

## CHAPTER 7

# Chemical demilitarisation in Syria: an overview

Dominique Anelli and Mehran Rouzbahani

## Background

The main objectives of the Syrian chemical demilitarisation programme, which began in October 2013, were to eradicate Syria's chemical weapons production capabilities and to destroy the stockpile of chemical weapons in the state. This is being achieved by the destruction of chemical weapons production facilities as well as the removal and destruction of approximately 1,330 metric tonnes (MTs) of chemicals and related materials from the Syrian Arab Republic, in accordance with the OPCW Executive Council decisions.<sup>1</sup> This has been an enormous undertaking presenting a host of security and logistical challenges amidst an active conflict.

## Chemical weapons production facilities

The Syrian Arab Republic declared 27 chemical weapons production facilities. These included both mobile chemical weapon production units and specialised structures, which were located above and below ground. 24 of these production facilities, including all mobile units, have been destroyed to date, and progress is being made on the destruction of the remaining facilities.

## Chemical weapons storage facilities

The Syrian Arab Republic also declared several locations across its territory, where chemical weapons were stored (chemicals stored in bulk form and unfilled munitions). The chemical weapons stored in these locations belonged to Category 1, 2 and 3 chemicals, in accordance with the Chemical Weapon Convention (CWC).<sup>2</sup> The unfilled munitions (Category 3 chemical weapons) were all destroyed inside Syria.

## Removal of chemical weapons from Syria

All chemical weapons classed as bulk chemicals (Category 1 and 2 chemical weapons), with the exception of isopropanol, were removed from the Syrian territory and transferred to disposal sites outside of the country.

**Table 1** List of assisting CWC states parties for removal programme

State party	Assistance offered
The Russian Federation	<ul style="list-style-type: none"> <li>■ Equipment and materials needed for removal of the chemicals from Syria.</li> <li>■ Naval security.</li> </ul>
Denmark	<ul style="list-style-type: none"> <li>■ Maritime transport of chemicals from Syria.</li> <li>■ Naval protection.</li> </ul>
Norway	<ul style="list-style-type: none"> <li>■ Maritime transport of chemicals from Syria.</li> <li>■ Naval protection.</li> </ul>
China	<ul style="list-style-type: none"> <li>■ Naval escort.</li> </ul>
Finland	<ul style="list-style-type: none"> <li>■ Chemical weapons emergency-response capabilities.</li> </ul>
Italy	<ul style="list-style-type: none"> <li>■ A port for trans-loading of chemicals to the US ship.</li> </ul>
US	<ul style="list-style-type: none"> <li>■ Destruction technology and full operational support to neutralise the Category 1 chemicals aboard a US vessel at sea.</li> </ul>

In accordance with the OPCW Executive Council decision, the majority of the chemical weapons were removed from the Syrian Arab Republic. This required the support of CWC states parties to provide the necessary packing material, as well as vehicles and vessels for road and marine transfers, in accordance with the international dangerous goods transportation code. Through a decision of December 2013, the council welcomed offers made by the parties, which offered logistical support for the removal programme.<sup>3</sup> Table 1 demonstrates the types of assistance provided by CWC states parties to pack and remove the chemical weapons outside of the Syrian Arab Republic.

In total, 181 maritime shipping containers containing declared chemicals were removed from Syria. Out of these 181 containers, 62 were transferred by the Norwegian vessel Taiko.<sup>4</sup> The remaining 119 containers were on board the Danish vessel, Ark Futura. These two marine vessels were provided as in-kind contributions by Norway and Denmark.

- *Category 1 chemical weapons*: the secretariat verified the delivery and destruction of Category 1 chemical weapons in facilities provided by states parties as in-kind contributions and at commercial disposal facilities which were selected through an OPCW tender process. These chemical weapons comprised seven different Schedule 1 chemicals or chemicals used in binary chemical weapons systems. The total weight of declared Category 1 chemical weapons was approximately 1,050 MTs.

This quantity included approximately 130 MTs of isopropanol, which was destroyed in Syria by dilution with water. All Category 1 chemical weapons have been destroyed.

- *Category 2 chemical weapons:* the secretariat verified that approximately 265 MTs of the declared Category 2 chemical weapons were transferred to the facilities that states parties provided as in-kind contributions and at the commercial disposal facilities selected through the OPCW tender process for destruction. These chemicals comprised thirteen different scheduled and non-scheduled chemicals. By mid-November 2015, the secretariat had verified the destruction of 255 MTs (96.2 per cent) of Category 2 chemical weapons, which were transferred outside of Syria. The only remaining Category 2 chemical, which is still going through destruction, is hydrogen fluoride (HF) in Veolia ES Technical Solutions, LLC in the US—in order to ensure that a safe disposal process, the destruction of the HF in this facility was delayed.
- *Rinsates and effluents:* in addition, as part of the removal and destruction program, three types of rinsate (A-Solution, B and BB solution rinsate) were produced in Syria during the repacking of declared chemicals. These rinsates were considered as Schedule 1 chemicals and destroyed accordingly at disposal facilities outside of Syria. Additionally, there were around 300 storage tanks located in several Syrian chemical weapons storage facilities containing residual mustard agent, which was destroyed in Syria between 2013 and early 2014.
- *Category 3 chemical weapons:* the secretariat verified the destruction of approximately 1,200 items of Category 3 chemical weapons, which comprised aerial bombs and missile warheads intended to be filled with chemical weapons across several storage facilities in the Syrian Arab Republic.

Table 2 (below) provides a list of declared chemicals and related materials and their disposal locations.

## Maritime operations

*Port of embarkation:* the Syrian port of Latakia was designated as the port of embarkation. All of the Syrian chemical weapons that were removed were decanted, if required, and then packed into standard maritime shipping containers within the Syrian Chemical Weapon Storage Facilities under verification of OPCW inspectors or by application of remote monitoring measures. These containers, escorted by military convoys, were gradually transferred to Latakia between 5 January and 23 June 2014. The containers were loaded on-board the designated vessels provided by assisting states parties.

**Table 2** List of declared chemicals by the Syrian Arab Republic

Chemical weapon category	Chemical	Disposal location
Category 1-Unitary	Sulphur mustard (HD)	Cape Ray-US
Category 1-Binary	DF	Cape Ray-US
	Substance A, Hexamine	Ekokem-Finland
	Substances B and BB	Veolia-UK
	Isopropanol	Syria
Category 2	Phosphorus chlorides and sulphides	Veolia-US
	Hydrogen fluoride	Veolia-US and Mexichem-UK
	Hydrochloric acid	Veolia-UK
	Amines, phosphites and alcohols	Ekokem-Finland
Others	Substance A, B & BB rinsate	Veolia-UK
	Containers with residual mustard	Syria
Category 3	Aerial bombs and missile warheads	Syria
Effluents <sup>5</sup>	Effluent resulted from hydrolysis of DF	Ekokem-Finland
	Effluent resulted from hydrolysis of HD	GEKA-Germany

The two vessels used to transfer Syrian chemical weapons to the ports of disembarkation were *Taiko*, from Norway, and the Danish Vessel *Ark Futura*. During the loading operation, the ships docked around 20 times in the port of Latakia. The UN-OPCW joint mission verified the whole operation.

- *Taiko*: the Norwegian vessel was used to upload chemical weapons to be destroyed in two commercial disposal facilities in Finland and the US. *Taiko* delivered her first consignment, comprising declared Category 1 and 2 chemicals, to the port of Hamina Kotka, Finland, on 21 June 2014. These chemicals were transferred to the commercial chemical disposal facility of Ekokem OY AB. *Taiko* later sailed to Port Arthur, in the US, where she delivered her second and last consignment comprising of Category 2 chemicals on 9 July 2014. These chemicals were transferred to the Veolia ES Technical Solutions, L.L.C.
- *Ark Futura*: the Danish vessel arrived in the Port of Gioia Tauro, Italy, on 1 July 2014. The OPCW inspection team verified that 224 storage tanks filled with approximately 580 MTs of Methylphosphonyldifluoride (DF) and 15 storage tanks filled

with approximately 20 MTs of sulphur mustard (HD), both declared Category 1 chemicals packed into 78 shipping maritime containers were trans-loaded from Ark Futura to Cape Ray for further destruction in the Field Deployable Hydrolysis System (FDHS) (see section below for technical details). The trans-loading operation was completed within one day in the civilian port of Gioia Tauro with application of extensive safety and security measures by the Italian authorities. Ark Futura continued her trip to Marchwood Military Port in the UK, where her consignment of declared Category 1 and 2 chemicals was delivered on 15–16 July. She completed her mission on 20 July 2014 by delivering her last consignment, which was destined for the Ekokem facility at the port of HaminaKotka.

Together, Taiko and Ark Futura successfully delivered approximately 1,170 MTs of Syrian chemicals into the trans-loading and disembarkation ports in Italy, Finland, the UK and the US. The OPCW inspection teams verified all the trans-loading and delivery of chemicals at the disembarkation ports.

## Destruction programme

Following the OPCW Executive Council decision, which set detailed requirements for the destruction of Syrian chemical weapons and Syrian chemical weapons production facilities, the council requested the OPCW Director General to explore possible options to destroy these chemicals in commercial chemical disposal facilities.<sup>6</sup>

The OPCW Director General in an official OPCW Note called for proposals for treatment and disposal of chemicals, effluents, and related packing materials with respect to the destruction of Syrian chemical weapons.<sup>7</sup> This document explained the procedure for selecting the commercial companies to participate in the destruction programme.

**Table 3** Syrian chemical weapon destruction-related facilities

Destruction facilities provided by the CWC states parties (in-kind continuation)	Commercial disposal facilities (selected through OPCW tender process)
The Cape Ray field deployable hydrolysis system chemical weapons destruction facility, US.	Ekokem Riihimäki waste disposal facility, Finland
Ellesmere Port High Temperature Incinerator (Veolia-UK), UK.	Veolia ES Technical Solutions, L.L.C., US
Mexichem, UK.	
Gesellschaft zur Entsorgung von Chemischen Kampfstoffen und Rüstungsaltslasten MBH (GEKA MBH), Germany.	

The OPCW Executive Council later authorised the OPCW Director General to enter into contracts with the qualified commercial chemical disposal facilities for the destruction of certain chemicals and effluents. They also accepted in-kind contributions made by assisting states parties, which sponsored commercial entities to implement the Syrian chemical weapons destruction programme.

## Disposal facilities

### Facilities provided by states parties

*Cape Ray*: this is a US owned motor vessel, equipped with the FDHS a transportable, high-throughput modular demilitarisation system designed to render chemical warfare material into compounds not usable as weapons. The system used neutralisation technology to destroy bulk chemical warfare agents and their precursors by mixing and heating with reagents, such as water, sodium hydroxide and sodium hypochlorite to facilitate chemical degradation resulting in a destruction efficiency of greater than 99.9 per cent. The neutralisation process generated effluents in volumes of five to 14 times the volume of the chemical warfare material being treated. The effluent could then be disposed of, in accordance with host-nation environmental laws.

A team of OPCW inspectors aboard the ship monitored and verified all of the destruction activities of uploaded chemicals. These chemicals comprised approximate 580 MTs of DF, a binary precursor for sarin gas, which was completely destroyed by 12 August 2014, and approximately 20 MTs of sulphur mustard, which was destroyed by 18 August 2014. The DF hydrolysis effluent (approximate 5,900 MTs) and HD hydrolysis effluent (approximate 330 MTs) were offloaded at the port of HaminaKotka in Finland and the port of Bremen in Germany, for further disposal in designated disposal facilities.

*Ellesmere Port High Temperature Incinerator (Veolia–UK)*: destruction in this facility was provided through an in-kind contribution by the Government of the UK. The facility agreed to destroy three declared Category 1 chemicals. In addition, another Category 2 chemical weapon—which was originally destined for the US (Veolia ES Technical Solutions, L.L.C.) but as a result of unexpected changes to the shipping schedules, could not be removed on time by Taiko—was added to the disposal portfolio of the facility. All of the chemicals, approximately 180 MTs, were received in the military port of Marchwood and, after initial screening, were gradually transferred to the facility. Destruction of these chemicals was completed by 6 August 2014. The OPCW inspection teams visited the disposal facility regularly to verify the ongoing destruction activities and its consistency with respect to the provisions of the Executive Council Decision.<sup>8</sup>

*Mexichem, UK:* the facility received approximately seven MTs of a Category 2 chemical, hydrogen fluoride, which was also originally destined for the US (Veolia ES Technical Solutions, L.L.C.). The chemical could not be picked-up on time by Taiko as originally planned because of security circumstances. Mexichem completed destruction of the declared Category 2 chemical by May 2015. The OPCW inspection teams visited the facility regularly, and the OPCW Secretariat received regular briefings on the progress of the destruction process.

*Gesellschaft zur Entsorgung von Chemischen Kampfstoffen und Rüstungsaltslasten MBH (GEKA MBH), Germany:* the facility, through an in-kind contribution by the Federal Republic of Germany, provided its services to destroy effluents resulting from neutralisation of sulphur mustard on-board the Cape Ray. The facility received approximately 330 MTs of effluent, which was completely disposed of by March 2015 through incineration at high temperatures. The on-site verification activities at this facility were governed by the decision of the OPCW Executive Council.<sup>9</sup>

## Facilities selected as part of the OPCW tender process

*Ekokem Riihimäki Waste Disposal Facility, Finland:* destruction in this facility was governed through a commercial contract concluded with the OPCW. The company was selected through a tender process, in order to destroy two Category 1 and eight Category 2 chemicals. Approximately 320 MTs of declared Category 1 and 2 chemicals, in two consignments were delivered to Ekokem OY AB on 21 June and 20 July 2014. By the end of October 2014, the facility disposed of 100 per cent of its Category 1 and 2 chemicals.

OPCW inspection teams visited the facility regularly until the completion of the destruction programme. The inspection teams verified that destruction activities were consistent with the provisions of the OPCW Executive Council decision and the commercial contract.<sup>10</sup>

The main technology used for destruction of the Category 1 and 2 chemical weapons was incineration in a high temperature rotary kiln. This method produced a destruction efficiency of greater than 99.99 per cent.

Furthermore, and as part of the commercial contract, the facility received 5,867 MTs of DF hydrolysis effluents to be destroyed over a period of 300 days (until June 2015). By the end of June 2015, the facility disposed of 100 per cent of these effluents.

*Veolia ES Technical Solutions, L.L.C.:* the facility received an approximate 60 MTs of Category 2 chemicals, in the form of four different inorganic chemicals. By mid-November 2015, around 84.3 per cent of chemicals had been destroyed. There are still technical challenges for destruction of one of the declared chemicals, hydrogen fluoride, while around 60 per cent of the HF has already been destroyed, the remaining chemical will be destroyed during 2015 and the beginning of 2016. The facility has been

inspected regularly by the OPCW inspection teams to ensure that the commercial contract has been followed as well as provisions of the OPCW Executive Council.<sup>11</sup>

## Conclusion

Removal and destruction of Syrian chemical weapons has been a great achievement for the OPCW. This was accomplished by the dedication and commitment of Technical Secretariat staff with direct support of the CWC states parties. This operation was an excellent example of 'Working Together for A World Free of Chemical Weapons'.

## Endnotes

- 1 Contained in EC-M-34/DEC.1, 15 November 2013, EC-M-36/DEC.2, 17 December 2013, and EC-M-38/DEC.1, 30 January 2014.
- 2 Category 1 chemical weapons are chemical weapons on the basis of the CWC Schedule 1 chemicals and their parts and components (paragraph 16, Section C, Part IV (A), Verification Annex, CWC). This definition also includes all the chemicals used in any binary chemical weapon system (i.e. Hexamine). Category 2 chemical weapons are chemical weapons on the basis of all other chemicals and their parts and components (paragraph 16, Section C, Part IV (A), Verification Annex, CWC). Category 3 chemical weapons are unfilled munitions and devices, and equipment specifically designed for use directly in connection with employment of chemical weapons (paragraph 16, Section C, Part IV (A), Verification Annex, CWC).
- 3 EC-M-36/DEC.2, dated 17 December 2013
- 4 This number only refers to containers with declared chemical weapons and not containers with related material or solid wastes.
- 5 As a result of destruction of two Category 1 chemicals in the Cape Ray Field deployable Hydrolysis System Chemical Weapons Destruction Facility, US, two types of effluents from hydrolysis of Methylphosphonyldifluoride (DF) and sulphur mustard (HD) were produced.
- 6 EC-M-34/DEC.1, dated 15 November 2013
- 7 EC-M-36/DG.4, dated 16 December 2013.
- 8 EC-76/DEC.5, dated 11 July 2014
- 9 EC-M-40/DEC.1, dated 29 April 2014
- 10 EC-75/DEC.4, dated 5 March 2014
- 11 EC-M-42/Dec.2, dated 17 June 2014