Provisional Translation

STUDY REPORT

MAY 1999

TECHNOLOGY STUDY GROUP
FOR
THE DESTRUCTION OF ABANDONED CHEMICAL WEAPONS

INTRODUCTION

The Government of Japan has been making efforts to solve the issue of chemical weapons abandoned in China by setting up the Abandoned Chemical Weapons Coordination Council (hereafter called the Coordination Council) in August 1997, following approval of the Cabinet. As part of the effort, the Technology Study Group for the Destruction of Abandoned Chemical Weapons (hereafter called the Study Group) was established. Its task was to study various technologies for destruction of the Abandoned Chemical Weapons (hereafter called the ACWs) from technological and professional viewpoints, and to present its view to the Coordination Council.

It was considered necessary for the Group's study that prospective technologies should be solicited from domestic/foreign private enterprises and other entities, ensuring a fair and transparent process. As a result of announcement in the Public Bulletin of July 6, 1998, "the Invitation for Submission of Technology Proposal for the Destruction of Abandoned Chemical Weapons", a substantial number of proposals were submitted by domestic/foreign private enterprises and other entities. The scope of this invitation for the proposals covers the destruction technologies (Pre-treatment, Treatment and Post-treatment Technologies) that form part of the total disposal process, which consists of excavation/recovery, transportation/storage, destruction, etc., necessary to destroy all the ACWs, estimated at about 700,000. Most of these chemical weapons are assumed to be buried at the Haerbaling District, Dunhua, Jilin Province (the largest burial site) and other burial sites.

This report has been prepared to summarize the information on the destruction technologies and related matters acquired through the study by the Study Group and the recommendations regarding future review subjects, and to present those to the Coordination Council.

The study and review by the Study Group has been performed as part of the effort to collect information and data related to available technologies to destroy the ACWs. The study is not intended as a pre-qualification for tenders which may be invited by a government procurement entity.

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Chapter 1. Summary of the Technology Study

Since May 1st, 1998, eight meetings have been held at which the Study Group has studied and reviewed destruction technologies. This report summarizes the recommendations of the Study Group. It covers the characteristics of the ACWs in China in Chapter 2, the organization and management of the Study Group in Chapter 3, the study of the destruction technologies in Chapter 4, the suggestions for the destruction undertaking in future in Chapter 5 and other recommendations in Chapter 6. The findings of technical study and review are addressed in Chapter 4. The main findings in Chapter 4 are summarized below.

The main subject of study in Chapter 4 is the constituent process technologies of the Pre-Treatment and Treatment processes. The technologies proposed in response to the invitation in July 1998 have been sorted in terms of Pre-Treatment and Treatment. These are shown in the table below. The constituent process technologies have been studied and reviewed.

Note: The "constituent process technology" in this text means each of the following; Pre-Treatment for preparatory process such as munitions dismantling and separation; Treatment for disposal process of the materials pre-treated in the Pre-Treatment process (in case of chemical agents, explosives and metal parts being separated at the Pre-Treatment process, Treatment for each of those materials); Post-Treatment for releasing or disposing of residues and other wastes produced in the Treatment process to the environment in compliance with the environmental emission standards.

Pre-Treatment Technologies	Treatment Technologies		Others
	Thermal	Chemical	
• Boring/ Machining • Plasma Torch Cutting • Fluid-Abrasive Cutting • Cryogenic Fragmentation • Detonation Chamber	• Fuel-fired Combustion Furnace • Radiation Furnace • Plasma Arc Furnace • Molten Media Furnace • High Temp. Gas Phase Reduction • Detonation Chamber • Underground Detonation	• Neutralization • Supercritical Water Oxidation • Mediated Electrochemical Oxidation • Solvated Electron Reduction • Sodium Reduction	• Superheated Steam Tunnel Furnace • Spray Washing • Dry Ice Blasting

Based on information and data acquired to date, a preliminary review has been performed. The characteristics of constituent process technologies and the subjects for consideration have been sorted for future study and review. Among these described in Chapter 4, the subjects for consideration in common among Pre-Treatment technologies and those among Treatment (thermal, chemical) technologies are summarized below.

【Pre-Treatment Technologies】

The subjects for consideration are mainly associated with the risks related to explosion and leakage, the chemical/physical robustness of materials and equipment and the effects due to the physical condition of the old chemical weapons.

1) Methods of feeding and placing munitions into the Pre-Treatment process
2) Effects due to deformation, corrosion and the variety of sizes of munitions, bombs, etc.
3) Method of leak prevention of chemical agents and the like (inclusive of those vaporized) in the process of Pre-Treatment and during feeding into the Treatment process
4) Methods to remove solid and gelled chemical agents and the like, and to wash out chemical agents adhering to the inner surfaces of munitions
5) Method of feeding removed chemical agents and the like (inclusive of those vaporized) from the Pre-Treatment to the Treatment process
6) Explosion risks due to impact, thermal or other energy transfer to explosives in the process of Pre-Treatment
7) Durability of materials of the Pre-Treatment process equipment against chemicals (chemical agents, chlorine, sulfur, etc.) under specific operational conditions
8) Effects due to involuntary feeding of conventional munitions
9) Effects on process speed due to replacement frequency of worn-out or contaminated tools (drill, cutting edge, nozzle, die and other tools), materials and equipment.

【Treatment Technologies】

The subjects for consideration in common among all Treatment technologies are: (1) the durability of equipment materials against chemicals (chemical agents, chlorine, sulfur and the like) under specific operational conditions, (2) the monitoring method of hazardous substances in the waste stream, and (3) the management of hazardous chemical substances in the process when process upsets occur in systems such as fuel supply, electricity supply, etc. The subjects for consideration in each of thermal and chemical treatment technologies are summarized below.

[Thermal Treatment Technologies]

1) Effects on process speed due to replacement frequency because of breakdown and deterioration of the furnace components that will be heated
2) Risks due to highly heated and pressurized gas (overpressure, explosion, rupture, etc.)
3) Risks of insufficient treatment in the event of under-exposure to heat by overfeeding chemical agents

4) Collection and post-treatment methods of vaporized and sublimated heavy metals in the process

[Chemical Treatments Technologies]

1) Optimum pre-process method (making substances in a form of liquid, slurry or paste, size-reducing, etc.) for substances including solid and gelled chemical agents to feed into the Treatment process
2) Effects due to impurities

It was previously scheduled that if possible, the Study Group would study and review the characteristics and the subjects for consideration regarding the technology combinations (integrated systems) of constituent technologies for Pre-Treatments, Treatments and Post-Treatments. However, the Study Group's concrete study on these aspects has been deferred due to the following reasons, as addressed in Clause 4.2.2.

(1) Options should not be narrowed for viable combinations of constituent process technologies.
(2) Sufficient information and data are not available on the characteristics of the ACWs and the conditions of feeds in the disposal process.
(3) The emission standards and other requirements related to environmental protection are yet to be determined.
(4) Sufficient information and data have not yet been collected to review and assess the combinations of constituent process technologies.

As an issue related to Post-treatment, the disposal management of the effluents containing arsenic has been studied and reviewed. The basic strategies for this issue are summarized below:

(1) Discharge of liquid or gaseous wastes into the environment, if any, should comply with applicable environmental regulations in China.
(2) As for solid wastes containing arsenic, detailed comparisons and review on a variety of disposal solutions should be performed, including a consideration of costs, with the provision of complying with the regulations for environmental protection. Disposal solutions include landfill of solid wastes containing arsenic and recycling of arsenic before landfilling.

In addition to the above, the technical requirements for the destruction technologies (inclusive of the outline of safety measures), the consideration for the destruction undertaking in future and other matters have been studied and reviewed. The findings on these subjects are addressed later in Chapters 4 and 5.

Chapter 2. Characteristics of the ACWs in China

The burial sites (the unearthed sites and the not-yet unearthed sites) where the existence of ACWs has been confirmed or where site investigations have been conducted based on the information provided by the Chinese concerned authorities are shown in Figure 2-1. The quantities of the ACWs confirmed or assumed to be in existence are shown in Table 2-1. The locations of the temporary storehouses currently holding the ACWs are shown in Figure 2-2.

(1) Characteristics of the ACWs

As principle characteristics of the ACWs, five points are described as follows;

1) A wide variety of the ACWs are assumed to be buried. The total number of the ACWs are asuumed to be approximately 700,000.
2) Most of the ACWs are buried in the Haerbaling District of the City of Dunhua, Jilin Province. Based on the investigations so far conducted, the burial sites and the temporary storehouses are widely scattered from Zhejiang Province in the south to Heilongjiang Province in the north.
3) Most of the unearthed ACWs are found corroded and damaged due to a long period of burial since the end of the war.
4) Since some of the ACWs contain picric acid as booster or bursting charge, they may have developed picrates highly sensitive to explosion.
5) Many of the chemical agents contain arsenic.

(2) Types of the ACWs of the former Japanese Army

The names of the chemicals used by the former Japanese Army are as shown below.

Type		Name by the former J. Army	Chemicals
Toxic/Lethal	Blister	Yellow	Mustard, Lewisite
	Choking	Blue	Phosgen
	Blooding	Brown	Hydrogen Cyanide
Riot Control	Vomiting	Red	Diphenylcyanoarsine Diphenylchloroarsine
	Tear	Green	Chloroacetophenone
Smoke	Smoking	White	Trichloroarsine

The main chemical weapons of the former Japanese Army are as shown in Table 2-3(1/3) to (3/3).

Figure 2-1: Location Map of the Unearthed and Not-yet Unearthed Sites

Table 2-1 Locations and Types of the Unearthed and Not-Yet Unearthed ACWs

Div.	No.	Location	Types of ACWs
1. Already Unearthed	①	Fulaerji Area of Qiqihar City, Heilongjiang Prov. ⇨Ⓐ (All except a projectile with fuse were moved to Ⓐ)	39-75mm chemical projectiles, 184-90mm chemical mortars (incl. one with fuse), 5-105mm chemical proj., 12-150mm chemical proj. Total: 240 (incl. some probable conventional munitions)
	②	Bayan Prefecture, Heilongjiang Prov. (in an armed storehouse) ⇨Ⓐ	24-150mm chemical proj., 12-105mm chemical proj., 2-90mm chemical mortars, 2-75mm unidentified proj.
	③	Shangzhi City, Heilongjiang Prov. ⇨Ⓐ	★47-105mm chemical proj.(incl. some probable conventional munitions)
	④	Shuang Cheng Heilongjiang Prov. (in a militia storehouse)	2-75mm chemical proj., 6-90mm chemical mortars, 2-105mm chemical proj., 1-150mm chemical proj.
	⑤	Mudanjiang City, Heilongjiang Prov. ⇨Ⓐ	8-75mm Yellow proj., 11-75mm Red proj., 1-75mm Blue/White proj., 108-90mm Yellow proj., 76-90mm Red proj., 2-105mm Yellow proj., 1-105mm Red proj., 4-150mm Yellow proj. Total: 211
	⑥	Suburb of Jilin City, Jilin Prov. ⇨Ⓑ	47-75mm chemical proj., 1-150mm chemical proj.
	⑦	Shenyang City, Liaoning Prov. ⇨Ⓑ	6 drum cans (Yellow agent), 4-150mm chemical proj.
	⑧	Fushun City, Liaoning Prov. ⇨Ⓑ	6-75mm Yellow proj., 92-75mm Red proj., 1-90mm Yellow proj., 8-90mm Red proj., 8-105mm Red proj. Total: 115
	⑨	Huhehaote City, Inner-Mongolia, Autonomous Region ⇨Ⓒ	4 drum cans (Yellow agent)
	⑩	Suburb of Xuzhou City, Anhui Prov. ⇨Ⓓ	3 drum cans (Yellow agent)
	⑪	Damiaoxiang-Huanghuzishan, Xiaguan District, Nanjing City, Jiangsu Prov. ⇨Ⓓ	Approximately 6,000 toxic smoke canisters and the like (For details, re-identification is required)
	⑫	Hefei City, Anhui Prov.	31-75mm Red proj.
	⑬	Hangzhou City, Zhejiang Prov. (in a public security's warehouse) ⇨Ⓓ	10-75mm chemical proj.
	⑭	Haerbaling Area of Dunhua City, Jiling Prov. (in a watch station)	5-75mm Yellow proj., 4-75mm Red proj., 5-90mm Yellow proj., 2-90mm Red proj., 3-105mm Yellow proj., 1-150mm Yellow proj., 1-150mm Red proj., 2 Red canisters Total: 23

Table 2-1 (continued)

Div.	No.	Location	Types of ACWs
2. Not-yet Unearthed	1	Sunwu City, Heilongjiang Prov.	★Approximately 500 chemical proj. 1 drum can (chemical agent) 2 boxes of toxic smoke canisters
	2	Bei'an City, Heilongjiang Prov.	★75mm, 105mm and 150mm proj. 90mm mortars and other munitions Total: Approximately 1,500 (incl. some probable conventional munitions)
	3	Bayan Prefecture, Heilongjiang Prov. (in an ironworks)	★Approximately 100 chemical proj.
	4	Haerbaling Area of Dunhua City, Jiling Prov.	☆75mm, 105mm and 150mm proj. 90mm mortars and other munitions Total: Estimated approximately 670,000 (incl. some probable conventional munitions)
	5	Shijiazhuang City, Hebei Prov.	★52-75mm chemical proj.
	6	Damiaoxiang-Huanghuzishan, Xiaguan District, Nanjing City, Jiangsu Prov.	★Approximately 3,000 toxic smoke canisters (3 of them were disassembled and investigated in Shenyang City) Samples (one 90mm chemical projectile and one fuse) are in storage at Ⓒ

Notes: Storage locations:

Ⓐ : Temporary storehouse in the suburb of Harbin City, Heilongjiang Prov.
Ⓑ : Temporary storehouse in the suburb of Shenyang City, Heilongjiang Prov.
Ⓒ : Temporary storehouse in the suburb of Beijing City
Ⓓ : Temporary storehouse in the suburb of Nanjing City, Jiangsu Prov.

Division 1: Munitions that have been unearthed and identified as the ACWs by numerous site investigations, and are currently in temporary storage. (The munitions of ③ and ⑪ have not yet been confirmed in detail by the Japanese Government.)

Division 2: Munitions that have been site-investigated but not yet unearthed, and require further site investigations. (Because they are buried underground and the quantity and sizes are unknown, further investigations such as unearthing and identification are required.)

☆ : Estimated quantity based on the site investigations to date conducted

★ : Quantity based on the information provided by the Chinese Government

Figure 2-2: Location Map of the Temporary Storehouses of the ACWs

Table 2-2 The ACWs in Temporary Storehouses

No	Temporary Storehouse	Types ACWs	Breakdown of Identified ACWs
Ⓐ	Suburb of Harbin City, Heilongjiang Prov.	59-75mm chemical proj. 2-75mm unidentified proj. 369-90mm chemical mortars 67-105mm chemical proj. 40-150mm chemical proj. Total: 537 (incl. some probable conventional proj.)	75mm: 37 Yellow proj. 11 Red proj. 1 Blue/White proj. 90mm: 237 Yellow mortars 126 Red mortars 105mm: 7 Yellow proj. 4 Red proj. 150mm: 17 Yellow proj. 1 Red proj.
Ⓑ	Suburb of Shenyang City, Liaoning Prov.	145-75mm chemical proj. 9-90mm chemical proj. 8-105mm chemical proj. 5-150mm chemical proj. 6 drum cans containing chemical agent Total: 167 proj. and 6 drum cans	75mm: 7 Yellow proj. 129 Red proj. 90mm: 1 Yellow proj. 8 Red proj. 105mm: 8 Red proj. 6 drum cans containing Yellow agent
Ⓒ	Suburb of Beijing City	4 drum cans containing chemical agent	4 drum cans containing Yellow agent
Ⓓ	Suburb of Nanjing City, Jiangsu Prov.	10-75mm chemical proj. 3 drum cans containing chemical agent Approximately 6000 toxic smoke canisters (For details, re-identification is required)	75mm: 10 Red proj. 3 drum cans containing Yellow agent

Note: The above breakdown of the ACWs is based on the identification by X-ray or observing external appearances.

Table 2-3 Main Chemical Weapons of the Former Japanese Army and Filled Chemical Agents

(1/3)

Type of Munition	Specific Name	Size of Shell (mm)	Total Weight (kg)	Chemical Components	Weight of Filled Chemical Agent (g)	Booster (g)		Burster (g)
						RDX [Tetryl]	Picric Acid	TNT80% +N20%
Projectiles Mortars	Type-92 yellow munition	75	5.61	H:L=50:50	800		60	
	Type-92 blue/white munition		5.50	CG:AT=90:10	726		30	
	Type-92 red munition		6.28	DC(note 1)	180		40	
	Prototype-97 brown munition		5.14	AC	365		30	
	Type-95 yellow munition	90	5.32	H:L=50:50	857	[20]	100	
	Type-95 red munition		5.34	DC(note 1)	238	[11]	29	605 (85%:15%)
	Prototype-99 brown munition		6.84	AC	1029		160	
	Prototype blue munition		8.00	CG	2,080		160	
	Type-92 neo-yellow munition	105	15.84	H:L=50:50	2,230		40+100	
	Type-92 neo-blue/white munition		15.57	CG:AT=90:10	1,960		40+100	
	Type-93 neo-red munition		16.45	DC(note 1)	630		40	1,210
	Prototype-97 neo-brown munition		14.59	AC	980		40+100	
	Type-92 neo-yellow munition	150	31.28	H:L=50:50	5,710	41	160	
	Type-92 neo-blue/white munition		30.59	CG:AT=90:10	5,030	41	160	
	Type-93 neo-red munition		32.10	DC(note 1)	1,275		74	3,325
	Prototype-97 neo-brown munition		28.08	AC	2,520	41	160	
Somke Canisters	Prototype-98 red canister	55	0.27	DC, DA	90			
	Prototype-99 red canister	111	1.45	DC, DA	456			
	Prototype-100 red canister (Ejection Type)	200	1.02	DC, DA	54			

(2/3)

Specific Name	Total Weight (kg)	Chemical Components	Weight of Filled Chemical Agent (g)	Booster (Picric Acid) (g)	Burster (g)
Type-95 15kg red bomb	14.25	DC(note 1)	368	75	1,210 (TNT80%+N20%)
Type-100 50kg blue/white bomb	46.37	CG:AT=90:10	16,800	unknown	1,770
Type-100 50kg yellow bomb	48.51	H:L=50:50	18,940	unknown	1,770
Type-100 50kg brown bomb	37.74	AC	8,170	unknown	1,770
Type-99 50kg brown bomb	41.28	AC	9,450	59	2,630 (TNT or picric acid)

(3/3)

Yellow Agent Container (bulk)	Length (cm)	Diameter (cm)	Filled Chemical Agent	Weight of Filled Chemical Agent (kg)
Type-A (Note 2)	73	47	H	100
Type-B (Note 2)	73	47	L	100

Legend:

- H: Mustard
- L: Lewisite
- CG: Phosgene
- AT: Trichloroarsine
- DC: Diphenylcyanoarsine
- DA: Diphenylchloroarsine
- AC: Hydrogen cyanide
- N: Naphthalene

Notes:

1. Unconfirmed, but possibly mixed with diphenylchloroarsine
2. There is possibility that Mustard and Lewisite are mixed and stored in a drum can
3. Existence of the chemical weapons shaded with [shaded box] are identified by site investigations.

Chapter 3. Activities of the Study Group

3.1 Organization of the Study Group

The destruction of the ACWs calls for study and review covering a wide variety of technical and professional fields. Such fields include destruction of the munitions, chemical agents and metal parts, the system design, the environment and safety. Japan does not have any technology or experience of the destruction of the ACWs. Under such circumstances, the Study Group was organized, appointing the Director-General of the Abandoned Chemical Weapons Coordination Division, Councilors' Office on External Affairs as a chairman. Ten members with expertise in the related fields formed the Study Group.

Members of the Study Group

Chairman:

Seigi HINATA	Director General, Abandoned Chemical Weapons Coordination Division, Councilors' Office on External Affaires, Cabinet Secretariat

Members: (in alphabetical order)

Tomie AMARI	Former Commandant of Chemical School, Ground Self Defense Force
Yuji ENOMOTO	Deputy Director-General Mechanical Engineering Laboratory
Shuzo FUJIWARA	Director, Advanced Chemical Technology Department National Institute of Material and Chemical Research
Shigeji KOSHI	Technical Advisor, Technical Department Japan Industrial Safety and Health Association
Kouichi MIZUNO	Director, Environmental Assessment Department National Institute for Resources and Environment
Masatoshi MORITA	Director, Regional Environment Division National Institute for Environmental Studies
Shoji NAKAHARA	Former Professor at the National Defence Academy
Hiroaki SHIRAISHI	Section Head, Analytical Quality Assurance Section National Institute for Environmental Studies
Masaru TANAKA	Director, Department of Waste Management Engineering Institute of Public Health
Mitsugu TANAKA	Director, Department of Decommissioning & Waste Management Japan Atomic Energy Research Institute

3.2 Study Approach

The purpose of the Study Group is to study and review, from technological and professional viewpoints, various technologies in the possession of private enterprises and other entities for the destruction of the ACWs. The Study Group will then present its view to the Coordination Council. For this purpose, information on prospective technologies were solicited from domestic/foreign private enterprises and other entities in a fair and transparent manner, and reviewed the technologies principally in accordance with the following study policies.

(1) Materialization of Technical Requirements

Further in detail study and review the Technical Requirements imposed for collection of information on various technologies in the possession of private enterprises and other entities. If more specific Technical Requirements are needed, study and review those as well.

(2) Study of Each Constituent Process Technology

Identify main advantages and disadvantages in each constituent process technology of Pre-Treatment and Treatment. Study further technically critical matters, as required.

For Post-Treatment, study its design concept including study what kind of Post-Treatment is the most favorable for the disposal management of solid wastes because it is critically associated with Post-Treatment.

(3) Study of Combination of Treatment Technologies

Identify main advantages and disadvantages in each of the viable combinations of constituent technologies for Pre-treatment, Treatment and Post-Treatment. Study further technically critical matters, as required.

(4) Others

Identify outstanding technical matters which may require further detailed investigations and study, and as required, also study technical matters related to excavation, recovery, transport and storage of the ACWs as well.

3.3 Outline of Study

The Study Group has conducted study and discussions at a total of eight meetings held since May 1st, 1998. Primary results of their study and findings are outlined as follows;

(1) The First Meeting

1) Date and Time

May 1st, 1998 (Friday) 14:00-16:00

2) Primary Agenda

a. Outline of the issue of the ACWs

b. Examples of destruction technologies

3) Contents

The Secretariat (Abandoned Chemical Weapons Coordination Division) explained the issue of the ACWs in China, the characteristics of the abandoned weapons, the tentative destruction schedule considered in accordance with the Chemical Weapons Convention, and the background in setting up the Study Group. Further, the current situation of foreign destruction was explained based on the reports of research teams dispatched to the US and Europe. Questions and answers followed.

(2) The Second Meeting

1) Date and Time

June 23rd, 1998 (Tuesday) 14:00-16:00

2) Primary Agenda

Invitation for submission of technology proposal for the destruction of the ACWs (including the technical requirements (the first stage))

3) Contents

The documents of “Invitation for Submission of Technology Proposal for the Destruction of Abandoned Chemical Weapons” and “Technical Requirements (The First Stage)” were examined and adopted by the Study Group.

(3) The Third Meeting

1) Date and Time

July 30th, 1998 (Thursday) 14:00-16:00

2) Primary Agenda

a. Technical Requirements (the second stage) for technology proposals for the destruction of the ACWs

b. Evaluation criteria for technology proposals

3) Contents

Technical Requirements (the second stage) and evaluation criteria were discussed.

(4) The Fourth Meeting

1) Date and Time

September 29th, 1998 (Tuesday) 14:00-16:30

2) Primary Agenda

The Interim Report (Draft) of “The Study Group for the Destruction of Abandoned Chemical Weapons”

3) Contents

The Interim Report (Draft) was reviewed and discussed.

(5) The Fifth Meeting

1) Date and Time

November 6th, 1998 (Friday) 10:30-12:30

2) Primary Agenda

a. The Interim Report (Draft) of “The Study Group for the Destruction of Abandoned Chemical Weapons”

b. Review of each of constituent process technologies

3) Contents

The Interim Report (Draft) was reviewed and adopted. The constituent process technologies of proposed Pre-Treatments and Treatments were reviewed and discussed.

(6) The Sixth Meeting

1) Date and Time

December 7th, 1998 (Monday) 10:30-12:30

2) Primary Agenda

a. Review of each of constituent process technologies

b. Identify questions on each of the proposed disposal technologies

c. Small disposal plant

3) Contents

First, in succession from the previous Meeting, outstanding issues to be further reviewed on each of constituent process technologies of the proposed Pre-Treatment and Treatment technologies were reviewed and discussed.

Secondly, questions on each of the proposed disposal technologies were reviewed and adopted.

Finally, after the purpose and positioning of deployment of the small disposal plant were explained by the Secretariat, the Technical Requirements for the plant were reviewed and discussed.

(7) The Seventh Meeting

1) Date and Time

February 12th, 1998 (Friday) 10:30-12:30

2) Primary Agenda

a. Review of constituent process technologies and combinations

b. Disposal management of the wastes containing arsenic

c. The technical requirements

3) Contents

First, the constituent process technologies of Pre-Treatment and Treatment, the characteristics of the combinations of these technologies and outstanding issues were reviewed and discussed.

Secondly, disposal management of the wastes containing arsenic were reviewed and discussed.

Finally, the Technical Requirements for the destruction of the ACWs were reviewed and discussed.

(8) The Eighth Meeting

1) Date and Time

May 12th, 1999 (Wednesday) 15:00-17:00

2) Primary Agenda

The Study Report (Draft) of "Technology Study Group for the Destruction of Abandoned Chemical Weapons"

3) Contents

The Study Report (Draft) of "Technology Study Group for the Destruction of Abandoned Chemical Weapons" was reviewed, discussed and adopted.

Chapter 4. Study of Destruction Technologies

4.1 Proposed Technologies

In order to perform proper study and review, it was considered an appropriate first step to acquire and study information and data on available destruction technologies from domestic/foreign enterprises and other entities, ensuring a fair and transparent process. For this purpose, proposals on prospective technologies were invited.

For the invitation for proposals, considering the characteristic aspects of this disposal project, the Technical Requirements described below were shown to solicit such disposal technologies that could satisfy these primary requirements.

【Technical Requirements】

(1) Efficacy/Integrity

The technology shall be an effective disposal system such that the Red and Yellow munitions and the Red canisters, at least, of the ACWs can be disposed of in an integrated process.

Further, pursuant to the requirements of the Convention, the technology shall be able to convert chemical agents in an essentially irreversible way to a form unsuitable for production of chemical weapons, as well as munitions and other devices irreversibly unusable. Also, such disposal methods as dumping in any body of water, land burial or open-pit burning, as prohibited by the Convention, shall not be used.

The proposal for part of a total disposal system will not be evaluated. Disposal technology to be proposed shall be a disposal system comprising Pre-Treatment, Treatment and Post-Treatment processes as defined hereafter. However, the disposal system is not necessarily required to divide its system into these three processes.

[Definition]

Pre-Treatment:	Preparatory process for Treatment such as munitions dismantling and separation
Treatment:	Process consisting mainly of irreversible conversion of chemical agents extracted from pre-treated munitions
Post-Treatment:	Treatment process of residues and effluents after the Treatment in order to meet environmental emission standards prior to discharge or discard

(2) Schedule Requirement

The technology shall have the capacity to complete the disposal of the estimated 700,000 munitions, and shall conform to the schedule as specified in the Convention.

(3) Environmental Emission Standards

The technology shall satisfy the environmental regulations and emission standards (national standards) of China.

(4) Safety

The technology shall be capable of effectively minimizing various risks and safely disposing of the chemical weapons.

(5) Maturity

The technology shall satisfy at least one of the following requirements:

a. Destruction operation or proving testing has been implemented with chemical weapons, conventional munitions or toxic wastes.

b. Proving testing is currently in the process of implementation with chemical weapons, conventional munitions or toxic wastes.

As a result of an open invitation for technology proposals in accordance with the above technical requirements, a considerable number of proposals were submitted by domestic/foreign enterprises and other entities. Useful information and data on destruction technologies were collected. The proposed technologies were identified and sorted as shown in Table 4-1 and 4-2. These technologies were reviewed as destruction technologies (Pre-Treatment and Treatment) to dispose of Yellow munitions (the munitions filled with so-called "Yellow Agent" inclusive of mustard and lewisite) and Red munitions (the munitions filled with so-called "Red Agent" inclusive of diphenylcyanoarsine and the like).

Further, auxiliary technologies that are not listed in Table 4-1 and 4-2 but treat metal parts, etc. after dismantling/separating in the Pre-Treatment process were also studied (ref: Table 4-3).

Table 4-1 Pre-Treatment Technology

Technology Name	Description of Technology
Boring/Machining	Mechanical boring or cutting, usually applying coolant or other cooling agents to cool off munitions in cutting process and dismantling/separating of munitions and chemical agents
Plasma Torch Cutting	Cutting munitions with plasma torch at super high temperatures
Fluid-Abrasive Cutting	Crosscutting and dismantling munitions with high pressured fluid (250 to 4,000 bars) containing abrasives. Fluids are water, alkali water solution, ammonia and the like.
Cryogenic Fragmentation	Submerged and embrittled in cryo-bath of liquid nitrogen, and fractured down into pieces mechanically by press, hammer, shredder or other mechanical means
Detonation Chamber	Detonated and fragmented in a chamber. Two methods; Thermally Initiated (heated chamber detonation) and Explosive Supplemented (detonation with supplemented explosives)

Note: The Pre-Treatment Technologies in the above table are listed arbitrarily. The order of listing has no intention or reasons.

Table 4-2 Treatment Technology (inclusive of the technologies integrating Pre-Treatment and Treatment into one process)

Technology Name		Description of Technology
Thermal Treatment	Direct, Fuel-Fired Incinerator	Burning chemical agents and others in a furnace by combustion of fuel. Several kinds of incinerators available depending on the state of materials to be treated and the required temperatures
	Radiation Furnace	Dissolving chemical agents and the like in a furnace indirectly heated with fuels or electricity
	Plasma Torch Furnace	Dissolving chemical agents and the like with plasma torch at extremely high temperatures. The reactor environment applies inert, reduction or oxidized atmosphere.
	Molten Media Furnace	Oxidizing chemical agents and the like in a molten media melted at high temperatures, normally using glass, metals, salt, sulfur or the like as a media.
	High Temperature Gas Phase Chemical Reduction	Thermally destroying chemical agents and others in a furnace of a reduction environment saturated with hydrogen and steam
	Detonation Chamber (Thermally Initiated and Explosive Supplemented)	Breaking projectiles and the like by detonation in a chamber and thermally destroying chemical agents, etc. by heat. Two methods; Thermally Initiated (heated chamber detonation) and Explosive Supplemented (detonation with supplemented explosives)
	Underground Detonation	Burying underground and detonating munitions with supplemented explosives, and at the same time destructing chemical agents and the like with explosion energy
Chemical Treatment	Neutralization	Detoxifying chemical agents by mixing with reagent, including chemical reaction processes of hydrolysis, oxidation and neutralization
	Supercritical Water Oxidation	Oxidizing chemical agents in water above super-critical conditions
	Mediated Electrochemical Oxidation	Oxidizing chemical agents with metallic ion in a carrier fluid
	Solvated Electron Reduction	Reducing chemical agents with free electrons in a carrier solvent
	Sodium Reduction	Reducing chemical agents in a carrier of alcohol solvent of metallic sodium

Note: The Treatment Technologies in the above table are listed arbitrarily. The order of listing has no intention or reasons.

Table 4-3 Other Technologies (inclusive of decontamination of munitions)

Technology Name	Description of Technology
Superheated Steam Tunnel Furnace	Decontaminating metal parts, etc. by using superheated steam
Spray Washing	Washing surfaces of metal parts, using alkali water solvent, water or other fluids
Dry Ice Blasting	Removing debris from metal surfaces by blasting dry ice

Note: The technologies in the above table are listed arbitrarily. The order of listing has no intention or reasons.

4.2 Study of Destruction Technologies

4.2.1 Study of Individual Constituent Process Technologies

The destruction technologies for study by the Study Group is limited to those available within the frame of this market survey. Procurement to shape a disposal system into a plant and to implemet this undertaking will be carried out by another entity independent of the Study Group in accordance with various relevant domestic and international regulations and laws. In order to prepare this report regarding the destruction technologies listed in Tables 4-1, 4-2 and 4-3, based on the information and data acquired from various technology proposals and the published documents on the destruction technologies and the experts' study and opinions, the following points were considered:

1) Generic technology names are used to avoid specific technology brand names of enterprises.
2) Constituent process technologies similar in terms of treatment process, characteristics and other aspects are categorized in a group as the same kind of technology.
3) With regard to constituent process technologies, their general characteristics and subjects to be considered in future studies are summarized.

Based on the above policy, the characteristics and the subjects to be considered are summarized in Table 4-4. Some of the proposed destruction technologies consist of more than one constituent process technology for complete destruction. This report will address only the individual study and review results on each constituent process technology.

Further, based on preliminary study and review of the information and data acquired to date, the characteristics of the technologies and the subjects for consideration described hereafter are summarized for the purpose of future detailed investigations and assessments. It should be noted that the contents and amounts described on the subjects to be considered do not account for grading various constituent process technologies.

Table 4-4 The Characteristics of the Constituent Process Technologies and the Subjects to be Considered

(1) Pre-Treatment Technology

Technology Name		Characteristics	Subjects to be Considered
Common among All Pre-Treatment Technologies			a) Methods of feeding and placing munitions into the Pre-Treatment process b) Effects due to deformation, corrosion and the variety of sizes of munitions, bombs, etc. c) Method of leak prevention of chemical agents and the like (inclusive of those vaporized) in the process of Pre-Treatment and during feeding into the Treatment process d) Method to remove solid and gelled chemical agents and the like, and to wash out chemical agents adhering to the inner surfaces of munitions e) Method of feeding removed chemical agents and the like (inclusive of those vaporized) from the Pre-Treatment to the Treatment process f) Explosion risks due to impact, thermal or other energy transfer to explosives in the process of Pre-Treatment g) Durability of materials of the Pre-Treatment process equipment against chemicals (chemical agents, chlorine, sulfur, etc.) under specific operational conditions h) Effects due to involuntary feeding of conventional munitions i) Effects on process speed due to replacement frequency of worn-out or contaminated tools (drill, cutting edge, nozzle, die and other tools), materials and equipment
Mechanical Cutting	Boring/ Mechanical Cutting	1) Method using devices commercially available and practiced 2) Comparatively easy method in case of treating liquid chemicals	a) Optimum fluid, gas and/or lubricating oil for cooling, and quantity of their waste streams b) Explosion risks due to friction heat in boring and cutting operation, and applicability of this method for extraction of explosives
	Plasma Torch Cutting	1) Method using devices commercially available and practiced 2) High cutting speed	a) Explosion possibility due to very high temperatures (explosion risks), and operational reliability considering the explosion possibility

Technology Name		Characteristics	Subjects to be Considered
Fluid-Abrasive Cutting	Fluid-Abrasive Cutting (using water, sodium hydroxide solvent or ammonia	1) Method using devices commercially available and practiced 2) Low temperatures at the cutting edge, relative to Boring/Machining Cutting 3) Preferable for a combination with Treatment process where chemical agents and explosives are to be processed as a solution (slurry) 4) Probable higher applicability in case of using ammonia fluid in combination with Solvated Electron Reduction	a) Appropriate cutting methods from a viewpoint of process speed and waste stream (pressure, and the quantity of fluids, abrasives and the like) b) Explosion risks due to heat accumulated in the lump of RDX in case of using sodium hydroxide solvent, where RDX is heated by reacting to the solvent.(RDX reacts at 50°C) c) Leaking risks of ammonia vaporized by heat-generation by contact of ammonia and picric acid/phosgene. (Ammonia is prone to become an explosive mixed gas when mixed with air) d) Strength of the vessel against internal pressure generated by vaporization of ammonia in case of using ammonia
Fragmentation	Cryogenic Fragmen-tation	1) Possible large process volume (speed) of a single press in case of treating the munitions of the same kind and size	a) Ability to fracture brass used as booster tubes. (If not fractured, booster charge is likely to remain trapped in the tube, which could induce explosions during the Treatment process, depending on the type of Treatments) b) Press dies applicable to various kinds and sizes of munitions c) Explosion risks in the process of fragmentation of the munitions (Possible explosion risks, in case of formation of picrate, when press force concentrates at defects within the crystal and the like formed in freezing process. Further, RDX is likely to impose localized stress concentrations because of its anisotropy of thermal expansion when its temperature is rapidly changed.)

Technology Name		Characteristics	Subjects to be Considered
Fragmentation	Detonation Chamber (Thermally Initiated Method and Explosive Supple-mented Method)	1) Possibility of relatively large process volume (speed), if it is not cumbersome to feed the munitions into and take out from a chamber) 2) No risks of unintentional explosions after fed into and enclosed in a chamber (Less explosion risks relative to cutting method) 3) Probable less effects due to corrosion and deformation of the munitions	a) Possibility of incomplete fragmentation of munitions due to non-detonation or incomplete detonation, and if possible, the subsequent countermeasures b) Durability of inner walls, monitoring and controlling gears in the chamber, automated feeders and receivers, closing devices and gates against repeated detonation operations

(2) Treatment Technology

Technology Name		Characteristics	Subjects to be Considered
Common among All Treatment Technologies			a) Durability of equipment against chemicals (chemical agents, chlorine, sulfur, etc.) under specific operational conditions b) Monitoring method of hazardous substances in the waste stream c) Management of hazardous chemical substances in the process when process upsets occur in systems such as fuel supply, electricity supply, etc.
Thermal Treatment	Common among Thermal Treatment Technolog-ies		a) Effects on process speed due to replacement frequency because of breakdown and deterioration of the furnace components that will be heated b) Risks due to highly heated and pressurized gas (over-pressure, explosion, rupture, etc.) c) Risks of insufficient treatment in the event of under-exposure to heat by overfeeding chemical agents d) Collection and post-treatment methods of vaporized and sublimated heavy metals in the process
	Fuel-fired Combust-ion Furnace	1) The most experien-ced technology 2) The largest off-gas volume, and a rela-tively large scale emission control system required	a) Management system appropriate to minimize generation of incompletely burned products, and prevention method to avoid generation of dioxin and the like by using an appropriate quenching system
	Radiation Furnace	1) Chemical weapons treated in Germany using a certain type of Radiation Furnace 2) Off-gas volume is less than in case of Fuel-fired Com-bustion Furnace. The less emission, the smaller emission control system	a) Possibility of adherence of carbonized deposits to inner walls, and if possible, the consequent effects and the prevention methods

Technology Name		Characteristics	Subjects to be Considered
Thermal Treatment	Plasma Arc Furnace	1) Rotary plasma furnaces have been commercially operated to treat industrial hazardous wastes, and are about to start destruction of the chemical agents, contaminated soil, etc. in Germany 2) Volume of incompletely burned products such as dioxin are less than in case of incineration, due to decomposition at very high temperatures 3) Off-gas volume is less than in case of Fuel-fired Combustion Furnace. The less emission, the smaller emission control system. 4) Possible high levels of decomposition of chemical agents, etc. because of very high process temperatures 5) Vitrification capability of arsenic using the same equipment as for the Treatment process	a) Effects on process speed due to replacement frequency of worn-out electrodes and torches

Technology Name		Characteristics	Subjects to be Considered
Thermal Treatment	Molten Media Furnace (Glass, metal, salt, sulfur or the like is used as a media)	1) Probable less volume of hazardous wastes, if acid gases including chlorine, sulfur, etc. generated in the process are effectively trapped in the molten media 2) Off-gas volume is less than in case of Fuel-fired Combustion Furnace. The less emission, the smaller emission control system.	a) Reduction in process speed and efficacy due to deterioration of molten media b) Regular replacement of molten media, and stabilizing method and the volume of salts generated in the process (inclusive of review on waste management methods and recovery rates of deteriorated media containing arsenic) c) Capturing rates of such chemicals as chlorine, sulfur, arsenic in the molten media
	High Temp. Gas Phase Chemical Reduction	1) Off-gas volume is less than in case of Fuel-fired Combustion Furnace. The less emission, the smaller emission control system.	a) Possibility of generation of such toxic gases as arsine, hydro-sulfide, etc., and if possible, the subsequent countermeasures b) Explosion risks due to mishandling of hydrogen
	Detonation Chamber (Thermally Initiated and Explosive Supple-mented)	1) Dismantling process (Pre-treatment) for the ACWs is not required because both Pre-treatment and Treatment are integrated as a single process 2) Usually, necessary to be followed by a secondary incinerator	a) Possibility of non-detonation or incomplete detonation, and if possible, the subsequent treatment procedure for untreated chemical agents and projectiles b) Durability of inner walls, monitoring and controlling gears in the chamber, automated feeders and receivers, closing device and gates against repeated detonation operations c) Feeding method of munitions and ejection method of such residues as fragments and gases, and leak prevention measures for these contaminated materials

Technology Name		Characteristics	Subjects to be Considered
Thermal Treatment	Under-ground Detonation	1) Dismantling process (Pre-treatment) for the ACWs is not required because both Pre-treatment and Treatment are integrated as a single process 2) Need a large space for blast operation, but probable dest-ruction of a large amount of the ACWs in a single detonation process	a) Possibility of non-detonation or incomplete detonation, and if possible, the subsequent treatment procedure for untreated chemical agents and projectiles b) Effectiveness of off-gas containment and recovery methods after the detonation process c) Possibility of expanded damages due to sympathetic detonation during arrangement of munitions in a detonation pit d) Possibility of contamination of the underground water, and its appropriate prevention method
Chemical Treatment	Common among Chemical Treatment Technolog-ies	1) Easy recovery of precipitated arsenic compounds. Little possibility of inclusion of arsenic compounds in off-gases	a) Optimum pre-process method (making substances in a form of liquid, slurry or paste, size-reducing, etc.) for substances including solid and gelled chemical agents to feed into the Treatment process b) Effects due to impurities
	Neutraliza-tion	1) Mustard and lewisite have been destroyed by this process in Canada and other countries 2) Processed at relatively low temperatures and under low pressure	a) Optimization of the process necessary to completely decompose generated arsonic acid (strong blister gas) and to precipitate arsenic, in the caustic neutralization process of lewisite (slow reaction) b) Optimization of the process necessary to completely decompose diphenylarsinic acid (highly toxic) generated in the caustic hydrolysis process of DC and to precipitate arsenic c) Measure to dispose of effluents generated in great volume d) Optimization of the waste treatment system that is more complicated than those of other chemical treatments, in order to treat the complicated and toxic hazardous products assumed to be generated in the process of chemical neutralization e) Prevention measures for possible explosions and fires of a large volume of acetylene (flammable gas) probably generated in the process of neutralization of lewisite

Technology Name		Characteristics	Subjects to be Considered
Chemical Treatment	Super-critical Water Oxidation	1) Complete mineralization of organic chemicals and the like, and recovery as inorganic salts	a) Corrosion resisitancy of the process equipment for a long period of operation, and removing method of adhered scales b) Safety measures for the operation at high temperatures and under very high pressure
	Mediated Electro-chemical Oxidation	1) Processed at relatively low temperatures and under low pressure 2) Complete mineralization of various chemicals depending on process periods	a) Applicability for processing feeds in a form of slurry or paste (liquid feeds are most suitable for this process)
	Solvated Electron Reduction	1) Solvated solution causes a highly vigorous reduction and high process speed 2) Processed at relatively low temperatures and under low pressure	a) Safety measures for handling of metallic sodium b) Operation and control method of the process accompanying the complicated reactions which generate various by-products (inclusive of polyethylene-like polymers), and the optimization of the consequent waste management for the by-products (Complete mineralization of chemicals is difficult in this process) c) Explosion risks due to mishandling of ammonia, in case of using ammonia, (ammonia is prone to become explosive mixed gas when mixed with the air), and the pressure resistancy of the vessel against increased pressure due to rapid evaporation of ammonia d) Monitoring and controlling of the sodium concentration corresponding to the evaporation of ammonia, in case of using ammonia (the reaction causes highly active heat generation, and is sensitive to the mix rate in weight of ammonia and sodium) e) Effects due to feeds containing moisture (The process requires the feeds to be anhydrous)

Technology Name		Characteristics	Subjects to be Considered
Chemical Treatment	Sodium Reduction	1) Processed at relatively low temperatures and under low pressure	a) Safety measures for handling of metallic sodium b) Effects due to feeds containing moisture (The process requires the feeds to be anhydrous)

(3) Other Treatment Technology (inclusive of Decontamination of Munitions)

Technology Name	Characteristics	Subjects to be Considered
Superheated Steam Tunnel Furnace	1) Decontamination capability up to 5X, the highest decontamination level of the US Army	a) Corrosion of equipment materials due to ionized chlorine, sulfur and other chemicals b) Effectiveness of the treatment where gelled or solidified chemical agents, etc. adhere to shells
Spray Washing	1) Simple technology of spray-washing metal parts with caustic solution, water and other liquids	a) Attainable decontamination level
Dry Ice Blasting	1) Possible generation of gaseous chemicals, but no liquid effluent	a) Attainable decontamination level b) Explosion risk due to impacts in the decontamination process of buster tubes

4.2.2 Study of Combinations of Constituent Process Technologies (as integrated systems)

It was previously scheduled that if possible, the Study Group would study and review the characteristics and subjects to be considered regarding the combinations (integrated systems) of individual Pre-Treatment, Treatment and Post-Treatment process technologies. However, the Study Group's concrete study on the combinations is deferred due to the following reasons.

(1) Considering the current situation that a substantial number of constituent process technologies were proposed and numerous cases of the combinations among them are possible for further review, the possibility of combinations will be limited, if at this stage only the specific combinations of the proposed ones are reviewed.

(2) Information and data are not readily available on the actual characteristics (chemical components, munitions configurations, corrosion grades, sensitivity of explosives, and the like) of the chemical agents, munitions, explosives and the like. Thus, it is difficult to assess the situations of feeds in both events of feeding-in and processing.

(3) The requirements for treated final properties and products of the wastes such as the emission standards related to environmental protection and the treatment method of solid wastes are yet to be established. Therefore, it is impossible to properly assess prospective treatment processes without these requirements.

(4) Without a certain plan of a treatment process which is at least preliminarily designed and optimized, it is difficult to assess the rationality, safety, reliability, efficiency and other requirements. Therefore, it is considered appropriate that further review will be conducted after more detailed information and data are accumulated.

Thus, this report is limited to addressing the subjects that are to be considered for possible combinations of the constituent process technologies and the disposal systems. The following are the subjects that to date are assumed to be considered.

【Subjects to be Considered】

1) Applicability and compatibility of Pre-Treatment Technologies to Treatment Technologies to be assessed on such aspects as separation of the chemical agents and explosives, fragmentation and diluting the feeds into a form of slurry

2) Applicability and compatibility of Post-Treatment Technologies to Treatment Technologies to be assessed on such aspects as the capability to remove arsenic from the effluents

3) Ease of system operation and control, management of waste stream in the process, etc.

4) Compatibility with the principles of safety control to the provisions for containment of explosion and chemical agents, and the safety measure in case of breakdown or emergency

5) Ease of system recovery when accidents or process upsets occur.

4.3 Disposal Management of the Wastes Containing Arsenic

After the chemical agents have been converted in an essentially irreversible way to a form unsuitable for production of chemical weapons pursuant to the Convention, the residual materials and effluents shall be treated in the process of Post-Treatment in order to be emissioned or to be disposed of as wastes, complying with the emission standards required for the environmental protection. One of the most important subjects assumed to be further studied regarding Post-Treatment is how to treat and dispose of the arsenic contained in the chemical agents. This is considered as one of the most important issues for this project. Regarding the final disposal method of the wastes containing arsenic, the principle approach for further specific review, the legal requirements of China and other related subjects are discussed in this section.

4.3.1 Approach for Disposal Management of the Wastes Containing Arsenic

(1) In case of discharge of liquid or gaseous wastes into the environment, the discharge shall comply with the emission standards of China for the environmental protection. For example, “the Total Waste Water Discharge Standards” stipulates that the discharge of the liquid waste containing arsenic shall comply with the allowable discharge rate of 0.5mg/l. However, regarding the allowable discharge rate for the emission of the gaseous waste containing arsenic, the legal regulations in China does not show any specific values.

(2) As for solid wastes containing arsenic, detailed comparisons and review on a variety of disposal solutions should be performed, including a consideration of costs, with the provision of complying with the regulations for environmental protection. Landfill of solid wastes containing arsenic or recycling of arsenic before landfilling the residue can be considered as a disposal method.

1) Several methods of landfill and stabilization are available for landfill of solid waste containing arsenic. It should be reviewed whether each method meets the regulations in China. Furthermore, based on the assumed volume of the total waste to be disposed, comparisons and study should be conducted on the costs of such items as stabilization, construction of landfill sites, transportation and management. In addition, the procedure for procurement of landfill sites needs to be considered.

2) Various methods are available for recycling of arsenic depending on purification rates, reusing method, transportation conditions and the like. Comparisons and study should be carried out on the costs of such items as recycling treatment and transportation. Consideration also needs to be given regarding the question of how to secure a receiver for the recycled materials.

4.3.2 Legal Regulations in China Relating to Disposal Management of the Solid Wastes Containing Arsenic

Presently, the management of solid wastes in China is regulated by the Environmental Protection Law for Solid Wastes. (It is necessary to ask the Chinese side whether the Law applies to this project. Anyhow, it is important to understand the current regulations in China.) From these regulations, the following should be noted as important articles.

Chapter 3. Environmental Protection for Solid Wastes

Section 2. Environmental Protection for Industrial Solid Wastes

Article 32. Pursuant to the regulations of the management division of the National Environmental Protection Agency, the Applicant shall build his own places and facilities required to store or treat the industrial solid wastes that the Applicant has generated and are not re-usable or temporarily not re-usable.

Article 33. In case of open yard storage of smelting residue, mineral residue in chemical industries, coal residue, mining wastes, sorting ore residue and other industrial wastes, the Applicant shall build storage facilities and places for his own exclusive use.

Article 34. The construction of the facilities and places for storage and treatment of the industrial solid wastes shall comply with the regulations of the management division of the National Environmental Protection Agency.

Chapter 4. Special Regulations for Environmental Protection for Hazardous Wastes

Article 44 The facilities and places where the container and its wrapping materials of hazardous wastes as well as hazardous wastes are accumulated, stored, transported or treated shall be posted with the identification signs as hazardous materials.

Article 47 The local government of a city shall build a centralized treatment facility for hazardous wastes.

Article 48 In the event of the Applicant’s non-compliance with the regulations of the management division of the National Environmental Protection Agency in case of treatment by a land reclaiming method, the Applicant shall pay a charge for disposal of the hazardous wastes. As for the specific payment method, the Applicant shall follow the regulations stipulated by the Cabinet’s Office.

The main words in the above regulations shall have the meanings hereby assigned to them (Ref: Article 74 of the Law):

a) "Industrial Solid Wastes" means the solid wastes generated in production activities such as industry, transportation and the like.

b) "Hazardous Wastes" means the hazardous wastes that are registered in the national list of the hazardous wastes or that are designated in accordance with the identification standard and method based on applicable national regulations.

c) "Treatment" means the process by which the physical, chemical and biological properties of solid wastes are converted in a form of the materials reduced in volume and quantity in order to reduce or remove the hazardous/toxic components, or the process by which the solid wastes are permanently stored in such facilities that comply with the requirements of the Environmental Protection Law in order not to recover the wastes.

With regard to the above Laws, it is necessary to confirm the interpretations of the regulations related to the disposal procedure for the solid wastes containing arsenic.

4.3.3 Future Study Approach

Regarding the disposal management of the wastes containing arsenic, it is recommended that the future review and assessment are conducted according to the following approach.

1) Study and review each of the effluent disposal processes from technical and financial points of view, and collect and organize the information and data in order to assess and select a suitable effluent disposal process.

2) In the event that the waste disposal in China is planned, make efforts to effectively conduct the review work by consulting with the concerned parties of China and confirming the legal regulations and other matters as well as conducting a study and review by a study team similar to the Study Group.

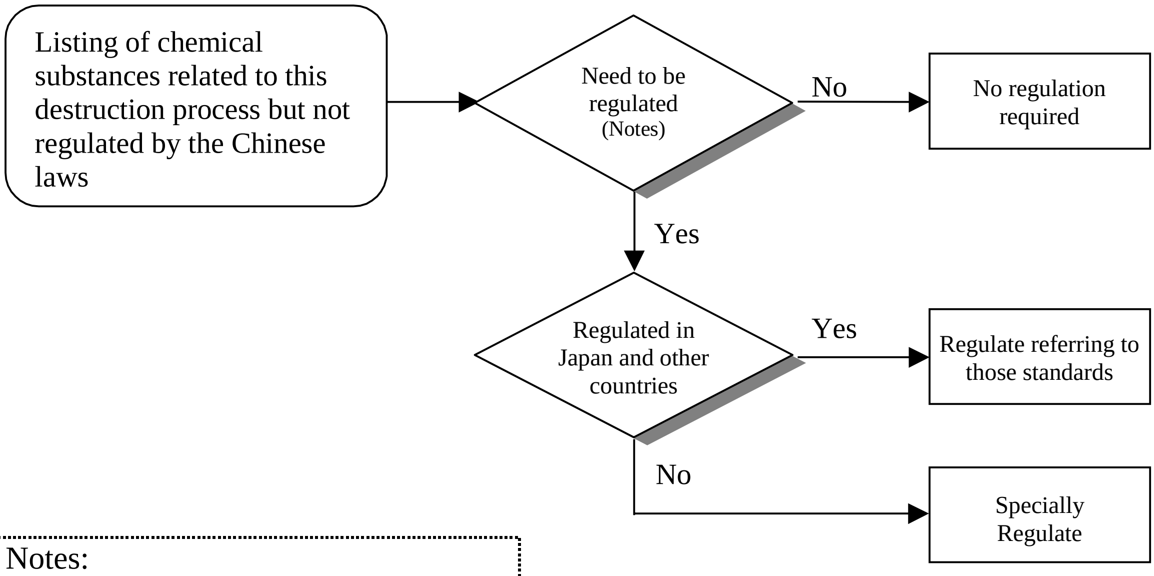
4.4 Consideration for Technical Requirements

The overall plan of the ACWs destruction project is not yet decided. Furthermore, prospective destruction technologies are still in the process of study and review. Consequently, the Study Group has limited their study and review to two aspects of environmental protection and safety measures regarding the Technical Requirements for destruction technologies.

(1) Environmental Protection

As the emission standards for environmental protection are currently under discussion between the concerned parties of Japan and China, the consideration of the Study Group for regulating the emission standards is addressed hereafter.

It is assumed to be a principle requirement that the substances regulated by the Chinese laws should comply with the relevant standards in accordance with their applicable grades and the like. On the other hand, it is assumed to be appropriate that chemical substances related to this destruction process which are not regulated by the Chinese laws should comply with the emission standards determined in the procedure as shown below.



Notes:

Considering factors to decide whether any regulations are required or not.

a. Toxicity is not so strong
b. A substance is included in other category (e.g., arsenic compound)
c. Hydrolysis is fast (in case of effluent standards or the like)

Further, appropriate procedures for the solid waste disposal management should be determined based on the investigation and review results of disposal technologies, costs and other data and the outcome of the discussions between the concerned parties of Japan and China.

(2) Safety Measures

For designing, testing operations and loaded operations of the destruction facilities, more specific safety measures, considering the basic principles and measures described below in “the Outline of Safety Measures”, should be established to prevent any accidents. “The Outline of Safety Measures” was prepared based on preliminary technical review. Therefore, the requirements related to safety should be modified or added, as required, based on the results of future review of various technological aspects.

The Outline of Safety Measures

In the destruction project of the ACWs in China, for the purpose of conducting in a safe manner all disposal process activities from the delivery of the ACWs into a destruction facility to the final waste disposal, the activities shall comply with the following safety measures.

It should be noted that the items described below address only the outline of basic safety measures. In the actual implementation of the disposal facilities, it is necessary to plan and modify, as required, more detailed safety measures based on the assessment of safety for operation procedures, management method and workers training at each phase of design, testing operation and loaded operation.

1. Basic Principles

(1) In order to secure safety for the nearby residents and the workers in the facility, a comprehensive safety plan and safety and accident prevention measures to minimize the frequency of accidents including minor ones in process operation, targeting at the zero hazards to humans shall be provided.

(2) The safety for each of facilities and equipment shall in principle comply with the relevant laws and regulations in China. However, where necessary, such relevant laws and measures in Japan as the Labor Safety and Hygiene Law, the Explosive Control Laws, the Toxic and Hazardous Material Control Law, the Fire Services Acts and the High Pressure Gas Safety Law shall also be referred.

(3) Facilities and equipment critical from a safety viewpoint shall be planned and designed in such a manner that no accident takes place by human error or fail-safe devices function in case of a process upset.

2. Safety Measures for Explosions (inclusive of chemical agent release)

(1) The dismantling process of the ACWs shall be provided and controlled with remote control devices.

(2) Such processes as a munitions dismantling process and other explosion-prone processes shall be protected by walls and other explosion-proof measures. Such barriers shall protect against the brisance caused by the largest amount of the ACWs laid in one place so that the neighboring rooms and the vicinity can be well protected from the explosion and consequential release of chemical agents.

(3) All facilities and equipment shall be provided with preventive measures against static electricity.

(4) Safety measures similar to (2) and (3) above shall be provided for processes where explosion due to superheated vapor, gas, etc. may possibly occur.

3. Safety Measures for Leakage Risk

(1) Any part of the process potential for chemical agent leaks shall be provided with containment measures.

(2) The transfer of contaminated substances among the work rooms shall be prevented by arranging the work rooms, considering the workers' movement in protection clothing, exchange and washing of the clothing, rest and other activities in and among the work rooms which are required to be protected against exposure to chemicals.

(3) A suitable drainage system shall be provided considering possible leaks of liquid chemicals.

(4) Any compartment or room which has a potential for contamination by possible chemical leaks shall be equipped with air-exhaust and purifier. The purified air shall be exhausted outdoors via properly installed exhaust ducts without recycling the air into the room.

(5) The contents of hazardous chemicals in the air of working rooms shall be monitored to detect the leakage of hazardous substances such as chemicals. The exhausted air passed through a ventilation/purifying system shall also be monitored to confirm whether it has been purified or not.

4. Others

(1) Containment measure of leaked chemicals shall be provided for any accidents.

(2) Such facility and equipment that, in the case of fire, can minimize both explosion risks (caused by flammable gases) and contamination (caused by chemicals) shall be provided.

(3) Such facility and equipment that may be exposed to fire shall be made of nonflammable or heat resisting materials.

(4) The materials used for chemical destruction process shall have corrosion resisting strength or durability to resist the corrosive effects of the feeds and

generated substances. In case the materials are under high pressure or at a high temperature, they shall have sufficient physical strength and durability against repeated operations for a long period.

(5) In order to keep the process in specific stable conditions during operation, the process shall be equipped with a system sufficient to control and monitor various parameters such as the feeding amount of chemicals, reaction agents and so forth.

(6) The destruction process shall be provided with such safety measure that does not cause any safety problems in the event of a process upset or breakdown. A duplicated electricity supply system shall be provided to sufficiently meet the requirements of various units of equipment, to safeguard against power failure.

(7) All the processes in operation shall be visibly monitored from a central monitoring room, from which all workers can be contacted. An emergency alarming device shall be provided.

(8) The destruction facilities shall be planned and designed taking into account the temperatures and other meteorological conditions at the construction site of the facilities.

Chapter 5. Consideration for the Destruction Undertaking in Future

It is recommended that the destruction of the ACWs in China be conducted in an orderly manner in which the ACWs are destroyed following a reasonably phased procedure. This should take into account the destruction time limits imposed by the Convention and adopt destruction technologies suitable for safety and environmental protection. For this purpose, it is necessary that the order of destruction of the substances is well considered, and that treatment facilities of an appropriate scale and configuration are deployed in each phase of the destruction.

(1) Consideration for the Order of Destruction

The ACWs include various kinds of munitions. The deadlines for destruction are stipulated in the Convention and an early start of destruction operation is required. It is desirable to set the order of destruction and commence the destruction in phases. The following aspects need to be taken into account.

1) Ease of Safety and Environmental Protection Measures

The destruction objects that require a relatively long period for study of such aspects as safety and environmental protection in the disposal process should be destroyed only after the measures for these aspects are well studied. It is considered appropriate that the destruction objects which need relatively simple measures for safety and environmental protection from the following viewpoints are to be destroyed earlier.

a) Necessity of Excavation and Recovery
In general, the characteristics of explosives of the ACWs buried underground tend to change once unearthed. This is due to the changes of the surrounding conditions such as temperature, humidity, etc. Subsequent to the changes, the explosion sensitivity is likely to increase. Therefore, once unearthed and recovered, the ACWs destruction should be conducted without holding them in store for a long time.

b) Explosiveness
In general, the ACWs containing explosives need to be dismantled in a Pre-Treatment process such as cutting, fracturing or detonation fragmentation. However, explosion risks due to heat, impact, etc. in case of the cutting or fracturing process and the durability of the sealed chamber in case of the detonation fragmentation process are a matter of concern. Further, to date the containment measure of explosion have not been thoroughly studied. Because of the above reasons, Pre-Treatment technologies to treat the ACWs containing explosives should be carefully studied for selection, and the destruction should be conducted after establishing effective safety measures.

c) Toxicity Grade, Possible Exposure
For treating such chemical agents as mustard and lewisite which are blister agents and pose risks such as toxicity, possible exposure, etc., thoroughly worked-out safety measures should be established. These safety measures

should include containment of the chemical agents and protection of workers from any exposure. Carefully worked-out measures should be established to safeguard the environment as well. For the above reasons, it is recommended that destruction of the chemical agents, which are highly risky, should be thoroughly studied before the destruction operation.

2) Requirements of the Convention

Pursuant to the Convention, the destruction of the chemical weapons other than Schedule 1 chemicals (lewisite and mustard are applicable in this project) are required to start earlier than that of Schedule 1 chemicals.

Comprehensively taking into consideration the matters as addressed above regarding the necessity of excavation and recovery, the explosiveness and the toxicity grade, etc., it is considered appropriate that those chemical weapons which have already been unearthed and present less risk due to explosiveness and toxicity should be destroyed first.

(2) Suggestions for Destruction Procedure

Based on the consideration described in the above (1) and mindful of the need for an early start of the destruction, it is considered appropriate that the destruction facilities that can destroy the red canisters (if possible, inclusive of the cans containing yellow agents) which involve less risks of explosion and are subjected mainly to detoxification should be deployed at first. Experiencing this actual destruction work in cooperation with each other, the concerned parties of Japan and China will be able to form a common perception, and it is expected that technological and organizational issues, effectiveness of the measures for safety and environmental protection and other concerns will be identified and confirmed. It is also expected that more information and data can be accumulated for subsequent phased deployment of the destruction facilities which will be able to treat more risky destruction objects.

On the other hand, the number of ACWs that have been unearthed, recovered and identified is not so great. The risks due to explosion are yet to be thoroughly clarified, and the ACWs have a wide variety of characteristics, sizes and shapes. For these reasons, it is a difficult task to definitely show at this stage in what capacity and how to deploy the most suitable destruction technology which will correspond to the substances to be treated. This subject will be considered in the future.

The procedure and purpose of destruction, and other considerations are summarized in Table 5-1.

Table 5-1 Procedure and Purposes of Destruction

Procedure of Destruction and the Destruction Objects	Chemical Weapons Stored Aboveground in Temporary Storehouses Chemical Weapons with Less Risk of Explosion Red Canisters Cans Containing Yellow Agents and Others	Chemical Weapons with Explosives	All Substances Required to be Destroyed Including the Chemical Weapons Buried Underground
Purposes	• Early start of destruction • Formation of a common perception for execution between the concerned parties of Japan and China • Collection of information and data on process operation of destruction	• Listing of subjects for consideration concerning full-scale mass destruction to apply for design and operation planning of the disposal facilities • Accumulation of experience in operation of the destruction process with Pre-Treatment	• Completion of destroying all the destruction pursuant to the Convention
Experience and Data for Subsequent Step	• Information and data on the chemical agents and their handling procedures • Assessment of technical aspects of destruction technologies and other related matters • Assessment of safety and environmental protection measures • Information and data on monitoring procedures • Cooperative operation of the destruction	• Assessment of technical aspects of design, operation and other related matters of the facilities • Assessment of safety measures against risk due to explosion and other risks	

Chapter 6.　Other Recommendations

The Study Group ended its activity by completing this Final Report. Under the control of the Prime Minister's Office that is an implementing body, further review on technical aspects of the destruction technologies has to be continued. For this purpose, it is necessary to arrange a new study organization to assist this destruction project from a technical viewpoint. In order for the new organization committee to efficiently and effectively conduct a technical study, the Study Group makes the following recommendations.

(1) Establishment of Study Teams

For conducting smooth destruction of the ACWs at a future date, further detailed study and review are necessary. Various technical subjects such as explosion risks, analysis methods of the chemical agents, safety in working environment, identification methods of the ACWs and destruction technologies need to be considered. For this purpose, it is recommended that an organization containing experts in each technical field is established. This organization can flexibly and efficiently conduct study by setting up various study teams as required on the basis of the progress of the disposal process. One possible scheme for setting up study teams and study subjects is as follows.

Name of Study Team	Study Subject
Explosion Risk and Countermeasures Study Team	・ Assessment of explosion risks ・ Safety measures against explosion risks ・ Subjects to be investigated and studied in future
Chemicals Analysis Study Team	・ Study of sampling and analysis methods ・ Analysis and review of the chemical agents contained in the ACWs ・ Analysis and review of the leaked-out chemicals (soil, the air and the like) ・ Subjects to be investigated and studied in future
Safety Measures in Working Environment Study Team	・ Study of toxicity of the chemical agents ・ Study of exposure limits in working environment ・ Safety measures in working environment ・ Subjects to be investigated and studied in future
Excavation/Recovery Study Team	・ Study of safety measures for excavation, recovery, transport and storage ・ Identification of the ACWs in terms of burial condition and corrosion grade ・ Study of identification method and results
Destruction Technology Study Team	・ Study of destruction technologies ・ Study of suitable effluent management methods ・ Study of emission standards ・ Subjects to be investigated and studied in future

(2) Arrangement for Execution of Analyses, Tests, etc. in Japan

To facilitate deployment of the disposal facilities for the ACWs, considering the peculiar conditions of the ACWs in China, it is recommended to conduct various kinds of analyses, tests and experiments as required and accumulate technical supporting data in the implementing authority. By doing so, it is expected to achieve smooth coordination on the technical issues between both governments of Japan and China.

For this purpose, it is necessary to make arrangements for conducting analyses, tests and investigations regarding various themes such as explosion sensitivity of picric acid, components of the chemicals, excavation, identification, Pre-Treatment, Treatment and Post-Treatment in the above-mentioned study teams.

(3) Identification of the Characteristics of Destruction Objects and the Forms of Final Wastes

For further detailed review and assessment of the destruction technologies to treat the ACWs, it is considered necessary to identify as many as possible of the characteristics of the substances to be fed into the process and the forms of the final wastes in compliance with the standards and regulations for environmental protection. Whilst early carrying out the analysis of the chemical agents, and carrying out the investigation into the sensitivity of explosives, especially out of the various analyses, tests and investigations described in (2), it is essential to coordinate with the concerned parties in China, at an early stage, regarding the technical requirements related to final waste management and possible environmental impacts which may be result from destruction operation.