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Study on disposal and destruction of Abandoned Chemical Weapons by the Japanese Army in China

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Abstract

Abandoned chemical weapons (ACW) by the Japanese Army in China belong to old chemical weapons, which were produced in World War Ⅱ, buried underground or underwater. There are significant differences between old chemical weapons and chemical weapons in stock. The aim of the paper is the investigation and study on the disposal and destruction of ACW. We present the methods how to recognize and identify ACW, how to distinguish what kind of chemical warfare agents inside it. Its destruction principle and basic program of ACW, the operation technological processes for destruction of yellow munitions, red munitions, irregular munitions, contaminated solid material and water, other wastewater are specially emphasized.

Keywords: disposal, destruction, chemical warfare agent, controlled detonation chamber

1. Introduction

There are significant differences between ACW by the Japanese Army in China and chemical weapons in stock. Firstly, the symbols of old chemical weapons are difficult to identify and classify because they were destroyed or eroded, and a special method is needed to help identifying the old chemical weapons. Secondly, it is practically impossible to disassemble the old chemical weapons because of the serious corrosion. Thirdly, there are many kinds of the old chemical weapons, mustard agent and arsenious agent are in the majority.

The pertinent data demonstrated that Japanese forces used chemical weapons in 19 provinces in China during aggression against China. The types of toxic chemicals involved included sulfur mustard, lewisite, hydrocyanic acid, phosgene, chloropicrin, diphenylchloroarsine, disphenylcyanarsine,

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chloroacetophenone, and so on. The agent-delivering weapons employed included aero-bombs, shells, gas canisters, artillery projectiles and aircraft spray tanks. By the end of the aggression against China, millions of pieces of chemical weapons were abandoned in the Chinese earth and waters.

Besides survey, point location and excavation of ACW, the main works needed in the disposal and destruction of the old chemical weapons includes recognization, identification, preparation for disintegration, destruction of chemical warfare agents and so on.

2. Recognization and identification of ACW

The symbols of old chemical weapons are difficult to identify and classify because they were destroyed or eroded, and X-ray optical detection is needed to help identifying the old chemical weapons. X-ray optical detection is a method which displays the inner structure of chemical ammunition on a computer screen or negative film, and ascertains what kind an unknown chemical weapon belongs to by the means of compare perspective drawing with design drawing. Only in a few cases, a chemical weapon can be directly ascertained what kind belongs to by the external shape and features. X-ray optical detection system consist of X-ray generator, image booster, shell fixed station, image acquisition and processing system, electrical machine, and radiation dosage indicator. At present, X-ray optical detection has been accepted as an important approach to identify the chemical weapons by the OPCW and other countries.

In addition, ultrasonic pulse reflex method is used to distinguish between chemical ammunition and ordinary ammunition, which is based on the fact that reflect signal comes from front wall and back wall and booster tube. That is to say, if reflect signal only comes from front wall, it is easy to ascertain that it belongs to an ordinary ammunition.

3. How to distinguish what kind of chemical warfare agents

When confirmed, the chemical weapon is to be distinguished what kind of chemical warfare agent inside the chemical weapon further. It is well known that chemical analysis is the best and final method to know the filling material what kind belongs to. However, nondestructive examination (NDE) is an more effective method to ascertain chemical warfare agent inside the chemical weapon. It is important that it is not needed to destroy the structure of chemical weapons.

Neutron active analysis is one of NDE, which is used to identify chemical element, especially to identify chlorine, arsenic, bromine that included in the arsenic compounds or the blister agents. Neutron active analysis consists of two steps. As a first step, the chemical weapon can be irradiated by the thermal neutron or fast neutron from CF-252 neutron source, the chemical elements in the chemical agent will be activated materials, different activated isotope releases γ-ray possessing a certain characteristic energy. The next step is to measure the γ-ray by the means of using high resolution γ detector, such as HPGE. Neutron active analysis schematic diagram was illustrated in Fig. 1. Elective thermal neutron intercept and γ radiation energy generated activated isotope was illustrated in Table 1.

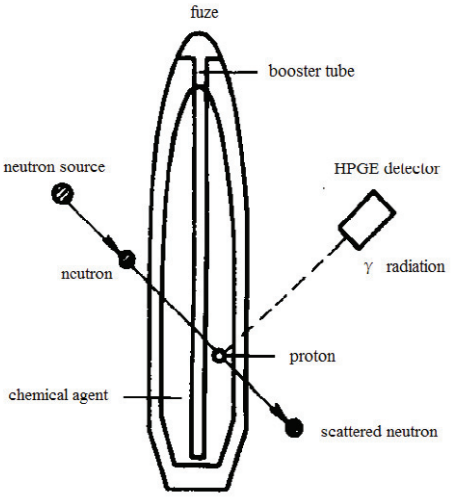

Fig. 1. Neutron active analysis schematic diagram

Table 1. Elective thermal neutron intercept and γ radiation energy generated activated isotope

Chemical element	Nuclear reaction	Half-life period	Radiation energy (KeV)	Relative density (%)
Arsenic	$As^{75}(n)\ As^{76}$	26.4 h	559	44.6
			657	6.4
Chlorine	$Cl^{37}(n)\ Cl^{38}$	37.2 min	1642	32.8
			2167	44.0
Bromine	$Br^{79}(n)\ Br^{80}$	17.6 min	617	7.2
			666	1.1

4. Principle and basic program of destruction of the old chemical weapons

The destruction of chemical weapons should abide by the principle of the irreversibility in the process and the principle of special facilities for destruction. The chemical weapons convention (CWC), in which top priority should be given to insuring the safety of people and environment in the process of destruction of chemical weapons. The methods have been prohibited, such as dumped in the sea, buried beneath the surface, incinerated in the air, etc.

The destruction of chemical weapons should consist of pretreatment, real destruction and post-treatment, according to the safety and environmental guidelines of the CWC. The pretreatment of the chemical weapons is to dismantle or disintegrate it, separate chemical warfare agents from chemical weapons in order to prepare for the real destruction. The real destruction of the chemical weapons is to destroy irreversibly the chemical warfare agents and chemical pollutants. The post-treatment is to make the residue and emissions of destruction of the chemical weapons to content with the environmental standard.

Pretreatment of chemical weapons only adopts technology of heated detonation chamber or technology of controlled detonation chamber (CDC). Technology of heated detonation chamber is a method that

chemical weapons are automatically and directly put into heated detonation chamber, and are heated to 550 degree Celsius, giving rise to explosion. Technology of CDC is method that chemical weapons packed by TNT are detonated by detonator in the controlled detonation chamber, in which chemical weapons are destroyed by the explosive power of TNT. CDC consists of detonation cabin, expanding chamber, effluent control unit. Expanding chamber is large space, connected to the detonation cabin. Effluent control unit includes partical filtering equipment and activated carbon adsorption bed. When the chemical weapons were put into the detonation cabin, the gate of the detonation cabin and the exit of expanding chamber were closed. After that, the detonation may occur, the pressure and temperature of air in the expanding chamber maintain two minutes. At last, the air in the expanding chamber exhausts through the exhaust orifice discharge cavity, partical filtering equipment and activated carbon adsorption bed. When the air is refreshed, the next detonation will be taken place.

Real destruction of chemical weapons, at present, mainly adopts the technology of cremation under high temperature or the technology of chemical decomposition. The technology of cremation under high temperature is the most popular method that chemical agents in the form of gasification, atomization or vaporization, are burned by the spray of natural gas, LPG or vaporized diesel in the temperature 1200 degree Celsius. If the gas of chemical agents, which is burned in the heated detonation chamber, meets the requirement of time not less than two seconds and oxygen density not less than eight percent, the chemical agents are eliminated by 99.9999 percent.

Post-treatment of chemical weapons includes exhaust gas disposal, scrap metal disposal and abraum salt disposal. When chemical warfare agents are burned, gas generates and it is needed to burn further. The gas and smoke generated in the incineration chamber will be sent to contamination control system in order to filtrate and disinfect. If the gas satisfies its safety standard, it can be discharged into air. After the chemical weapons are burned, the metal will be decontaminated and recycled. Contaminated water generated in the process of disinfection is needed to be checked its innocuity. After drying the effluent brine, abraum salt appears. Abraum salt will be collected into a certain container and buried in some specified areas.

Consequently, the basic process of destruction of the chemical weapons basically includes storage, check-up, separate chemical warfare agents from explosive, incineration of explosive, incineration of chemical ware agents, exhaust gas disposal, scrap metal and abraum salt disposal. Else the chemical weapons were buried underground or underwater, many other necessary works are needed such as survey and point location, excavation and recognization, leakage check-up, elimination the pernicious influence, safety dispose. The technological process of destruction of the chemical weapons was illustrated in Fig. 2.

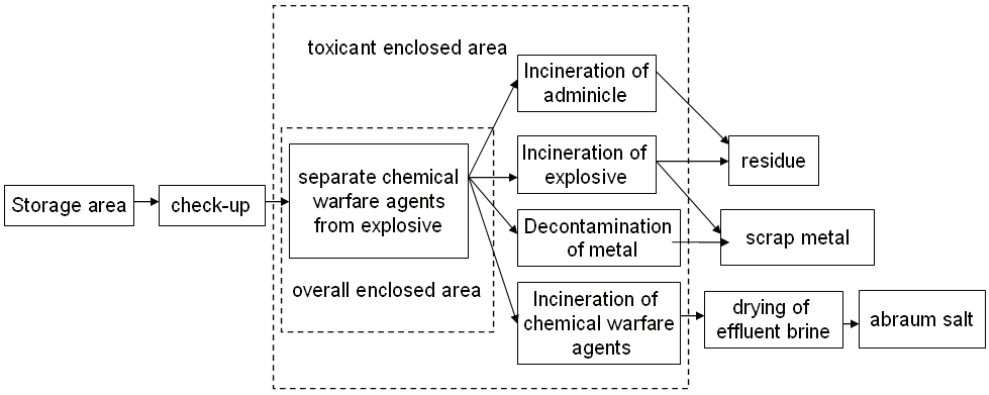

Fig. 2. The technological process of destruction of the chemical weapons

5. The operation technological processes for destruction of yellow munitions, red munitions, irregular munitions, contaminated solid material and water, other wastewater

5.1. Destruction of yellow munitions (mustard, lewisite)

In the process of pretreatment, the yellow munitions are detonated in the heated detonation chamber. In the process of real treatment, the warfare agents are burned two times in the first burning furnace and the second burning furnace, the gas generated is sent into gas contamination control system. When it is filtrated and decontaminated in the gas decontamination system and disposed by the means of environment protection, it can be discharged into air. Shell splinters of the yellow munitions are also burned two times in the burning furnace with a dismountable bottom and the second burning furnace, the gas generated in the burning shell is filtrated and decontaminated in gas decontamination system for the gas generated in the burning shell and disposed by the means of environment protection. The metal of shell will be decontaminated and recycled. The technological process of destruction of the yellow munitions was illustrated in Fig. 3.

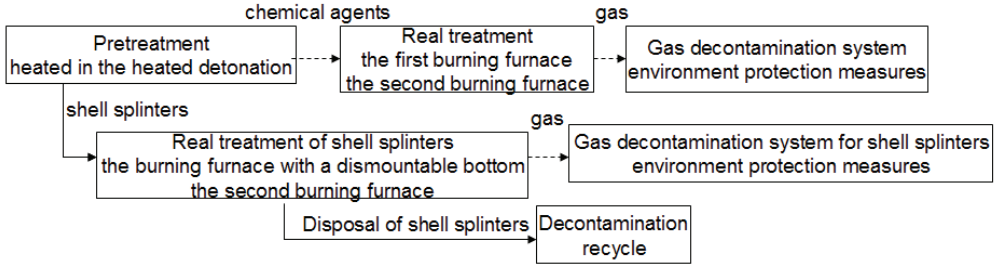

Fig. 3. The technological process of destruction of the yellow munitions

5.2. Destruction of red munitions (diphenylchloroarsine, disphenylcyanarsine)

At first, the explosive of the red munitions will be eliminated by waterjet cutting and the shell is cut by the round saw, so chemical warfare agents exude from the red munitions. Secondly, the warfare agents and shell are burned two times in the burning furnace with a dismountable bottom and the second burning furnace, the gas is generated. When filtrated and decontaminated in the gas decontamination system and disposed by the means of environment protection, the gas can be discharged into air. The metal of shell will be decontaminated and recycled. Explosive of the red munitions are burned in the rotary burning furnace and the second burning furnace, the gas generated is filtrated and decontaminated to meet the acquirement of environment protection, then can be discharged into air. The technological process of destruction of the red munitions was illustrated in Fig. 4.

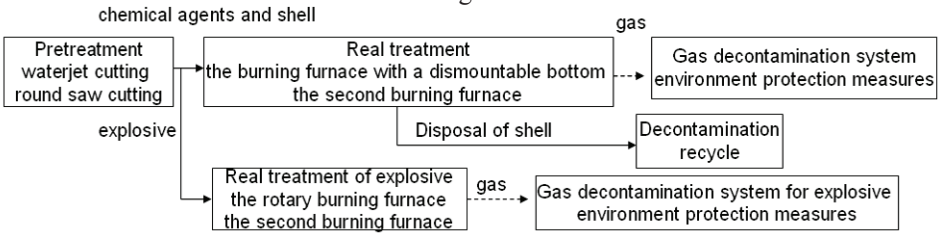

Fig. 4. The technological process of destruction of the red munitions

5.3. Destruction of irregular chemical munitions

At first, irregular chemical munitions with more explosive, such as 150mm red, are needed to eliminate explosive by waterjet cutting, irregular chemical munitions such as gas canister are needed to detonate in the heated detonation chamber, irregular chemical munitions such as chemical drums are needed to evaporate chemical warfare agents. Secondly, what is worth mentioning, the vapor of chemical warfare in chemical drums is need to burn in the burning pipe. The technological process of destruction of the irregular munitions is similar with red munitions in content, was illustrated in Fig. 5.

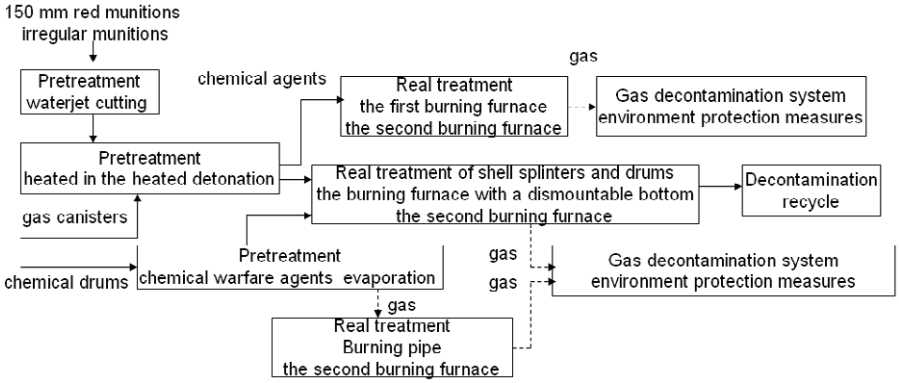

Fig. 5. The technological process of destruction of the irregular munitions

5.4. Disposal of contaminated solid material and water

Contaminated solid material and water are divided to contaminated liquid, combustible solid material, incombustible material, metal, contaminated water by yellow munitions and contaminated water by red munitions. The technological process of destruction of the contaminated solid material and water was illustrated in Fig. 6.

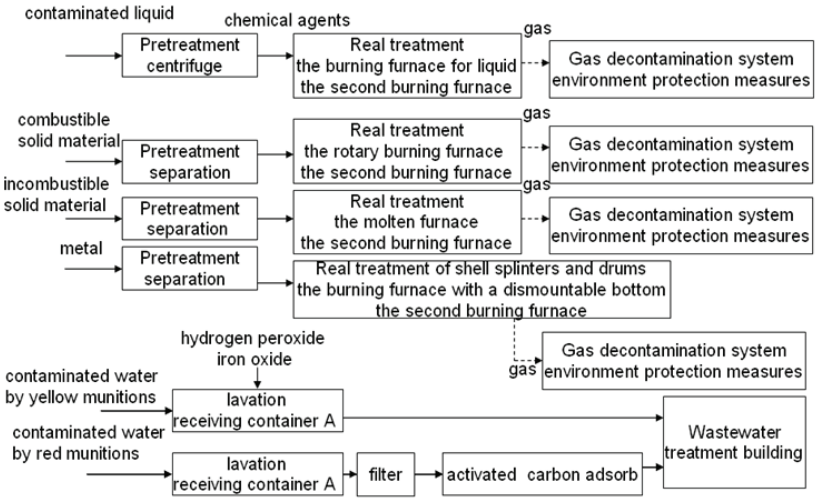

Fig. 6. The technological process of destruction of the contaminated solid material and water

5.5. Disposal of other wastewater

The technological process of destruction of the wastewater was illustrated in Fig. 7.

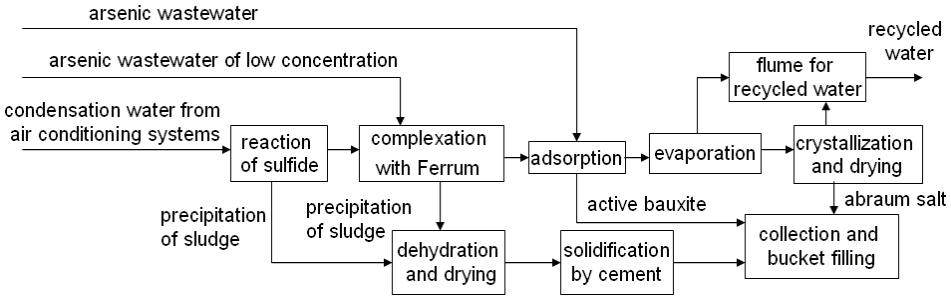

Fig. 7. The technological process of destruction of the wastewater

6. Main facilities for destruction of old chemical weapons

The main facilities for destruction of old chemical weapons can be divided into two parts, main factory facilities and sub-factory facilities. The main factory facilities are designed to dispose and destruct the regular yellow munitions and the regular red munitions. The main factory facilities consist of yellow munitions receiving building, yellow munitions destruction building, red munitions receiving building and red munitions destruction building.

The sub-factory facilities are designed to dispose and destruct the irregular yellow munitions, the irregular red munitions, other kind of chemical weapons, contaminated soil and water. The sub-factory facilities consist of irregular munitions receiving building, irregular munitions destruction building, decontamination building, wastewater treatment building. Irregular munitions destruction building is built for dispose irregular yellow munitions, irregular red munitions, other kinds of chemical weapons, such as chemical weapons with detonator, chemical aerial bombs. Decontamination Building is built for dispose hurtlessly the waste water, the combustible solid material and incombustible solid material, which contaminated by chemical warfare agents and came from yellow munitions destruction building, red munitions destruction building, irregular munitions destruction building and other buildings. Wastewater treatment building is built for dispose hurtlessly the waste arsenic water and the condensate water in air conditioning system, which came from yellow munitions destruction building, red munitions destruction building, irregular munitions destruction building and decontamination building.

7. Conclusion

The disposal and destruction of ACW by the Japanese Army in China is a realistic, necessary and urgent task in the environment protection. Key techniques include X-ray optical detection, Neutron active analysis and technology of controlled detonation chamber. The real destruction of ACW has been done since September, 1, 2010.

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