soviet Chemical Weapons Plants," p. 78; Pikayev and Tucker, eds., *Eliminating a Deadly Legacy of the Cold War*, p. 70.

[8] Pavlodar plant representatives, interviews by author, June 1999.

[9] Berketov was an ethnic Kazakh, a rare case in Soviet defense enterprises, which were mostly headed by ethnic Slavs. Ibid.

[10] Ibid.

[11] Ibid.

[12] In 1987, the Soviet Union and the United States began negotiating bilateral agreements designed to facilitate the completion of the CWC. On September 23, 1989, US Secretary of State James Baker and Soviet Foreign Minister Eduard Shevardnadze signed an MOU in Wyoming that provided for a two-phased data exchange and bilateral inspections of CW storage and production facilities. The following Bilateral Destruction Agreement (BDA) signed by Presidents George Bush and Mikhail Gorbachev on June 1, 1990, envisioned the destruction of CW stockpiles down to the level of 5,000 metric tons of agent on both sides by the year 2002. Both parties also agreed to stop producing chemical weapons and to conduct on-site inspections to verify the destruction of the stockpiles. However, there have been many delays in the implementation of the bilateral accords. The bilateral agreements have been further superseded by the CWC, which was opened for signature on January 13, 1993, and entered into force on April 29, 1997. US Congress, Office of Technology Assessment, *Proliferation and the Former Soviet Union*, OTA-ISS-605 (Washington, DC: US Government Printing Office, September 1994), p. 16; Tucker, "Converting Former Soviet Chemical Weapons Plants," pp. 79-81.

[13] On April 10, 1987, Mikhail Gorbachev announced that the production of CW would cease and that former CW enterprises would be converted to civilian production. Western countries have asserted that international inspections are needed at Russian CW plants that had been unilaterally converted in the late 1980s, before the CWC entered into force. Pikayev and Tucker, eds., *Eliminating a Deadly Legacy of the Cold War*, p. 18; Tucker, "Converting Former Soviet Chemical Weapons Plants," p. 78-83.

[14] Pavlodar plant representatives, interviews by author, June 1999.

[15] Phosphorus trichloride (PCl_3), listed on the CWC's Schedule 3, is a primary precursor for G-series nerve agents such as tabun, sarin, and soman, as well as V-series agents. PCl_3 is also produced in significant commercial quantities for purposes not prohibited under the CWC. Civil uses include insecticides, gasoline additives, plasticizers, surfactants, and dyestuffs. *The Biological & Chemical Warfare Threat* (undated brochure provided to author by an official of the US Department of Defense), pp. 37, 43.

[16] US Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, OTA-BP-ISC-115 (Washington, DC: US Government Printing Office, December 1993), pp. 25-26.

[17] Hastalloy reactors and pipes, which have a nickel content in excess of 40 percent by weight, are examples of dual-use equipment. Pavlodar plant representatives, interviews by author, June 1999; *The Biological & Chemi-*

cal Warfare Threat, p. 47.

[18] No other information on the role of this building was available.

[19] US government official, interview by author, May 1999.

[20] Incinerators specially designed to destroy CW agents, precursors, or organophosphorus compounds are examples of key dual-use chemical production equipment. *The Biological & Chemical Warfare Threat*, p. 49.

[21] Pavlodar plant representatives, interview by author, June 1999.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] In binary weapons, relatively non-toxic ingredients are stored in separate canisters; they are mixed and react to form the final lethal agent when the munition (bomb, projectile, grenade, etc.) is on its way to the target. Binary weapons are not necessarily new agents. Chemicals produced in the US binary weapons were well-known, i.e., sarin, soman, and VX nerve agents. The United States began to produce binary weapons in 1985. US Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, p. 34; Clarke, "Chemical Weapons in Russia," p. 48.

[26] In October 1991, Russian scientist Vil Mirzayanov, who worked at the GosNIIOKhT institute in Moscow, published an article in the Russian press where he stated that the institute had developed a series of "third generation" nerve agents. His statements were confirmed by two other Russian scientists, Andrey Zheleznyakov and Vladimir Uglev. The *novichok* effort reportedly began in 1973-76 under the secret Foliant program. In the early 1980s, the Soviet Union developed and field-tested three novel unitary agents designated as Substance 33, A-230, and A-232. The agents were produced at the Novocheboksarsk, Volgograd, and Shikhany CW facilities. These unitary agents were the basis for the development of the extremely lethal *novichok* series of binary weapons beginning in 1982. From five to 10 metric tons of the first Soviet binary agent *novichok*-5 were produced at Volgograd and field-tested in 1989-90 at the Ust-Yurt site in Uzbekistan. Another *novichok*-# agent was field-tested at the Ust-Yurt and Shikhany sites and adopted by the Soviet Army as a chemical weapon in 1990. In 1993, GosNIIOKhT reportedly tested a *novichok*-7 agent. *Novichok*-8 and *novichok*-9 agents were also reportedly developed but not tested.

Although their chemical structures are unknown, the novel agents were supposedly organophosphorus compounds made from simple precursors not controlled by the CWC. The Russian government has not included the new agents in any data exchange under the bilateral agreements with the United States. Clarke indicates that Russian officials never directly disputed the facts disclosed by Mirzayanov, only their interpretation. When asked to explain Mirzayanov's charges, Russian authorities maintained that the accords concerned stockpiled weapons and made a distinction between production and research, and development of chemical weapons. Tucker, "Converting Former Soviet Chemical Weapons Plants," pp. 78-79; Pikayev and Tucker, eds., *Eliminating a Deadly Legacy of the Cold War*, pp. 89-92; Clarke, "Chemical Weapons in Russia," pp. 47-48.

[27] Pavlodar plant representatives, interviews by author, June 1999; US Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, p. 26.

[28] Pavlodar plant representatives, interviews by author, June 1999.

[29] Trade name derived from the chemical class of the compounds, acrylates.

[30] The following chemical structures were written using the Pavlodar plant's production catalogue (Pavlodar Industrial Association Khimprom, *Production for Industrial and Technological Purposes of Industrial Association "Khimprom,"* January 1, 1991), with the help of organic chemists from Kazakh State University.

[31] *The Biological & Chemical Warfare Threat*, p. 45.

[32] Pavlodar plant representatives, interviews by author, June 1999.

[33] *The Biological & Chemical Warfare Threat*, pp. 45-46.

[34] Pavlodar plant representatives, interviews by author, June 1999.

[35] In particular, aluminum trichloride was used for the synthesis of aluminum hydride. Ibid.

[36] Ibid.

[37] Ibid.

[38] Sharov was dismissed by the Kazakhstani Rehabilitation Bank, which dealt with bankrupt enterprises, due to the poor performance of the plant. Ibid.

[39] Shchetinin, who previously worked at Site Number One, was cleared to head Site Number Two in October 1991. His predecessor in 1990-91 was chief engineer Kolesnikov (first name unknown). Ibid.

[40] Ibid.

[41] There have also been plans to use some reactors at the phosphorus trichloride building for the production of phosphorus pentasulfide (P_2S_5). Although P_2S_5 is not listed on the CWC schedules, it is included in the Australia Group export control list of dual-use chemicals. Civilian use of P_2S_5 includes insecticides, lubricant oil additives, and pyrotechnics. Pavlodar plant representatives, interviews by author, June 1999; US Congress, Office of Technology Assessment, *Technologies Underlying Weapons of Mass Destruction*, p. 56; US Arms Control and Disarmament Agency, Office of Public Information, *Fact Sheet: Australia Group Export Controls on Materials Used in the Manufacture of Chemical and Biological Weapons; Control List of Dual-Use Chemicals: Commercial and Military Application* (October 25, 1993), p. 2; US Arms Control and Disarmament Agency, Office of Public Information, *Fact Sheet: Australia Group* (February 10, 1995), p. 1; and *The Biological & Chemical Warfare Threat*, p. 41.

[42] Pavlodar plant representatives, interviews by author, June 1999.

[43] Ibid.

[44] The use of mercury electrolysis resulted in the contamination of the surrounding territory because of mercury leaks from the old equipment. In April 1999, the Kazakhstani government organized emergency cleaning of the site. Ibid.

[45] Plant management estimated that $17 million in credit for 10 years would be needed to establish a new chlorine production line, even taking into account the existence of some infrastructure. No information on any outside assessment is known to the author. Ibid.

[46] Ibid.

[47] Ibid.

[48] These are, for example, the city coal-fired station and oil refinery. Ibid.

[49] Ibid.

[50] The Rehabilitation Bank, no longer operating, was in charge of bankrupt enterprises providing them with loans under certain conditions.

[51] Ibid.

[52] Ibid.

[53] In late 1999, the US and Kazakhstani governments started discussions on US assistance for the conversion of former CW-related facilities in Kazakhstan. US government official, interview by author, January 2000.

[54] Visits by US organizations and companies to Pavlodar included the Monsanto company in 1993, which bought a 20-foot container of PCl_3 from the plant and contractors of the USAID mission in Almaty, who installed metering pipes at the PCl_3 manufacturing lines. Ibid.

[55] Kazakhstan has demonstrated a strong nonproliferation policy concerning the weapons of mass destruction that remained on its territory after the dissolution of the Soviet Union. A former Soviet nuclear successor state, it has decided to give up its nuclear weapons and has dismantled its large nuclear arsenal. Although not a signatory to the Biological and Toxin Weapons Convention, Kazakhstan has dismantled its former biological weapons production plant in Stepnogorsk with the help of the US Cooperative Threat Reduction Program. Jonathan B. Tucker and Kathleen M. Vogel, "Preventing the Proliferation of Chemical and Biological Weapons Materials and Know-How," *The Nonproliferation Review* 7 (Spring 2000), p. 92.

[56] The plant's research personnel were not successful in proposals they submitted to the European Copernicus Fund in the fall of 1998 and to the US Civilian Research and Development Foundation (CRDF) commercialization seminar in April 1999. Pavlodar plant representatives, interviews by author, June 1999.