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HISTORY

History of Russia's chemical weapons

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The aim is to provide a general review of the former research, development and use of different chemical agents in Russian (Soviet) Army. A comprehensive assessment is given on Russian chemical warfare despite of the inadequate data available. Development and use of chemical warfare has been classified as secret for many years in Russia as well as in other states of the world. Russian chemical weapons history can be divided into three periods. The first part had been lasted from the beginning of the twentieth century until the World War II. In the second period (from World War II to the 1970s) toxic agents captured from the Germans were shown and chemicals of new generation were developed during the Cold War. The third period has been extended till recent days in which the newest and super secret lethal chemical weapons and new generation of the non-lethal ones have been evaluated. Finally there stand a few words on Russian disarmament process, on difficulties of Russian Government to be faced and initiatives and activities to be done by other States Parties to help Moscow in elimination of its chemical weapon stocks.

First period of the Russian chemical warfare history (1917–1939-40)

It had never been officially acknowledged that the Soviet Army had chemical weapons. Despite the above Russian Army has been placed priority on chemical weapons from the czarism time. First attempts at using chemical weapons by Russian Army are known during the Civil War period (1917–1922) in the beginning of the twentieth century. All cases of chemical agents' use were caused by internal political problems. Toxic agents were used in suppressing the residents uprising in Yaroslavl in 1918, by Don Cossacks in 1919 and in suppression of peasants' uprising in Tambov in 1921.[1]

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Table 1. Chemical casualties of World War I

Country	Casualties	Rate of lethality
Germany	200,000	4.5%
France	190,000	4.2%
Great Britain	189,000	4.2%
USA	73,000	2.0%
Russia	475,000	11.8%

A specially created German-Soviet joint stock company named "Bersol" had been organized from 1923 to 1926 and produced yperite in industrial scale. Probably the German company called "Stolzenberg" delivered and set up equipment for production. From 1927 plants were restructured under soviet direction and in 1931 the capacity of new plants reached 5000 tons of yperite per year.[1] Developing, production and use of chemical agents as well as their weaponisation were going on large scale in the thirties. Chemicals mainly used in first period of Russian Chemical Warfare History were developed in Germany, in USA and in other States being experienced by combat operations of World War I and in the following time. These toxic chemicals (TC) can be divided into three groups[1] on basis of their mechanism on living organism:

1. Skin-blistering and general toxic action: yperite (sulphuric mustard gas (HD)), nitrogen mustard gas (HN), Lewisite (L);
2. Blood and pulmonary agents: prussic acid (AC), phosgene (CG), diphosgene (DP);
3. Non-lethal agents: adamsite (DM), diphenyldichloroarsine (DA), chloroacetophenone (CN), diphenylcyanoamine (DC), CS-gas (2-chlorobenziliden-malondinitrile), chloropicrin (PS);

1. Yperites: sulphuric mustard gas is a viscous liquid at normal temperature. It is a strong vesicant, deep itching or burning blisters develop wherever this oil contacts the skin, on eyes conjunctivitis or blindness can cause. Damage of respiratory system can lead to pulmonary oedema. Common bleach can be used or decontamination solution DS2 (2% NaOH + 70% diethylenetriamine + 28% ethylene-glycol-monomethylether). Vesicants can be neutralised by oxidation or chlorination. Chemically it is a thioether: 2,2'-dichlorodiethyl sulphide.

Nitric derivates of sulphuric mustard: The most commonly used compound of them is trichlortriethylamine. Some of them were used as blister agents: HN1 – bis-(2-chloroethyl)-ethylamine, HN2 – bis(2-chloroethyl)-methylamine, HN3 – bis(2-chloroethyl)-amine.[2]

α-Lewisite: It is a liquid blistering agent. Chemically is 2-chlorovinyl-arsine dichloride. When inhaled it is a powerful respiratory irritant. The absorption of

Lewisite, which penetrates through the skin, may be fatal. It is neutralized by reaction with antilewisite (2,3-dimercapto-1-propanol).[3]

2. Cyanogenes: blood agents in form of crystallized salt, liquid and vapour are rapidly acting, highly volatile gases or liquids with bitter almond odours.[4]

Hydrogene cyanite (HN - water soluble form of HCN gas) affects virtually all body tissues, attacking the pervasive metaloenzymes and reducing them inactive. Its principal toxicity results from inactivation of cytochrome oxydase in mitochondria of the cells. Inhibits the cells oxygen utilisation, which causes cell death. Detoxication is a three-step process:

- amyl-nitrite ampoule inhalation;
- 300 mg (10 ml 3%) solution of sodium nitrite inject slowly;
- after sodium nitrite administer 12.5 mg (50 ml of 25%) solution of sodium thiosulfate.

Phosgene (carbonylchloride) is a highly toxic gas or a refrigerated liquid. The gas combines with water in the tissues of the respiratory track to form carbon dioxide and hydrochloric acid. The acid dissolves the membranes in the lungs. Fluid fills the lungs and death results from a combination of blood loss, shock and respiratory failure.

Diphosgene as a derivate of the phosgene is chemically trichloromethylchloroform is a liquid under normal circumstances. Diphosgene is safer to handle and easier to measure than phosgene gas. Administering of oxygen, giving bronchodilators and using inhalation steroid may less oedema.[5]

3. Irritants have been produced in human rapid sensory irritation or disabling physical effects which disappear within a short time. A substance is classified incapacitating if less than 1/100 of the lethal dose causes incapacitation. Incapacitating agents have been developed against combatants or criminals are intermixed with civilians as in urban warfare, hostage rescue, counter-terrorism and the like. Adamsite (DM), diphenyldichloroarsine (DA), diphenylcianoarsine (DC), chloropicrin belong to the group of vomiting agents or sneeze gases. They irritate the eyes, lungs, mucous membranes develop causing headache, nausea and persistent vomiting.

CN and CS gases are so called tear gases In contamination they cause pain in the eyes, flow of tears and difficulty in keeping eyes open.[6]

Since the twenties the Soviet Army has established organisations in purpose of developing and testing chemical weapons. In pre-war years yperite was being produced at plants in Chapayevsk (Volgograd), Dzerzinsk, Berezniki and Novomoskovsk. Lewisite production was started from the late thirties because of raw material and technical problems. The main sites of Lewisite production were Chapayevsk and Dzerzinsk. Chloroacetophenone, adamsite, phosgene were produced mainly at plants in

Moscow. Testing highly toxic agents directly on people were usual thing for Soviet Army in pre-war years. Yperite and Lewisite were tested on thousands of people.

Second historical period: World War II to the end of Cold War

Opposite sides refrained from using of chemical weapons during World War II despite of hoarded significant stockpiles of CW in the background. New generation of toxic agents were basically developed in Germany. In the forties Germans produced sarin and tabun on industrial scale in plants of Dyernfurth and Falkenhagen. Soviets captured both of the full-scale tabun and sarin plants before Nazis could destroy them. Soman was discovered by R. Kuhn in 1944. The documents on discovery data were buried, but Soviets discovered and removed the documents. Therefore production of these organophosphorus chemicals in Soviet Union were based on Western data. Industrial production of sarin began in 1958–59 and of soman began in 1967 and production of V-gas started in 1972. Second generation of chemical agents belong to another group of organophosphorus toxic chemicals (OTC) called V-series. This phosphoryl-thiocoline class was discovered independently by R. Gosh of ICI, by G. Schrader of Bayer and by L. E. Tammelin of the Swedish Institute of Defence Research in 1952–53. The US selected VX for manufacture in 1958. Soviet scientists had investigated the anticholinesterase activity of S-dialkylaminoethyl phosphono- and phosphorothioates. The Soviets had learned of the toxicity of V-series and probably had obtained the molecular formula ($C_{11}H_{26}NO_2PS$) or a faulty version of the structure. The fact is the Soviet-gas has the same formula (S-2(diethylamino)-ethyl-)-O-ethylisobutylphosphonothioate), but it has a slightly different compound from VX (S-2-(bis(1-methylethyl)amino)ethyl)-O-ethylmethylphosphono-tioate).[7]

In the following years three kinds of OTC were produced and being stored in army stockpiles: sarin, soman and Soviet V-gas. There was also a significant amount of tabun in possession of the Army captured from the Germans. At the same time the US Army has only Sarin and VX-gas. Industrial scale production of OTC and munitions charged with them were linked to the activity of chemical plants in Volgograd and Novocheboksarks. The practice of testing toxic chemicals directly on people persisted into post-war years. Toxic properties of V-gas were studied on people in the sixties.

Nerve gases are the second generation of chemical weapons. These chemicals are liquid at room temperature. Chemically they are organophosphates. They disrupt the mechanism by which nerves transfer messages to organs. The disruption is caused by blocking acetylcholine, which is a neurotransmitter. When acetylcholine transmitted the signal down, normally it is degraded into choline and acetic-acid by acetylcholine-estherase. This regenerates the receptor and renders it active again. Nerve agents act by

inhibiting of hydrolysis of acetylcholine by acetylcholine estherase. They bind chemically to the acetylcholine so it is unable to deactivate acetylcholine resulting in persistent and uncontrolled stimulation of receptor.

Poisoning by a nerve agent leads to contraction of pupils, profuse salivation, convulsions, involuntary urination and defecation and death by asphyxiation as control is lost over the respiratory muscles.

Chemicals are grouped in three classes:[8]

1. G-series: These compounds were discovered and synthesized by a German scientist Dr. Gerhard Schrader before and during World War II.

Sarin (GB) – (O-isopropyl-methyl-fluorophosphonate) Lethal concentration is about 0.2 mg/l with exposure of a minute. In liquid form causes complete poisoning through the skin. It is hydrolysing in water slowly.

Soman (GD) – (O-(3,3-dimethyl-secbutil)-methyl-fluorophosphonate) Its toxicity is higher than sarin's. Lethal concentration is about 0.02 mg/l with exposure of a minute. In vapour form causes general poisoning on the skin. It is hydrolyzing in water very slowly.

Tabun (GA) – (N,N-dimethylamino-O-ethyl-cianophosphate) Lethal concentration is 0.3 mg/l with exposure of one minute. In liquid form 50–70 mg/kg tabun results lethal poisoning. It is hydrolysing in water slowly.

2. V-series*:* Persistent agents remain on skin, clothes, on any other surfaces for a long period of time. The prototype of the series is:

VX – O-ethyl-S-(2-diiso-propylaminoethyl)-methyl-phosphonothioate. Other agents are less known:

VE – O-ethyl-S-(2-diethylaminoethyl-)ethyl-phosphonotioate;

VG – O,O-diethyl-S-(2-diethylaminoethyl)-phosphorotiate;

VM – O-Ethyl S-(2-(diethylamino)ethyl)methylphosphorotioate;

V-gas – The Russian equivalent of VX. The inhalation hazard is less than with G-agents. They have oil consistency, which renders them toxic by dermal exposures. It is oily liquid, penetrates into the organism through the skin and respiratory tract. Dozens of times more toxic than soman. It is hydrolysing in water slowly.

Two drugs: atropine and pralidoxime-chloride have been used as antidotes for nerve agents poisoning. Atropine blocks one type of acethylcholine receptor so then the acetylcholine cannot work in the synapse. Pralidoxime blocks the binding of the nerve agent to the acetylcholine.

3. Insecticides: They have been revealed by investigation of the Soviet Army on non-traditional means of attack. Its scientists prepared experimental amounts of highly toxic insecticides as a potent chemical warfare. These chemicals have the same effects as those of V-series. They block the action of acetylcholine.[9]

Tiolo,-tionophosphates (Vsn): they are liquid, highly toxic, they penetrate through the skin and per os.

Carbamates were used as insecticides. Their poisoning process differs from V-agents' as binding of carbamate and acetylcholine can be very slowly hydrolysed, the hydrolysing process cannot be facilitated by enzyme regenerators, so that 2-PAM is ineffective in carbamate poisoning. Carbamates are in solid state, they are stabile, slowly disintegrating compounds. They have been used in vapour form. They are suitable for persistent poisoning of water and food. Some of them are more toxic than VX.

Development of binary weapons in Soviet Union started in the sixties. The mechanism of action of binary chemical weapons consists in synthesizing the toxic agent from two or more non-toxic components (precursors) in the process of firing of a projectile, launching a missile, chopping an aerial bomb.

Third historical period: 1970s to the recent days

The development of new OTC weapons dated from 1973–1976. Third generation of chemical weapons developed in result of proliferation process between Soviet Union and the US during Cold War. In a result of applying new technological methods soman, sarin and also V-gas have been synthesized in binary form. Soviets began a few top-secret chemical weapon and biological weapon programs in the seventieth. Soviet leaders were preparing for an all out chemical-biological war. There were programs with different code names: "Flora"- developing herbicides, "Flute", "Fonetti" and "Fagot" – preparing for immunological war.[10]

The program with code name "Foliant" started for development of a new binary chemical weapon. In 1987 Soviets created a new binary nerve gas called "Novichok". This series of agents were developed to achieve Soviet's strategic objectives:[11]

1. circumvent the chemical weapons treaty,
2. Novichok agents are undetectable using NATO standard chemical detection equipment;
3. defeat NATO chemical protective gear.

Russia produced several new agents with code name of Substance 33, A-230, A-232, A-234, Novichok 5 and Novichok 7. These toxics are geared for the deployment of binary munitions. Binary weapons are safer to store, transport and handle. When a new poisonous substance had been synthesized and tested in laboratory, its factory production was developed in such a way, that the synthesis of the compound was interrupted before the final reaction, so it looked like it was broken down into two relatively harmless compounds. These compounds are stored in separate containers so

that safe to transport and store. The two compounds were mixed together right before the military application. Russian scientists have created Substance A-230 first. Its killing efficiency exceeds any known military toxic agents by five to eight times. Next step was the synthesis of a binary weapon based on Substance A-232, a toxic agent similar to A-230. A-232 had been an advantage: it could be used in cold temperatures and wouldn't freeze on the battlefield.

Novichok – choline esterase inhibitors (Novichok 5 and Novichok 7). They are effecting very rapidly, penetrate through the skin and respiratory system. Novichok 5 exceeds effectiveness of soman by 10 times and of VX by 5 to 8 times. Novichok 5 (Substance A-232) and its ethyl-analog (Substance A-234) can be produced in binary form by using acetonitrile and an organic phosphate compound.[12] System of agent A-232 components was successfully tested in Nukus Uzbekistan, in the military chemical proving ground in 1992. Existence of the "Foliant" program and Novichok were revealed in 1992 by chemists Lev Fedorov and Vil Mirzayanov in an article of the newspaper Moscow News. Mirzayanov said in an interview that these new binary agents probably were destroyed. They were exploded at a testing site near Saratov. Russia has officially never acknowledged the existence of the group Novichok.

Russian troops were alleged using a chemical warfare named "Black Rain" during the Afghanistan war. This compound is unknown, causes instant death.

Industrial production of TC in the Soviet Union was continued until 1987. In this year 19 specimen of chemical warfare were shown in front of official representatives of different nations and of press to be deployed at that time in the Soviet Army: 6 types of munitions charged with first generation TC (with lewisite and yperite-lewisite mixture), 8 types of munitions charged with OTC (with sarin and soman), 4 types of munitions charged with VX. Only 12 types of 19 were demonstrated because of destruction problem of OTC. In addition there were displayed 18 types of chemical weapons charged with riot control agent CS gas.[12]

First official data came into light in 1988, Politburo announced to the Disarmament Conference that the USSR's stockpile of chemical weapons is about 50.000 tons.

As the result of bilateral negotiations between the US and Soviet Union Wyoming Memorandum was signed in 1989. The Wyoming Memorandum of Understanding (MOU) called for a bilateral exchange of information and verification inspection for chemical weapons. During phase I of MOU parties have exchanged data on CW capabilities, types of chemicals used, percentage of devices in munitions, location of CW storage, production facilities and destruction facilities. Moscow has declared 20 former chemical weapon production facilities and filling plants. Phase II. consisted of

bilateral data exchange on development, production and storage of CW, and of five inspections by each country of facilities. The inspections have ended in 1994.[10]

On January 1993 in Paris Russia signed the multilateral Chemical Weapons Convention. The Soviet Army presented for inspection and destruction 40000 metric tons of CW stockpile: about 8000 metric tons of first generation TC and 32000 metric tons of OTC. Approximately 80 percent of the Russian stockpile was nerve agent. The specified agents were sarin, soman, viscous soman, mustard, lewisite, mustard-lewisite mixture, phosgene and Russian VX. R-VX occurred in both thickened (viscous) and non-thickened varieties. The Russian stockpile of R-VX, sarin, soman and phosgene was 100 percent weaponized, while mustard, lewisite and mustard-lewisite mixture were stored primary in large bulk containers. These agents were stockpiled in 7 locations, five stored nerve agents: Schuch'ye, Kizner, Pochep, Leonidovka, and Maradykovsky. The remaining sites Kambarka and Gorny primaly stored blister agents.

In 1993 Russian started the destroying process of chemical weapons and their facilities, while on the other hand the Russian R&D chemists-scientists have been working continually. Their research was developing the new generation of *incapacitants.* They investigated mainly those pharmaceutical substances that act the human brain, the nervous system. This group of incapacitants became known during the so called "Moscow theatre siege".[13]

Figures 1–3 show some Russian chemical warfares.

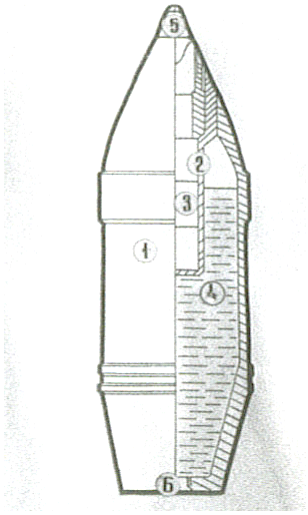

Figure 1. Russian chemical projectile 1. Body, 2. explosive well 3. explosive charge 4. fuse, 5. filling plug
The projectile contained 1.4 kg VX

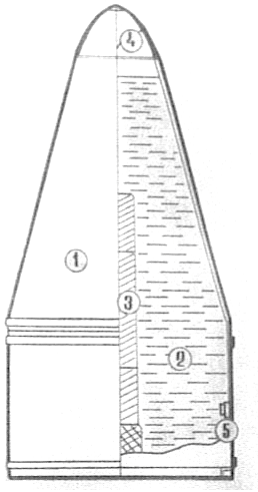

Figure 2. Russian chemical warhead for tactical missile. 1. Body, 2. chemical agent, 3.explosive charge, 4. fuze, 5. filling plug It contained 555 kg VX

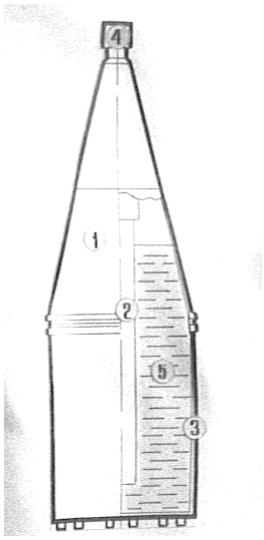

Figure 3. Chemical warhead of tactical missile . 1. Body, 2. explosive charge, 3. filling plug, 4. fuze, 5. chemical agent. The warheads contained 216 kg VX

The Moscow theatre hostage crisis

In 2002 approximately 50 Chechnya separatists took over a Moscow theatre, holding more than 750 people hostage. The hostage-takers were well equipped with automatic weapons and grenades and demanded the withdrawal of Russian troops from Chechnya. Russian Special Forces troops stormed the theatre, first releasing a potent narcotic into the ventilation system. The hostages and terrorists have fallen into a coma. The hostages were rushed into hospitals. In the end approximately 120 hostages died of overdose, but the rest, more than 600 people survived. A number of survivors are likely to have permanent disability. The incapacitating agent (Kolokol-1) used in the crisis probably was a derivative of fentanyl; this opium-based drug releases pain-killing endorphins inducing a state of euphoria. They can also induce sleep or unconsciousness. However large doses of fentanyl and its derivatives can cause respiratory depression. It can starve the brain of oxygen causing permanent brain damage when prolonged.[14] The exact nature of the active chemical has not been verified, the Russian newspaper Gazeta announced that the substance used had been trimethyl-fentanyl. This was likely a mistranslation of 3-methyl-fentanyl, a super potent fentanyl analogue (carfentanil), that is about 1000 times potent than morphine. It takes effect very quickly rendering its victims remain unconscious for two to six hours. One might consider remifentanil, another analogue of fentanyl to be a possible candidate of the incapacity agent in Moscow theatre. Remifentanil is extremely potent with fast action and relatively short duration. Effective antidote to opiates is widely available in the form of naloxon (Narcan).[15]

However this measure of Moscow authorities did not violate the Chemical Weapons Convention, as the treaty allows the use of chemical agents for law enforcement purposes. (Article II. 9/d), the use of Kolokol-1 was indirectly responsible for the death of over 100 victims. This tragedy could happen due to the mistake made by Russian decision-makers, who had taken inadequate attention to the safety of innocent civilians. On the other hand the Moscow hostage rescue could be considered a success, since more than 80 percent of the hostages were recovered alive and terrorists were liquidated.

Incapacitants are also called as non-lethal weapons. This expression is not covers the truth, their lethality is in the same category as those used in World War I. They killed about 7 percent of casualties. Non-lethal agents are not enough useful for law enforcement purposes because of their significant lethality and the ease of defence. In the hands of terrorists or criminals, who don't bother about the defenceless victims, they could pose a serious threat.

Conclusion

Signing the Chemical Weapons Convention Russia has joined the countries supporting the non-proliferation process all over the world. It became apparent soon that Russia was unable to begin and fulfil its obligations of CW destruction program. Russia highlighted its major destruction problems: personnel problems, inadequate funding related to CW elimination and financial problems. Russia asked help for implementation of its tasks. Don't we forget that former Soviet Union has the largest stockpile of CW in the world. There is widely known that Russian weapon facilities are poorly maintained, making insider theft or terrorist attacks possible. Moreover the collapse of Soviet Union has resulted a significant increase in corruption and organized crime in military sector. Corrupt military and state officials increase the threat of acquiring quantities of CW by terrorist or criminal groups. States Parties of CWC (primary the US) have a great responsibility for providing assistance in disarmament process of Russia. Leader states of the world should give all needed technical, legal, financial assistance, as well as training experts in the interest for implementation of Russian CW destruction program as quickly as possible. To be noted every day this process means a prolonged risk not only for Russian, but also for the US and the world security.

What does the future of incapacitating agents look like?

They can be a first step in use pharmacology and biotechnology for hostile purposes. In the near future the science is going to be able to manipulate human consciousness, emotions, motor control, reproductive capacity and common behaviour. Moreover might be useful as law enforcement tools in certain, rare circumstances because of the ease of protection. Unfortunately they have a much greater potential to be used by dictators, terrorists or criminals. The only reassuring solution of non-lethal weapons problem would be a new international treaty that prohibits the hostile manipulation of human organism, central nervous system, reproductive system etc. The aim of the CWC is to prevent nations from entering military conflicts with chemical weapons, than it should be prohibited development, stockpiling and processing incapacitants to prevent their military use.

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