CONFERENCE OF THE EIGHTEEN-NATION
COMMITTEE ON DISARMAMENT

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

COMMITTEE ON DISARMAMENT

CHEMICAL WEAPONS — WORKING PAPERS 1969-1981 SESSIONS

COMPILED BY:

ARMS CONTROL AND DISARMAMENT DIVISION OF
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PREFACE

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CONFERENCE OF THE COMMITTEE ON DISARMAMENT (CCD) - 1970-1979 SESSIONS

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CHEMICAL WEAPONS

This two-volume compendium is the result of a survey of working papers submitted to the Conference of the Eighteen-Nation Committee on Disarmament, the Conference of the Committee on Disarmament and the Committee on Disarmament during the period 1969-1981. It has been compiled to facilitate research on the issue of chemical weapons (CW) and is a compendium of the more significant material made available to the Committee on Disarmament.

Volume 1 covers the period 1969-1975 and Volume 2, the period 1976-1981. The full index appears in both volumes to facilitate cross references.

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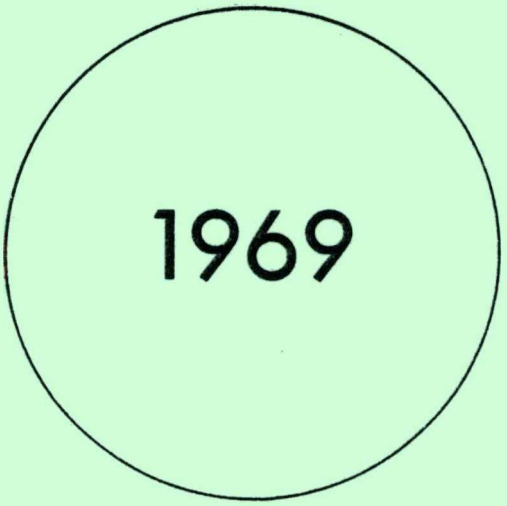
1969

Letter dated 1 July 1969 from the Secretary-General of the United Nations to the Co-Chairmen of the Conference of the Eighteen-Nation Committee on Disarmament transmitting the Report on Chemical and Bacteriological (Biological) Weapons and the Effects of their Possible Use

ENDC/254

I have the honour to transmit herewith the report* on chemical and bacteriological (biological) weapons and the effects of their possible use which, by General Assembly resolution 2454 A (XXIII), I was requested to prepare with the assistance of qualified consultant experts.

In accordance with paragraph 4 of the resolution, I am at the same time transmitting this report to the General Assembly and the Security Council, as well as to the Governments of Member States of the United Nations in time to permit its consideration at the twenty-fourth session of the General Assembly.

(Signed) U Thant
Secretary-General

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* The report has been distributed to all Members of the United Nations as Document A/7575 and S/9292.

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CONFERENCE OF THE EIGHTEEN-NATION COMMITTEE ON DISARMAMENT

ENDC/256
22 July 1969
Original: ENGLISH

POLAND

Working Paper concerning the Report of the Secretary-General of 1 July 1969 on Chemical and Bacteriological (Biological) Weapons and the Effects of Their Possible Use (A/7575)

I. The problem of the prohibition and total elimination of weapons of mass destruction is one of the urgent tasks facing the international community.

In the field of nuclear weapons certain steps have already been taken, to mention the 1963 Moscow Partial Test Ban Treaty, the 1967 Convention concerning peaceful utilization of the outer space and the 1968 Treaty on the non-proliferation of nuclear weapons.

These steps have significantly contributed to the slowing down of the nuclear arms race and the creation of conditions favouring other measures that may lead to further reduction, and ultimately total elimination of nuclear weapons.

II. Weapons of mass destruction are a class of weapons that includes also agents of chemical and bacteriological (biological) warfare. The danger inherent in these weapons has been particularly strongly exposed in the report of the Secretary-General on chemical and bacteriological (biological) weapons and the effects of their possible use (A/7575). The danger derives among others from the fact that these weapons can be manufactured relatively cheaper and easier than is the case with nuclear weapons. Thus, any country not necessarily technologically advanced or industrially developed could manufacture or acquire a capability in this type of warfare.

Chemical and bacteriological (biological) weapons are weapons of mass destruction that pose a threat to the whole of mankind. Their use has been declared a crime against humanity and a violation of the generally recognized principles of international law as well as the UN Charter.

One of the principal goals of the international community in the field of disarmament should therefore be an effort aimed at ensuring that the prohibition of use of chemical and bacteriological (biological) weapons is strictly and universally

observed as well as efforts designed to accomplish their total elimination, particularly through a prohibition of development, prohibition of manufacture and a prohibition of their stockpiling.

III. General Assembly resolution 2454 A(XXIII) of 20 December 1968 requested the Secretary-General to prepare, with the assistance of qualified consultant-experts, a report on chemical and bacteriological (biological) weapons and the effects of their possible use. The resulting report (A/7575), issued on 1 July 1969, is of great significance for the strengthening of effectiveness of the Geneva Protocol of 1925 and offers a considerable encouragement to further search for ways and means of total elimination of these weapons.

Prepared by highly competent consultant-experts, the report emphasizes the significance of the Geneva Protocol which, as they indicate, helped establish "a custom and hence a standard of international law". It also unequivocally places chemical and bacteriological (biological) weapons in a class of weapons of mass destruction underlining the high urgency of taking further steps that would ultimately lead to their complete elimination from military arsenals.

IV. Poland considers, therefore, that the report of the Secretary-General on chemical and bacteriological (biological) weapons and the effects of their possible use can serve as a suitable basis for further deliberations in this Committee concerning these weapons.

To our mind the starting point in this regard should be to work to strengthen the existing international juridical norms banning the use of these weapons in warfare and which, as we know, are contained in the Geneva Protocol of 1925. Bearing in mind that not all States have as yet acceded to the Protocol, it becomes imperative to ensure universal applicability of the Protocol's prohibitions and their strict observance.

The Polish delegation wishes to propose, therefore, that the Eighteen-Nation Committee on Disarmament, in its report to the General Assembly, should underline the importance and significance of the report of the Secretary-General, recommending its further consideration particularly in the light of the guidelines contained in the Secretary-General's foreword where U Thant urges the Members of the United Nations:

"1. To renew the appeal to all States to accede to the Geneva Protocol of 1925,

2. To make a clear affirmation that the prohibition contained in the Geneva Protocol applies to the use in war of all chemical, bacteriological and biological agents (including tear gas and other harassing agents), which now exist or which may be developed in the future;

3. To call upon all countries to reach agreement to halt the development, production and stockpiling of all chemical and bacteriological (biological) agents for the purposes of war and to achieve their effective elimination from the arsenals of weapons."

As in the past, Poland is ready to co-operate, both in this Committee, in the General Assembly and in other international organizations, with all States to ensure strict observance of the prohibition of use of chemical and bacteriological (biological) weapons and to make a sustained effort to achieve a complete elimination of those weapons from the armouries of States.

CONFERENCE OF THE EIGHTEEN-NATION COMMITTEE ON DISARMAMENT

ENDC/265
26 August 1969
Original: ENGLISH

ARGENTINA, BRAZIL, BURMA, ETHIOPIA, INDIA, MEXICO, MOROCCO, NIGERIA, PAKISTAN, SWEDEN, UNITED ARAB REPUBLIC AND YUGOSLAVIA

Working Paper on a proposed declaration by the United Nations General Assembly regarding prohibition of the use of chemical and biological methods of warfare

The General Assembly,

Considering that chemical and biological methods of warfare have always been viewed with horror and been justly condemned by the international community;

Considering that these methods of warfare are inherently reprehensible, because their effects are often uncontrollable and unpredictable and may be injurious without distinction to combatants and non-combatants and because any use would entail a serious risk of escalation;

Recalling that successive international instruments have prohibited or sought to prevent the use of such methods of warfare;

Noting specifically in this regard

that the majority of States then in existence adhered to the Geneva Protocol of 17 June 1925,

that since then further States have become Parties to that Protocol,

that yet other States have declared that they will abide by its principles and objectives,

that these principles and objectives have commanded broad respect in the practice of States, and

that the General Assembly, without any dissenting vote, has called for the strict observance by all States of the principles and objectives of the Geneva Protocol,

Recognizing therefore, in the light of all the above circumstances, that a customary rule of international law prohibits the use in international armed conflicts of all biological and chemical methods of warfare, regardless of any technical developments;

Mindful of the Report of the Group of Experts, appointed by the Secretary-General of the United Nations under General Assembly Resolution 2454 A (XXIII) of 20 December 1968, on chemical and bacteriological (biological) weapons and the effects of their possible use, published on 1 July 1969 (A/7575);

Considering that this Report and the Forword to it by the Secretary-General adds further urgency for an affirmation of this rule and for dispelling, for the future, any uncertainty as to its scope and, by such affirmation, to assure the effectiveness of the rule and to enable all States to demonstrate their determination to comply with the rule;

Condemns and declares as contrary to international law the use in international armed conflicts of

any chemical agents of warfare: chemical substances, whether gaseous, liquid, or solid, which might be employed because of their direct toxic effects on man, animals or plants, and

any biological agents of warfare: living organisms, whatever their nature, or infective material derived from them, which are intended to cause disease or death in man, animals or plants, and which depend for their effects on their ability to multiply in the person, animal or plant attacked.

CONFERENCE OF THE EIGHTEEN-NATION COMMITTEE ON DISARMAMENT

ENDC/266
26 August 1969
Original: ENGLISH

CANADA

Chemical and Bacteriological (Biological) Warfare: Draft United Nations General Assembly Resolution

To facilitate consideration at the XXIV United Nations General Assembly of that part of the Report of the ENDC on chemical and bacteriological (biological) warfare, the Canadian Delegation submits the following draft resolution which has been developed from the remarks made by the Canadian Representative at the 424th meeting of the Committee on 31 July 1969. The draft resolution takes into account the Report of the Secretary-General on chemical and bacteriological (biological) weapons and the effects of their possible use (A/7575 of 1 July 1969), the proposals of delegations, especially those of the Delegation of Poland, on this Report, the draft Convention on the Prohibition of Biological Methods of Warfare submitted by the Delegation of the United Kingdom (ENDC/255 of 10 July 1969) as well as other views advanced by various delegations on this subject during the 1969 session of the Committee.

GE.69-19323

DRAFT GENERAL ASSEMBLY RESOLUTION ON CBW

The General Assembly,

Recalling its Resolution 2454 (A) (XXIII) of 20 September 1968,

Having considered the Report of the Secretary-General of 1 July on chemical and bacteriological (biological) weapons and the effects of their possible use,

Noting the recommendations of the Secretary-General contained in the foreword to his Report,

Noting further the conclusion of the Report that chemical and bacteriological (biological) weapons stand in a class of their own as armaments which exercise their effects solely on living matter,

Sharing the sense of horror also expressed in the Report at the idea that bacteriological (biological) weapons could deliberately be used to spread disease,

Mindful of the further conclusion of the Report that the prospects for general and complete disarmament under strict and effective international control and hence for peace throughout the world would brighten significantly if the development, production and stockpiling of chemical and biological agents intended for purposes of war were to end and if they were eliminated from all military arsenals,

Having considered the Report of the Eighteen-Nation Committee on Disarmament on its preliminary consideration of the action to be taken in the light of the Report of the Secretary-General,

Recognizing the importance of the Geneva Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare signed at Geneva on 17 June 1925,

Conscious of the need to maintain inviolate the Geneva Protocol and to ensure its universal applicability,

1. Reaffirms Resolution 2162 (B) of 5 December 1966 and calls anew for strict observance by all States of the principles and objectives of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 17 June 1925;

2. Invites all States to accede to the Geneva Protocol;

3. Welcomes the Report of the Secretary-General on chemical and bacteriological (biological) weapons and on the effects of their possible use, and expresses its appreciation to the Secretary-General and to the consultant experts who assisted him;

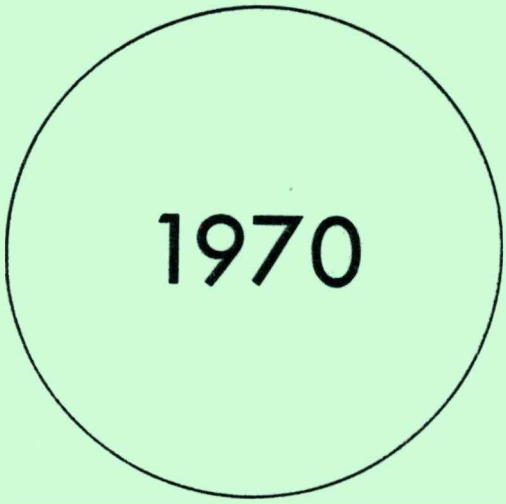
4. Requests the Secretary-General to publicize the Report in as many languages as is considered desirable and practicable, making use of the facilities of the United Nations Office of Public Information;

5. Recommends to all Governments the publication of the Report, translated as appropriate, so as to acquaint public opinion with its contents, and invites the specialized agencies, regional inter-governmental organizations, and national and international non-governmental organizations to use their facilities to make the Report widely known;

6. Recommends the Report of the Secretary-General to the Eighteen-Nation Committee on Disarmament as a basis for its further consideration of the question of the elimination of chemical and bacteriological (biological) weapons;

7. Commends the draft Convention on the Prohibition of Biological Methods of Warfare submitted by the United Kingdom and urges the Eighteen-Nation Committee on Disarmament to complete work on this draft Convention at an early date; and

8. Requests the Eighteen-Nation Committee on Disarmament to present a report on progress on all aspects of the problem of the elimination of chemical and bacteriological (biological) weapons to the XXV United Nations General Assembly.


1970

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/283
16 March 1970
Original: ENGLISH

UNITED STATES OF AMERICA

Working Paper on Chemical Warfare Agents and the Commercial Chemical Industry

1. Chemical agents, the effects of their use in warfare, and the possibility of subjecting such agents to arms control have been studied extensively in recent years. The reports of the United Nations Secretary-General, World Health Organization, and SIPRI have received worldwide attention. In addition, studies of this problem have been conducted by individual nations. The United States Government completed a thorough review of this subject in the Fall of 1969.

2. In considering the possibility of negotiating a new arms control agreement for chemical weapons, one of the areas which must be studied and understood is the relationship between the production of chemical agents for war and the production of chemicals for peaceful purposes by the commercial chemical industry. The chemical industry was in its infancy during World War I, when chemical warfare was first employed. Even so, in that conflict more than 100,000 tons of chemicals were produced for use as weapons, and 1,300,000 deaths and casualties were reported from the use of poison gas. Since World War I, many additional countries have developed a chemical industry, and the chemical production facilities of the more advanced countries have increased tremendously. In the 50 years since the end of World War I, for example, gross production of the worldwide chemical industry has increased in value from an estimated $5 billion to $150 billion, approximately a 30-fold increase. Between 1959 and 1969, world output of chemicals increased from an estimated $60 billion to $150 billion, and the magnitude of increase is continuing to accelerate.

3. Many of the chemicals which caused death and casualties in World War I are today produced in large quantities for industrial use. These chemicals might have military utility for states which may be unable, or might not desire, to manufacture or import modern nerve agents. For example, among thechoking agents, which resulted in more than 80 per cent of the deaths by gas in World War I, phosgene is currently produced in a number of countries. Annual production figures are unknown, but in at least some of these countries, annual production is thought to exceed 100,000 tons.

Phosgene is a widely used raw material in the manufacture of synthetic plastics, insecticides, paints, and pharmaceuticals. Being easily liquified, industrial phosgene could be diverted relatively easily for use in war should a nation decide to employ it, without necessarily requiring sophisticated delivery systems.

4. Among the blood gases developed during World War I, hydrogen cyanide (hydrocyanic acid) is a valuable intermediate in the manufacture of many organic chemical compounds, including benzyl cyanide, acrylonitrile, and dyes. Its world production volume is believed to be in excess of 1 million tons annually. Hydrogen cyanide is currently being produced by the United States, 6 Western European countries, Japan, the USSR, and Communist China. Another blood gas which also finds widespread commercial use is cyanogen chloride. It was used in limited quantities in World War I and is presently used as a fumigant and industrial intermediate.

5. Mustard gas, which was the most effective chemical weapon developed in World War I, is produced very simply from ethylene-oxide. On a worldwide basis, over one million tons of ethylene-oxide are produced annually for use, inter alia, in manufacturing detergents and disinfectants. The improper disposal of commercial mustard gas intermediates by industrial users has led on several occasions to casualties among fishermen and bathers, and has resulted in charges that mustard gas itself was the cause of injury.

6. The everyday production of commercial materials relevant to chemical warfare in the United States, as in other industrially developed countries, is quite substantial. For example, there are 19 locations for phosgene production and 11 facilities for hydrogen cyanide production in the United States. These produce in total approximately 350,000 tons of phosgene and 200,000 tons of hydrogen cyanide per year for commercial purposes. Of course, if one looks back into the commercial production of basic raw materials (for example, ethylene, sulphur, and chlorine, which are ingredients for mustard gas), the problem is much larger and the facilities more extensive.

7. Chemical agents of the World War I type, even though they may be effective against an unprepared enemy, are considered by those who have studied chemical weapons to be much less effective than the more recently discovered "nerve agents." The G and V families of organophosphorus nerve agents were discovered in 1936 and 1955, respectively, in the course of research on new commercial pesticides. These agents are similar to commercial organophosphorus pesticides, widely used in agriculture, which have, in fact, caused human deaths in cases of misuse. Both the nerve gases and

these related pesticides inhibit the enzyme acetylcholinesterase, causing death from respiratory and circulatory failure.

8. In addition to the similarities between the end products, many intermediates such as phosphorus trichloride, phosphorus oxychloride, ethyl and isopropyl alcohol, and ammonia are common to the production of pesticides and nerve agents. All are common industrial chemicals. In the mid-1960's, annual production of organophosphorus pesticides in the United States alone was approximately 30,000 tons. Present United States output is approximately 65,000 tons of organophosphorus pesticides per year, produced in the facilities of 14 basic manufacturers. Elsewhere in the world, there are at least 50 plants involved in the production or formulation, or both, of commercial organophosphorus pesticides in a total of 12 countries, including countries of Western and Eastern Europe. The total world output of the entire organophosphorus pesticide industry is estimated to be in excess of 130,000 tons annually.

9. The basic technical information for production of nerve agents, including descriptions of the chemical processes and amounts of raw materials required, is in the public domain. Such production does not present any insurmountable technical difficulties, although the problem of maintaining safety for plant personnel is, in view of the deadly character of the agents, quite complex.

10. From the foregoing discussion, it can be seen that the capacity for producing chemical warfare agents grows out of, and is linked to the commercial chemical industry of a given country. The raw materials for various chemical warfare agents, and even some agents themselves, are produced in vast amounts in a great many locations throughout the world.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/285
14 April 1970

ENGLISH
Original: RUSSIAN

HUNGARY, MONGOLIA AND POLAND

Working paper submitted by the delegations of the Hungarian People's Republic, the Mongolian People's Republic and the Polish People's Republic in connexion with the draft Convention on the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and on the destruction of such weapons

I

A new article is to be included in the text of the Convention reading:

"I. Each State Party to this Convention which finds that actions of any other State Party constitute a breach of the obligations assumed under articles I and II of the Convention, may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all possible evidence confirming its validity as well as a request for its consideration by the Security Council. The Security Council shall inform the States Parties to this Convention of the result of the investigation.

2. Each State Party to this Convention undertakes to cooperate in carrying out any investigations which the Security Council may undertake on the basis of the complaint received by the Council."

II

Draft Security Council Resolution

"The Security Council,

Highly appreciating the desire of a large number of States to subscribe to the Convention on the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and on the destruction of such weapons,

Bearing in mind that under article ... of the Convention the States Parties shall have the right to lodge complaints with the Security Council together with a request for their consideration by the Council,

Recognizing the need for appropriate measures with a view to ensuring the observance of the obligations contained in the Convention,

Taking into consideration the desire of the States Parties to cooperate with the Security Council with a view to ensuring the strict observance of the obligations contained in the Convention,

I. Declares its readiness:

- to give urgent consideration to any complaints lodged under article ... of the Convention,
- to take all necessary measures for the investigation of a complaint,
- to inform the States Parties to the Convention of the result of the investigation;

2. Calls upon all States Parties to the Convention to cooperate with a view to implementing the provisions of this Convention."

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/285/Corr.1
15 April 1970
ENGLISH ONLY

HUNGARY, MONGOLIA AND POLAND

Working paper submitted by the delegations of the Hungarian People's Republic, the Mongolian People's Republic and the Polish People's Republic in connexion with the draft Convention on the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and on the destruction of such weapons

Corrigendum

The last word of operative paragraph 2 of the draft Security Council resolution in part II of the working paper should read "resolution" instead of "convention".

CE.70-7195

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/286
21 April 1970
Original: ENGLISH

UNITED STATES OF AMERICA

Working Paper on Toxins

1. The United States has renounced the production, stockpiling and use of toxins, and has confined its military programme on toxins to research and development for defensive purposes only. Thus, the United States policy on toxins is identical to its policy on biological programmes.

2. Toxins are poisonous substances produced by biological organisms, including microbes, animals, and plants. Examples of microbial toxins are botulinum toxin, staphylococcus enterotoxin, diphtheria toxin, and tetanus toxin. Toxins produced by animals include puffer fish poison, snake and bee venom, and shellfish poison. Plant toxins include ricin, produced by the caster oil plant, cicutoxin produced by the poison hemlock, and abrin, produced by the Indian licorice seed plant. Laboratory experimentation has shown that, in general, these naturally occurring poisons are far more toxic than the known nerve agents.

3. Two bacterial toxins, botulinum toxin and staphylococcal enterotoxin, have long been discussed as potential agents of warfare. The botulinum toxin is one of the most poisonous substances known to science, and has been estimated to be up to 10,000 times as poisonous as nerve agents. For comparison purposes, if 15 tons of nerve agent would cause 50 per cent deaths over an area of up to 60 square kilometers, then about one and one-half kilograms of botulinum toxin would theoretically produce the same effect. Or, 15 tons of botulinum toxin could theoretically cause 50 per cent deaths in an unprotected population in an area up to 600,000 square kilometers. Effectiveness would of course depend upon dissemination technology, and actual coverage could vary significantly. Consequently, because of their inherently different characteristics (for example, toxicity), toxins and nerve agents have different possible military roles.

4. Where the target population is without protection, toxins could be delivered in a given area with relatively limited logistical effort. Even when masked, the target population would not be certain of protection against toxins because their extremely low dose rate would make masks with minor leaks ineffective, although effective masks would provide substantial protection.

5. In contrast to the biological organisms from which they are produced, toxins are not living organisms and are not capable of reproducing themselves. For this reason, the disease or poisoning caused by toxins is not transmissible from man to man. Thus, toxins cannot cause infectious disease, epidemics, or long-term sources of illness. Consequently toxins could create mass casualties among an adversary's population without risk of spreading to infect the nation initiating use of toxins. The characteristic symptoms of many bacterial diseases are caused by the toxins produced within the human body by living bacteria. Examples of diseases that can be produced by toxins are botulism, tetanus, diphtheria and staphylococcal food poisoning.

6. In common with biological agents, toxins generally have delayed poisonous effects. Their delayed action varies with the particular toxin. Because of their high potency, the effective dosage in man is extremely small if he is neither masked nor immunized. Toxins, if used as weapons, could be dispersed in aerosol form at considerable distances from the target and could cover a very large area, resembling the large areas that could be covered by biological agents. Casualties would therefore result after the target population had been subjected to extremely small quantities of the toxin.

7. With regard to the effects of toxins, botulinum toxin produces botulism, an acute and highly fatal disease. There are at present six types of this toxin of which four are known to be toxic for man. The disease, botulism, is characterized by the combination of extreme weakness, vomiting, thirst, fever, dizziness, blurred vision, dilated pupils, facial paralysis and weakness of respiratory muscles. Death is attributable to paralysis, respiratory failure, and associated cardiac arrest. These symptoms do not appear for 12 to 72 hours.

8. All persons are susceptible to the disease, which occurs naturally throughout the world. While almost completely effective immunization is possible, such measures would be effective only if administered well before any exposure. The mortality rate for naturally occurring botulism in the United States is approximately 65 percent. If effectively weaponized and delivered in a highly purified state, botulinum toxin could have a mortality rate approaching 100 percent. The toxin could be delivered either as an aerosol or through contamination of water supplies.

9. Staphylococcal enterotoxin is a stable protein which produces an acute incapacitation known as staphylococcal food poisoning. It is characterized by severe nausea, vomiting, abdominal pain, diarrhea, and prostration. Its effects generally last for 24 hours.

10. A plant toxin thought to have potential military utility is ricin, which is extracted from the caster bean. The lethal dose of ricin in man is not know, but it is estimated from animal studies to be about 80 millionths of a gram for the average man. Ricin causes death by paralysis.

11. The production of bacterial toxins in any significant quantity would require facilities similar to those needed for the production of biological agents. Though toxins of the type useful for military purposes could conceivably be produced by chemical synthesis in the future, the end products would be the same in the effects of their use and those effects would be indistinguishable from toxins produced by bacteriological or other biological processes.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/288
30 April 1970
Original: ENGLISH

JAPAN

Working Paper on the Question of Verification for Prohibition of Chemical and Biological Weapons

1. Chemical characteristics of nerve agents

(1) Tabun, Sarin, Soman and VX are known as typical nerve agents used for chemical weapons. All these agents are organophosphorus compounds. While Tabun which was developed in earlier stage, can be produced from yellow phosporus and through phosphorus oxychloride, Sarin, Soman and VX can be produced from yellow phosphorus and through such common intermediates as phosphorus trichloride, dimethylphosphite or methylphosphonic dichloride (or difluoride). It is pointed out in this connexion that these three agents contain methylphosphorus bond (alkyl-phosphorus bond) causing particularly strong poisonous effects on warm-blooded animals.

(2) Among the agricultural chemicals of organophosphorus family, which are widely used as insecticides or bactericides, there are some (for example, Parathion or TEPP) which can be used, due to their highly poisonous effects and depending upon their dosage, as nerve agents for weapon purposes. These agricultural chemicals of organophosphorus family can be produced from phosphorus trichloride, phosphorus oxychloride, phosphorus pentasulfide and phosphorus pentachloride.

(3) All of these organophosphorus compounds are produced from yellow phosphorus as their starting material which is then converted to phosphorus trichloride, phosphorus oxychloride, phosphorus pentasulfide or phosphorus pentachloride by chemical reactions. It is further noted that dimethylphosphite and/or methylphosphonic dichloride (or difluoride) which are the intermediates derived mainly from phosphorus trichloride, lead to the production of Sarin, Soman and VX.

2. Peaceful uses of raw materials and intermediates

(1) Yellow phosphorus is mass-produced as the material for various inorganic and organic phosphorus compounds.

(2) Phosphorus trichloride, phosphorus oxychloride, phosphorus pentasulfide and phosphorus pentachloride are produced from yellow phosphorus and are the common raw materials used widely for the production of agricultural chemicals, pharmaceuticals and dyestuffs, etc.

(3) Dimethylphosphite is mainly produced from phosphorus trichloride and is widely used for peaceful industry as synthesizing materials for insecticides, bactericides, flame retardants, and as additives to lubricants.

(4) Methylphosphonic dichloride (or difluoride) is mainly produced from dimethylphosphite. Detailed information regarding its use for peaceful purposes is limited. However, as this agent is reported to be used as material for the preparation of phosphorus polymer, it is likely that other peaceful uses of that agent might be found in future.

3. Possible check points

As shown above, the production of nerve agents and agricultural chemicals of organophosphorus family having poisonous effects equivalent to nerve agents, requires particular kind of materials which are widely used for the production of other industrial goods.

Therefore, it should become possible to see whether or not these materials are being used for the production of chemical weapons if we can trace the flow of such materials in each State by checking the amount of their production, import and export, or the amount of their consumption for different purposes, these materials are enumerated as follows: yellow phosphorus, phosphorus trichloride, phosphorus oxychloride, phosphorus pentasulfide, phosphorus pentachloride, dimethylphosphite and methylphosphonic dichloride (or difluoride).

In so doing, it should be possible to prevent these particular materials from being diverted into the production of nerve agents or to deter improper use of highly poisonous organophosphorus agricultural chemicals as chemical warfare agents.

N.B. It is understood that our study should be pursued on new intermediates which may be discovered in future, as organophosphorus chemical industry develops.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/289

30 June 1970
Original: ENGLISH

ITALY

Suggestions regarding the possible convening of a group of experts to study the problem of controls over chemical weapons and the way in which such a group should function

1. In the course of the informal meeting of the CCD on 22 April 1970, devoted to the question of the prohibition of chemical and biological weapons, discussions were mainly concentrated on the problem of control over the production and stockpiling of chemical weapons.

It thus appeared to be confirmed, in the opinion of various delegations, that the establishment of an effective system of controls is still the major problem among those that the Committee will have to solve with a view to achieving an agreement for the prohibition of chemical weapons.

Moreover, the participation in that same meeting of experts from various countries gave emphasis to the fact that the problem of controls presents some aspects that are predominantly scientific and a knowledge of which is essential before the various delegations can profitably embark on discussion of a draft treaty.

2. For the purposes of such a discussion, the committee has at its disposal, at the moment, three highly valuable scientific studies: the "Report of the Secretary-General on chemical and bacteriological (biological) weapons and the effects of their possible use"; the report by the World Health Organization entitled "Health aspects of Chemical and Biological Weapons"; and the as yet unfinished report by the Stockholm International Peace Research Institute (SIPRI) "The problem of chemical and biological warfare".

Of these three documents, the first aims at giving a scientific evaluation of the effects of chemical and biological weapons and informing the Governments of the consequences of any use that might be made of them, while the second is intended specially for the public-health authorities and leaves aside the purely military aspects of the problem. Neither of these two studies goes specifically or in any depth into the question of controls.

The SIPRI report, on the other hand, tackles all the different aspects of the problem, including that of verification, to which the whole of Volume IV is devoted.

This part of the report, although of exceptional interest and usefulness, is nevertheless of an incomplete and preliminary nature. Moreover, it was conceived with a more general purpose in view, not with the specific aim of being able to provide the Committee on Disarmament with an exhaustive technical study as a working tool.

3. The Italian Delegation accordingly believes that the above mentioned studies could be usefully supplemented by a specific study on the problem of controls of chemical weapons, which could constitute a background document for the work of the Conference. Such a study could be drawn up, as has been suggested by various Delegations, and in particular by the Japanese Delegation (ENDC/PV.428; CCD/PV.456), by an ad hoc group of experts. The group could include, among others, some of the experts who have already collaborated in producing the SIPRI report and the Report of the Secretary-General of the United Nations.

4. To enable the group of experts to produce, within a relatively short time, a document of use for the purposes indicated above, the Committee, in the Italian Delegation's view, should itself guide the group in its labours, deciding beforehand the lines on which it should work and the specific subjects with which it should deal.

5. On the basis of these considerations the Italian Delegation has thought fit to put forward the following suggestions:

(a) The C.C.D. should set up a group of experts whose task would be to study the technical questions connected with the problem of the control of chemical weapons and to draw up a report thereon which would serve as a background document for the Committee in its work.

(b) The C.C.D. should itself, as a preliminary step, single out the basic subjects which need to be clarified having recourse to expert opinion (for example, it could ask for a study of the possibility of control over the production of chemical agents used solely for warlike purposes, or again it could ask for the study to be extended to substances which can be used for both peaceful and warlike purposes, etc.).

(c) Once the general picture of the subjects to be investigated has been outlined, each Delegation should instruct the appropriate body in its own country to suggest a list of specific technical themes to be developed and studied in more detail (e.g., supposing that the C.C.D. had stated that it thought a technical opinion necessary in regard to the problem of control solely over chemical agents of warfare, the appropriate national bodies in a particular country might propose an investigation of the possibility of instituting controls over the raw materials and intermediates needed for the production of nerve gases and vesicants. In particular, with reference to nerve gases such bodies might propose that the possibility be examined of controlling international trade in phosphorus and the industrial production of organic-phosphorus esters [parathion].)

(d) Each proposal would be transmitted to the group of experts set up by the Committee. The group would have a first meeting to compare and examine the various proposals and then to combine them into a single document to serve as a programme of work.

(e) On the basis of this programme, the group of experts would meet with a view to drawing up a final report. This document should deal in detail with all the problems relating to controls of chemical weapons which are of interest to the Committee, and would constitute the technical background document for further discussions in the C.C.D.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/293
16 July 1970
Original: ENGLISH

UNITED STATES OF AMERICA

Working Paper Comparing Nerve Agent Facilities and Civilian Chemical Production Facilities

1. A working paper submitted by the United States delegation on March 16, 1970 (CCD 283) described the complex relationship between the production of chemicals for peaceful purposes by commercial chemical industries and the production of chemical agents for war. Another question related to a comprehensive ban on chemical weapons and also requiring further study is the extent of the external similarity between plants producing chemical weapons and plants producing industrial and commercial chemical products. In this paper the question is examined with respect to the production of nerve agents.

2. The chemical processing industry encompasses the conversion of various chemical raw materials into usable products of all descriptions. Chemical process plants through-out the world range in production rate from a few hundred pounds to several million pounds of finished product a year, and in area from a few thousand square feet to several thousand acres. The production of chemical nerve agents involves a chemical process in which the production facilities and equipment utilized are similar to the equipment and processes used by a major segment of the world chemical industry. With the advent of highly complex, inter-related chemical complexes, it is also possible that a wide variety of chemical products, including nerve agents, could be produced within a single chemical complex.

3. The US has undertaken as a part of its research programme to examine whether it would be possible by "off-site observation," either from the air or from the ground, to determine whether a particular chemical processing facility or complex was producing, or was capable of producing, lethal nerve agents. Three United States chemical processing plants that are similar in size and general appearance were examined by external inspection. The first of these plants is a cryogenic (low-temperature) natural-gas processing plant; the second is a high-energy fuel facility; and the third (the Newport Chemical Plant), is a VX nerve-agent production facility. The three plants were examined on the basis of general external appearance, e.g. raw-material input, storage facilities, consumption of utilities, and waste disposal, and more specifically on the basis of process equipment and safety features.

4. Raw Material Input - With respect to rail and truck deliveries, it was concluded that aerial observation cannot determine what materials are being supplied to the facility. Moreover, since many of the same basic raw materials used in producing nerve agents, e.g., elemental phosphorus, chlorine, and various petrochemicals, are widely used in commercial production, the identification of some deliveries, even if possible, would not in itself indicate that nerve agents, rather than plasticizers or pesticides, were being produced in the plant. In fact, observation of the containers used in shipping might not even indicate in a general way which of hundreds of chemicals or gases were being transported to the plant. (See paragraph 5 below).

5. Storage Facilities - The raw materials and the intermediate and end products commonly stored in the chemical process industry can be in solid, liquid, or gaseous forms. In all three forms materials can be stored in bulk or in unit containers, outdoors or under shelter. Unit containers are indistinguishable from facility to facility. Solid bulk materials are stored both outdoors and indoors in piles or in bins or bunkers. The bulk storage of all types of liquid materials is, of course, generally carried out in some form of tank, vertical, horizontal, rectangular, or spherical in shape. Tanks are constructed of metal, wood or concrete, and their storage capacity can range from 200 to 1 million gallons. Liquid materials can also be stored in barrels, kegs, drums, cans or glass containers, generally holding less than 75 gallons. Gases stored in bulk are also usually contained in tanks. The most common types of readily observable containers are the large spherical, cylindrical, or horizontal tanks which are used throughout the chemical industry to hold hundreds of different chemicals and gases. These same kinds of containers are also used in nerve agent production.

6. Utilities - The utilities requirements for nerve-agent production are not greatly different from those of regular chemical operations. Electrical power may be required in greater than normal amounts but not to a degree which is unique. This requirement and the more normal water requirement could affect the location of a plant. The availability of large amounts of these utilities to a plant would not, however, be a particular indicator of nerve-agent production since location of industrial chemical facilities near ample electrical and water supplies is common practice.

7. Wastes - The nontoxic wastes of a nerve-agent plant would be similar to those produced by some industrial chemical plants. On the other hand, the chemical waste from the final unit processes for nerve-agent production requires neutralization and

detoxification before it enters the final waste disposal system. Analysis of disposed materials might provide some indication of nerve-agent production, but this could not be done by off-site observation; rather on-site sampling with extremely sensitive instruments would be required. Disposal of toxic wastes is not, of course, a problem peculiar to nerve-agent manufacture.

8. Process Equipment - There are many basic types of chemical processing equipment used for the production of both nerve agents and industrial chemicals, and these basic types can often be converted from the manufacture of one chemical to another, with varying degrees of ease. While this equipment can often be readily observed from outside the plant, very little can be determined about its function or rate of operation.

a. Distillation equipment - Distillation is one of the fundamental processes used to separate a specific chemical or group of chemicals from a mixture. Separation is accomplished in what are generally referred to as distillation columns. These are vertical, cylindrical vessels whose height is usually much greater than their diameter. They range in size from less than 1 foot in diameter and 10 feet in height to more than 15 feet in diameter and 300 feet in height. It is not possible to identify by outside observation the processes taking place within the column. In many chemical plants, distillation columns, like other pieces of equipment, are frequently used in processes other than the one for which they were originally designed.

b. Furnaces - Furnaces are one of the principal components of chemical processing facilities. These industrial furnaces are found in a great variety of sizes and designs, and there is no particular type which would be characteristic of nerve-agent plants.

c. Reactors - A reactor is the processing vessel in which chemical reactions take place. Reactors of all shapes, sizes and configurations are used in the chemical industry, depending upon the specific process in which they are to be used. Some reactors differ only slightly from small storage tanks and small heat exchangers. Reactors can differ substantially in size and shape even though they are designed for similar processes. Again, there is no shape or other characteristic which is unique to nerve-agent production.

d. Scrubbers - There is a rather large variety of equipment generally referred to as scrubbers for the separation of solids, liquids, or specific gases from air or from a gas stream by using water to scrub out the unwanted materials. These scrubbers are

vertical, cylindrical vessels with a relatively large height-to-diameter ratio. The size of the scrubber depends on the amount of air that must be treated. External observation does not reveal the materials that are being treated within the scrubber, and almost any size or shape might be used in a nerve-agent plant.

e. Flare Stacks - These are tall thin towers, up to several hundred of feet high, containing at their centres pipes which carry waste gases to the top where they are burned in the atmosphere. Although flare stacks are highly visible, their appearance would provide no means of distinguishing one plant from another.

9. Safety - Because of the highly lethal nature of the agents being produced, a nerve-agent plant requires special safety measures. In particular, the containment of toxic chemicals requires rigid control of plant air. Air coming out of the toxic process area would need to be scrubbed to remove any toxic materials, and precautions would need to be taken to prevent any air from flowing out of the toxic process area into the non-toxic operating areas. Access between the toxic and non-toxic areas would require special controls such as airlocks. Personnel entering the toxic process area would have to wear masks and protective clothing. Such features, however, would not be observable from outside the plant, since they all pertain to operations within closed structures.

10. Summary - Our research indicates that the problem of identification of nerve-agent production facilities cannot be solved by off-site observation. Chemical process facilities are to be found in numerous locations throughout the world which contain many of the same raw materials, processes operations, equipment, and support installations as those required to produce nerve agents.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/295
28 July 1970
ENGLISH
Original: FRENCH

MOROCCO

Working paper on the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and on the destruction of such weapons.

The use of chemical and bacteriological (biological) agents for non-peaceful purposes may inevitably lead to the greatest death-dealing catastrophe and the worst immediate and long-range, predictable and unpredictable, disasters that mankind has ever experienced or imagined. The reports of experts at our disposal and the observations of a large number of delegations both in the Conference of the Committee on Disarmament and in the United Nations at New York are unanimous in affirming that primary fact. We strongly believe that we would be failing in our duty as human beings and as members of the United Nations family if we ever stopped worrying about that fact even for a moment. In keeping with this attitude, the delegation of Morocco is submitting to the Committee this working paper, which in four points outlines a system that permits the insertion of procedures for prohibiting the production of chemical and bacteriological weapons and for verifying such prohibition.

1. The development, production and stockpiling of chemical and bacteriological (biological) weapons should be jointly prohibited by the terms of one principal legal instrument which would also make provision for the destruction of such weapons.

2. The procedures concerning verification and guarantees ensuring observance of obligations would be dealt with separately for bacteriological (biological) agents and for chemical agents.

3. The verification procedures relating to bacteriological (biological) weapons would be laid down definitively in the provisions of the principal instrument, and the total elimination of such weapons could be effective upon the entry into force of that instrument.

GE.70-16259

4. In view of the technical difficulties connected with the verification problem as regards chemical weapons, the principal instrument should provide in quite precise terms for he manner in which a su sequent examination will be held with the object of arriving, within a period of time prescribed by the principal instrument, at the text of a supplementary document which would definitively lay down verification procedures for chemical weapons.

The supplementary document, whose legal form would be determined by the principal instrument, would put into effect the total and definitive implementation of the provisions prohibiting such weapons.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/299
6 August 1970
Original: ENGLISH

CZECHOSLOVAKIA

Working paper on the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and on the destruction of such weapons

The resolution of the XXIV General Assembly of the United Nations A/2603 (XXIV) has expressed the conviction that the "prospects for peace throughout the world would brighten significantly if the development, production and stockpiling of chemical and bacteriological (biological) agents intended for purposes of war were to end and if they were eliminated from all military arsenals" and therefore requested the Conference of the Committee on Disarmament "to submit a report on progress on all aspects of the problem of the elimination of chemical and bacteriological (biological) weapons to the General Assembly at its twenty-fifth session".

The Czechoslovak delegation considers it necessary to point out to the following aspects of the prohibition of chemical and bacteriological weapons:

1. Chemical and bacteriological weapons form one whole. Prohibition of one type of these weapons could incite the equipment of armies with the other type of weapons. Both categories of these warfare means as a whole create the possibility of a special warfare - the so-called "toxic war" in the terminology of some military experts (cf. for example, Rothschild, Tomorrow's Weapons). The basic characteristics of the two categories of agents is their non-selectiveness, small foreseeability of their effect, impossibility of an effective protection of population, etc. These properties evoke a general moral opposition to chemical and bacteriological weapons as a whole.

Chemical and bacteriological weapons form a special group of means of warfare aimed at:

- temporary disablement of men,
- or their liquidation without affecting other (material) values,
- or selective extermination of farm animals or plants.

Should individual agents (biological as well as chemical ones) be effectively used for military purposes, they would have to be incorporated in a "weapon system" (cf. Secretary-General's report A/7575/Rev.1, page 9).

The "weapon system" is the same for both categories of weapons: analogical ways of spreading, means of delivery to the target, verification of their effectiveness in the field, appropriate storing, personnel training, principles of protection, etc. Therefore both types of weapons are usually concentrated in one branch of army.

Separate prohibition of one type would therefore permit the existence and development of the whole system which could be completed with the other type of weapons at any time and without any greater difficulty.

The tendency to separate chemical and bacteriological weapons, motivated by allegations that they are completely different, can therefore be explained only by political and military considerations of some countries and is incompatible with the approach that has been applied in all international negotiations on this question, namely in the Geneva Protocol of 1925, in the Paris Treaty of 1954, in the Austria Treaty of 1955, in both draft treaties on general and complete disarmement submitted by the USSR and the United States of America respectively, and in military manuals and considerations of all countries.

2. Bacteriological and chemical weapons represent two categories of means of warfare which can be defined by their origin, way of interaction with organism and by other characteristic properties. Classification of some substances is uncertain: for example bacterial toxins (biological substances by their origin, chemical by the character of their effect on organism) are the best-known representatives of this group today, but the number of such substances may increase as the time goes on. Better knowledge of the effects of the agents we know today may lead to changes in their classification, or new substances with uncertain (mixed) characteristics may be synthetized, etc. It is known, for example, that nucleic acids, which are carriers of virus activity and can cause disease themselves, can be isolated from pathogenic viruses. Detailed enumeration of agents of both categories, having a lasting or sufficiently long validity, is impossible due to the permanent progress of knowledge and to the expansion of both categories.

The determining principle for classifying biological agents or chemical substances as bacteriological or chemical weapon is, however, their military use against men, farm animals or plants.

3. Bacterial toxins are by the way of their production and by the character of their effect closely related to other poisons and are normally - despite their biological origin - listed under chemical weapons (cf. Secretary-General's report A/7575/Rev.1). Toxins do not differ from other poisons used as a chemical weapon. If their effect and

military use are the same as those of other poisonous substances, this proves that a dividing line cannot be drawn between biological and chemical weapons. Separation of toxins could be an attempt to a new treatment of chemical and bacteriological weapons, that is, to their division into deadly and temporary disabling ones (defoliants, herbicides, etc.).

Separation of toxins has political aspects connected with new concepts of military strategy of some countries. Such a development would not lead to any solution - on the contrary, it would make the whole question even more complicated.

4. All studies dealing with the possible way of verification as regards the production of chemical and bacteriological weapons show that this question is very complicated, that it cannot be solved by purely technical methods on international scale. Difficulties connected with the verification problem, however, must not become a determining factor for the possibility of an agreement which would require, above all, a political decision. This idea is also contained in the report of SIPRI, 1970, where in its Part IV it is stated that in the last few years it has become increasingly true to say that the real obstacles to disarmament are the momentum of the arms race and the political problems of stopping it, not the technical problems of verification.

If the question of verification is not to become an artificial brake of the treaty by bringing in complicated technical problems, it is necessary that the parties to the treaty should agree upon such a procedure which would be based on a certain degree of trust.

National self-inspection and supervision seem to be the most suitable fundamental methods of verification. Each State would adopt, in conformity with its constitutional procedure, the necessary legislative and administrative measures concerning the prohibition of the development, production and stockpiling of chemical and bacteriological weapons and the destruction of such weapons. National self-supervision could be carried out by national bodies having an international reputation (for example, Academy of Sciences, etc.) or in other forms.

Problems arising in connexion with the verification would be clarified at consultations between the parties to the treaty. Complaints on the violation of the treaty would be considered by the Security Council which would adopt the most suitable procedure for this purpose.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/300
6 August 1970
Original: ENGLISH

CANADA

Working Paper on the Verification of Prohibitions of the Development, Production, Stockpiling and the Use of Chemical and Biological Weapons

1. The central problem area in the negotiations to strengthen and to supplement the Geneva Protocol of 1925 by prohibiting the development, production and stockpiling of chemical and biological weapons, is verification. Clearly, the technical and political considerations related to the negotiation of verification procedures are intrinsically interdependent. Although science may provide assistance in devising methods of detection surveillance and data analysis, the political intentions of all countries concerned will be the decisive factor in resolving the verification problem.

2. Every international agreement involves the acceptance, by parties to the agreement, of an element of risk of evasion or violation of the agreement. In arms control agreements this risk is directly related to vital security interests. Any country contemplating a violation of an arms control agreement would undoubtedly estimate the probability of detection or of successful evasion of any agreed prohibitions, and the adverse consequences resulting from verification of such a violation. The verification regime should serve as a deterrent to any violation. The risk that some party might successfully evade or violate an agreement should be reduced to the lowest possible level through verification procedures that are adequate and politically acceptable.

3. Verification procedures which are adequate for the prohibition of chemical and biological warfare will have to be complex, sophisticated and as reliable as can be conceived by utilizing modern data-processing methods. The relative ease with which chemical or biological weapons can be acquired through clandestine development, production and stockpiling renders detection of contravention of a ban on chemical and biological weapons particularly difficult.

4. The verification of a prohibition of chemical warfare involves difficulties of a different dimension from those encountered in the prohibition of biological warfare because of the widespread use in commercial industry of many chemicals which can also be used in the production of chemical agents of warfare. Although there are some common integers, many more are unique to each type of warfare.

5. Verification by complaint procedure as proposed in the British draft convention is, at present, probably the only feasible approach to supplementary prohibitions of biological warfare. This type of warfare is at a relatively early stage of development; moreover, there is no evidence that biological agents have ever been used as modern military weapons, and their utility as a weapon is open to question. Efforts to devise verification mechanisms other than those involved in the investigation of complaints concerning use, development, production or stockpiling of biological weapons seem technically futile because of the high risk of undetected evasion of any other procedures that might be promulgated. In the light of all these factors a political decision by governments accepting the risks inherent in verification through a complaint procedure for biological warfare would appear to be the most logical solution.

6. Different criteria must be considered in relation to chemical warfare which has been used extensively during this century and has attained a relatively sophisticated degree of development. Chemical weapons or components of them are known to be stockpiled in the arsenals of a number of countries and their potential uses in warfare are not in question.

7. Virtually all of the working papers submitted to the Committee to date concentrate on efforts to overcome the difficulties in verification for chemical weapons; they are postulated on the apparent consensus that the prohibition of the development, production and stockpiling of chemical and biological weapons cannot be verified by national means alone and that there is a requirement for some "international" procedures.

8. Within and beyond the broadly accepted point of view that verification is the crux of the problem and that international procedures for this purpose are required, there is a wide array of opinions and suggestions, some procedural and some substantive, ranging from proposals for verification by challenge to arguments for on-site inspection. Without attempting to interpret these views, the following represents a summary of the various proposals put forward to date as an indication of the types of approach which have been suggested.

(a) The draft convention on biological warfare proposed by Britain (ENDC/255/Rev.1) specifies verification procedures that call for any complaint concerning use of biological warfare to be lodged with the Secretary-General of the United Nations and any other complaint concerning breach of the convention to be lodged with the Security Council. Complaints of all kinds would be investigated immediately and a report would be submitted to the Security Council.

(b) The draft convention proposed by the USSR and its allies (A/7655) envisages an "obligation to consult and co-operate in solving questions which may arise in connexion with the observation of the provisions of the present convention". A separate article notes that "each State party to the convention shall be internationally responsible for compliance with its provisions by legal and physical persons exercising their activities in its territory and also by its legal and physical persons outside its territory".

(c) Hungary, Mongolia and Poland introduced an amendment to the Soviet-sponsored draft convention (CCD/285) providing for complaints of alleged violation of the convention to be lodged with the United Nations Security Council which would undertake any necessary measures to investigate complaints.

(d) Sweden has presented suggestions (CCD/PV.463) based on the concepts of "open information and internationalization" and has outlined a system of verification by challenge and of the obligations on parties with respect to verification which would be incorporated in a comprehensive convention.

(e) Yugoslavia has suggested (CCD/PV.465) a systematic elaboration of legal measures for national renunciations and controls, declarations and analysis of open information as a basis for further controls and international measures to be taken in cases of suspicion or of actual violations.

(f) Mongolia has suggested (CCD/PV.464) that special government agencies might be established to enforce compliance with prohibitions on chemical and biological warfare in a manner similar to that in the 1961 Single Convention on Narcotic Drugs

(g) Japan has proposed that a group of experts study various technical aspects of verifying a ban on chemical and biological weapons. It has also elaborated (CCD/PV.456) a complaints procedure through a roster of experts on call by the United Nations Secretary-General and proposed other procedures based on possible checkpoints in the weapons production cycle.

(h) A USA working paper (CCD/293) on the relationship between chemical weapons and peaceful chemical production deals with one of the specific problems to be overcome in the establishment of satisfactory verification procedures and concludes that off-site observation is inadequate.

(i) An Italian working paper (CCD/289) outlined a negotiating process for further detailed explorations of the problem of verification of any convention or conventions.

(j) Morocco has proposed (CCD/295) a comprehensive agreement prohibiting chemical and biological warfare with separate verification procedures for biological and chemical weapons. Verification procedures for biological weapons would be included in the treaty; verification procedures for chemical weapons would be negotiated in a prescribed period of time and then attached to the Convention as a supplementary document.

9. Even a cursory analysis of these proposals, which merit the most careful consideration, reveals that in the establishment of any adequate verification system, a combination of national and international procedures will be required. Various proposals relating to verification of a ban on chemical weapons urge the development of some monitoring system based on economic information. Others suggest the exploration of the sources of all available data - both that which has been published or is freely available; and that which governments would be prepared to make available. Compilation and collation of this information in a coherent form would serve as a useful first step in the development and negotiation of agreed verification procedures. For these purposes various relevant questions might serve to differentiate between aspects on which adequate information may be already available and other areas where special procedures may have to be devised.

10. It is evident that additional information is needed to facilitate the examination of the complex political and technical problems involved in verifying a ban on the development, production, stockpiling and use of chemical and biological agents of warfare. If such information could be made available, it would assist in developing a consensus concerning which measures to strengthen and supplement the Geneva Protocol could be negotiated. With this view in mind, member governments might consider the following questions:

A. National Policy and Controls

(1) Some governments have made declarations concerning their present policies on the development, production and stockpiling of chemical and biological weapons or agents of warfare and their views concerning the right of retaliation retained through reservations they may attach to the Geneva Protocol of 1925. Would other governments be willing to state or present their policies or views on these issues?

(2) What national controls are already in force governing the development, production, stockpiling or use of chemical and biological agents that are capable of being used or converted to use in the development or production of chemical or biological weapons?

B. Chemical Warfare

I. Production

(1) Are annual production figures for the years 1968 and 1969 published or readily available for the following chemicals: phosphorus, phosphorus pentasulphide, phosphorus pentachloride, phosphorus trichloride, phosphorus oxychloride, dimethylphosphite, methylphosphonic dichloride, diethylamino ethyl alcohol, pinacolyl alcohol, carbonyl chloride (phosgene), hydrogen cyanide, cyanogen chloride, thiodiglycol, sulphur dichloride, ethylene, all organosphosphorus compounds with a toxicity less than 200 micrograms per Kg intravenously?

(2) Is information concerning end-products of these chemicals available and are governments prepared to collect and provide such data?

(3) Is governmental approval or licensing required for the production of any of the above chemicals or for products using these chemicals in their production?

(4) Is it feasible to obtain information concerning all governmental and non-governmental facilities producing or using any of the above chemicals?

II. Stockpiling of Chemicals

(1) Are figures available for 1968 and 1969 on quantities of the above chemicals or end-products that are stockpiled in the countries concerned?

(2) Would governments be prepared to provide a list of locations where any of the above chemicals or end-products derived from them are stockpiled?

(3) Are export or import permits or declarations required and if so are any of the above chemicals or end-products derived from them imported or exported from the country?

(4) Is it possible to identify the importer or exporter?

(5) What safety regulations are applicable to the production, stockpiling and transportation of any of the above chemicals?

III. Research and Development

(1) Are the locations and descriptions of government controlled facilities for research and development of chemical agents and similar information concerning all non-governmental research and development facilities available or can these be provided?

(2) Under what conditions would governments be willing to consider the cessation of all training of troops for offensive action related to chemical and biological warfare?

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/301
6 August 1970
Original: ENGLISH

JAPAN

Working Paper on the Question of the Prohibition of Chemical Weapons

1. Report of statistics

(1) With regard to the verification of compliance with the prohibition of the production of chemical agents, we shall have to be content with recourse to ad hoc inspections based on complaint procedures. At the same time, it would be desirable to establish a reporting system on the statistics of certain chemical substances concerning the amount of their production, preferably on a factory basis, exportation and importation as well as consumption for different purposes, so that those statistics might be used as part of the data forming the evidence for a possible complaint.

Since it is impracticable to report the statistics of all chemical substances, it would be necessary to limit the scope of the items to be reported on. We feel that a certain level of lethal dose by hypodermic injection could be employed as a criterion for this purpose. In suggesting this, we have taken into account the fact that the information we have on the lethal dose of various chemicals has been obtained more from experiments on animals by hypodermic injection than from those by intraperitoneal or intravenous injection or by dosing through their mouths.

As the level of lethal dose (LD 50) to be employed as the criterion, we suggest 0.5 milligrams per kilogram of body weight. That suggestion is based on the consideration that among organophosphorus compounds, which have the most poisonous effects of all chemically synthesized substances today, none, having a poisonous effect not less than the level mentioned above, is used for peaceful purposes. A dose of 0.5 milligrams per kilogram of body weight by hypodermic injection has a lethal effect equivalent to that of a dose of about 1.0 milligram per kilogram of body weight administered through the mouth.

(2) The following are the categories which the chemical substances mentioned above come under.

(a) Nerve agents (e.g.)

VX

Sarin

Soman

Tabun

Diethoxyphosphorylthiocholine

Diethyl-S-(2-triethylammonium-ethyl)-thiophosphate

Dimethyl-S-[2-(S'-ethyl-S'-ethylthioethyl-sulfonium)-ethyl]-thiophosphate

(b) Toxins (e.g.)

Botulinus toxin

Tetrodotoxin

Ricin

Shikkimotoxin

(c) Alkaloids

Aconitine

Gelsemicine

(d) Plant heart poisons (Cardiac-active glycoside)

Scillaren

Digitoxin

The substances listed in (a) are nerve agents of the organophosphorus family. Although they do have the same effects as ordinary insecticides and bacteriocides, they are unsuitable for such peaceful purposes because their toxic effects are much too powerful. Toxins, alkaloids and plant heart poisons are chemical substances derived from animals, plants or microbes. While toxins are high molecular substances consisting mainly of protein and have an antigenous effect, alkaloids are low molecular substances and have no antigenous effects. Alkaloids and plant heart poisons are used for medical purposes in very small doses. Although some of the alkaloids and plant heart poisons may be chemically synthesized for academic purposes, it is through the extraction from plants that those substances are produced in any significant quantity.

(3) On the basis of the above considerations, relevant items to be reported on would be nerve agents of the organophosphorus family and the intermediates in their production. Since nerve agents themselves cannot be used for peaceful purposes and should be unconditionally prohibited, it would not make sense to require statistics

on them. Accordingly, the items to be reported on could be limited to the following seven kinds of substances: yellow phosphorus, phosphorus trichloride, phosphorus oxychloride, phosphorus pentachloride, phosphorus pentasulfide, dimethylphosphite and methylphosphonic dichloride. They are intermediates not only in the production of nerve agents but also in industry for peaceful purposes.

If new chemical substances were discovered whose poisonous effect equals or exceeds the level mentioned earlier, it would be necessary to consider the addition of such substances and their intermediates to the list of items to be reported on. In order to do this, those chemicals whose poisonous effects are reported in academic periodicals or meetings to be the same or more than the level suggested above and new chemicals which have been made public without any reference to their toxic effects and which experts picked out as those which might have considerable toxic effects must be tested by an appropriate international research institute.

2. Technical method of on-site inspection

As a possible technical method of on-site inspection of the production of chemical agents, the following one might be considered.

In recent years techniques of microanalysis have been developed to check quantitatively the contamination of rivers or living things by agricultural chemicals. Those techniques could also be applied in on-site inspections. For instance, we should be able to apply improved gaschromatography to microanalyze substances from the chemical plant concerned existing in very small quantities in liquid wastes, the soil and dust in and around the premises, on the production devices or on the workers' clothes. If an emission electrode for a flame thermionic detector is attached to the nozzle of a flame ionization detector in gaschromatography, a high sensitivity will be shown by phosphorus compounds and the minimum amount detectable will be 1×10^{-13} g/sec. Therefore, by using this method of gaschromatography, it would be possible to identify an unknown substance contained in a sample by comparing its retention time with that of authentic substances, such as VX.

Even when the substance itself cannot be identified through the method described above, we could obtain considerable information by detecting the

phosphorus, halogens and sulphur possibly contained in the substance. If we use a coulometry detector, the minimum amount required for detecting sulphur and halogen compounds will be 1×10^{-8} g. Employing that method in combination with other analytical methods, it might be possible even to determine the chemical structure of the unknown substance.

VX, Sarin and Soman have in their structures phosphorusmethyl (alkyl) bonds which do not cleave in mild decomposition. Therefore, it would be useful for the detection of the development, production and stockpiling of nerve agents of the organophosphorus family to check whether chemicals with phosphorus-methyl (alkyl) bonds might be found in liquid wastes, etc.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/302
6 August 1970
Original: ENGLISH

YUGOSLAVIA

Working Paper

on the Elements for a System of Control of the Complete Prohibition of Chemical and Biological Weapons

Consideration of the complex problem of chemical and biological weapons clearly indicates, that in the assessment of most countries it is indispensable and possible to reach as a matter of urgency an agreement on the prohibition of the development, production and stockpiling of all chemical and biological agents for war purposes and on their elimination from existing arsenals.

Consideration of this question has also demonstrated that one of the key problems of its solution is the question of control or verification of the fulfilment of the obligations under a treaty on the total prohibition of these weapons.

A study of the question of control leads to certain conclusions which could provide a basis for further efforts:

First, there is a need to control the fulfilment of the complete prohibition of chemical and biological weapons under the treaty.

Second, it appears that it would be possible to introduce a type of control that would be appropriate, adequate and politically acceptable even under the conditions prevailing in the world today.

Third, the success of the control will largely depend on the degree of political readiness on the part of governments to accept control. Technical problems do exist, but their solution seems to be possible if a positive political decision is taken.

Control of the complete prohibition of chemical and biological weapons, in order to be purposeful and at the same time politically acceptable, should above all meet the following requirements:

1. It should be effective to the point of leaving no possibility for secret violation of the treaty of major significance.

2. It should not inflict commercial or other damage through the disclosure of industrial, scientific or other secrets.

3. Its functioning should be relatively easy and simple, at both the national and international level.

4. The cost of control system should be kept to a minimum.

Obviously, it would be impossible to maintain one hundred per cent control over all institutions and installations which could be utilized for research, development and production of chemical and biological weapons. However, such control is not necessary to achieve the desired objective.

It is evident that it would not be possible by any reasonable kind of control to prevent the clandestine production of limited quantities of chemical and biological weapons, which would have no real military significance.

In devising such a control system the overall operation of which would provide sufficient guarantees for each party to a treaty, two categories of neasures may be required:

1. NATIONAL LEGISLATIVE MEASURES OF RENUNCIATION AND SELF-CONTROL BY EACH COUNTRY

(a) The enactment of a law prohibiting research for weapons purposes and of the development, production or stockpiling of agents for chemical and biological weapons.

(b) The enactment of a law for the compulsory publication of certain data from this sphere, which would facilitate international control, as for instance, the names of institutions and facilities engaged in or which, by their nature, could engage in the activities prohibited under the treaty. Certain data concerning the production of such materials or agents which could be used for the production of chemical or biological weapons would be regularly submitted to an international organ. The general list of such data would be established by the treaty itself, in an annex.

(c) The taking and promulgation of a decision to eliminate existing stockpiles and to abolish proving grounds for the testing of these weapons, and all installations related exclusively to such weapons.

(d) The cessation of training of troops in the use of chemical and biological weapons and the deletion from army manuals of all such instructions with the exception of those sections dealing with protection against chemical and biological weapons.

It is self-evident that a treaty on the Complete Prohibition of All Chemical and Biological Weapons will also preserve the rights of countries to continue research, development and production of means of protection.

Some of the present military institutions in this field could be re-adapted for research work for peaceful purposes or for protection, in keeping with the provisions of the treaty regulating these matters.

In enacting such laws, an exception could be made, in line with the provisions of the treaty on the Complete Prohibition of Chemical and Biological Weapons, for types and quantities of agents used for riot control purposes within the country.

The enforcement of these laws would be left up to each individual state.

National legislative measures of renunciation and self-control should represent the most important group of measures and the main deterrent to possible violation of the treaty on the complete prohibition of chemical and biological weapons.

All national legislative measures of renunciation and self-control by each country should be preceded by the enactment of a law placing under civilian administration or control - the Ministry of Health, the Ministry of Industry or a similar organ - all institutions now engaged in the research, development or production of chemical and biological weapons. Such a measure would significantly facilitate the implementation of the treaty and reduce the possibilities for illegal production of chemical and biological weapons.

2. MEASURES OF INTERNATIONAL CONTROL

(a) The collection of certain data which States would publish and report in line with their internal legislation (Item (b) from the first group of measures), and other relevant information which could indicate whether any prohibited activity was being undertaken.

The collection, receipt of reports and analysis of these data would be carried out by an international organ, one of those already in existence or one that would be especially set up for this purpose, which might also discharge other functions in connexion with the control of the prohibition of chemical and biological weapons.

(b) Governments should, at their own initiative, and within the framework of consultations and co-operation in good faith, if the need arises, make it possible through an appropriately regulated procedure, in accordance with the concept of verification by challenge, to ascertain that there is no activity on their territory prohibited by the treaty.

(c) The complaints procedure to the Security Council.

PROCEDURE IN CASE OF SUSPICION OF VIOLATION

In case any party to the treaty harbours any doubts about the implementation of provisions of the treaty by any other party, it should enter into discussions and consultations with such other party with a view to clarifying the situation and removing such doubts.

In case of suspicion that the treaty on the complete prohibition of chemical and biological weapons has been violated, a State harbouring the suspicion, should inform other parties to the treaty and also apply to the international organ, submitting the necessary information for the purpose of preliminary investigation, which should be provided for.

On this basis, the international organ would contact the state under suspicion, for the purpose of making relevant enquiries or conducting a preliminary investigation to ascertain whether the suspicion is founded.

If the procedure undertaken does not yield a satisfactory solution, the country under suspicion may offer verification under the "verification by challenge" procedure.

If the State harbouring the suspicion considers it has not received a satisfactory reply after this procedure, it may address itself to the Security Council which would endeavour urgently to find a solution.

The right of countries to address themselves to the Security Council remains unaffected and they may resort to it at any stage of the above procedure.

CCD/303
6 August 1970
ENGLISH
Original: RUSSIAN

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

Union of Soviet Socialist Republics

Working Paper on the complete prohibition of chemical and bacteriological weapons

1. The main problem as regards chemical and bacteriological weapons is to achieve their complete prohibition, namely the prohibition of their use, development, production and stockpiling and the destruction of stocks of such weapons.

The problem of prohibiting the use of chemical and bacteriological weapons is solved by the Geneva Protocol of 1925. This Protocol, to which about seventy States are parties, embodies an important and generally recognized rule of international law prohibiting the use of chemical and bacteriological warfare methods. It may be noted with satisfaction that the Protocol has recently been ratified by Japan and Brazil. However, the United States of America, which has a very highly developed chemical industry and produces and uses chemical means of warfare, is as yet not a party to it. In the present situation, in order to bring about a general renunciation of the use of chemical and bacteriological weapons and thereby make the Geneva Protocol more effective, all States of military importance, and in particular the United States of America, must by acceding to the Geneva Protocol undertake not to use chemical or bacteriological means for military purposes.

The complete prohibition of chemical and bacteriological weapons can only be achieved by the renunciation on the part of States of the development, production and stockpiling of such weapons and by their undertaking to destroy such weapons. It is this solution of the problem of chemical and bacteriological weapons which is envisaged in the draft convention of the nine socialist countries.

2. The conclusion of a convention on the prohibition of the production and stockpiling of chemical and bacteriological weapons and on the destruction of such weapons, widely acceded to by States throughout the world, is aimed to lead to the complete elimination of such weapons. This would complete the process which was initiated by

the conclusion of the 1925 Geneva Protocol. It would also solve the question of the reservations to the Protocol entered by a number of States. Those reservations, which have the effect of providing that the prohibitions of the Protocol are binding only with respect to States which are Parties and that they cease to be binding with respect to any State whose armed forces do not observe the restrictions laid down in the Protocol, have played their part in preventing the unleashing of a war involving the widespread use of chemical and bacteriological methods. The reservations served as the basis for the warning issued by the Allied Powers to the Government of Hitler Germany concerning the possible use of chemical weapons by the latter during the Second World War.

The conclusion of a convention aimed at the complete elimination of chemical and bacteriological weapons from the military arsenals of States will make the question of reservations to the 1925 Geneva Protocol superfluous.

3. The proposal by the United Kingdom to conclude a convention solely for the prohibition of biological weapons not only fails to solve the problem of the complete prohibition of chemical and biological weapons, but in essence means the expansion and legalization of chemical means of warfare. Given the present rapid progress of science and technology, it is precisely the chemical weapons which present the greatest danger, since they have assumed an important place in the armed forces of a number of States. Such weapons have already been widely used in the past and are being used at the present time. It is generally recognized, however, that the use of biological weapons involves tremendous risks, even to the country that might use them as a means of warfare.

Chemical and bacteriological weapons have consistently been considered together in view of the common characteristics of these types of weapons of mass destruction. The prohibition of the use of chemical and bacteriological weapons is provided for in a single international instrument - the Geneva Protocol of 1925. Attempts to adopt a different approach to the prohibition of chemical weapons and biological weapons and proposals to provide for their prohibition in separate agreements will mean undermining the existing generally recognized rules of international law embodied in the Geneva Protocol, which adopts a unified approach to chemical and bacteriological (biological) weapons alike. In these conditions, the implementation of the United Kingdom proposal, which is based on a separate approach to chemical and bacteriological weapons and provides for the prohibition of the latter alone, constitutes a direct danger in that it will promote the build-up by States of arsenals of chemical weapons and increase the risk of the use of such weapons in international conflicts.

4. The draft convention on the prohibition of the development, production and stockpiling of chemical and bacteriological weapons and on their destruction, proposed by the nine socialist countries, contains provisions ensuring the strict observance of the terms of the agreement by the parties to the convention. Those provisions have been arrived at on the assumption that the establishment of a system of international verification to determine whether chemical and bacteriological weapons are or are not being produced in a given country is an exceptionally complex and practically impossible task, since the process of manufacturing chemical and bacteriological substances for peaceful purposes is essentially no different from that of their production for military purposes. Under such circumstances, the most reasonable method is control exercised by national Governments, each of which will thus be internationally responsible for ensuring that not a single industrial undertaking or citizen in its country engages in the development or production of chemical or bacteriological weapons and that no such weapons are being stockpiled in the country's military arsenals. The relevant provisions are contained in articles 4 and 5 of the draft convention proposed by the socialist countries. They are supplemented by article 6, whereby the parties to the convention undertake to consult and co-operate with one another in solving problems connected with the application of the convention.

Of great importance also are the additions to the draft convention of the socialist countries, sponsored by Hungary, Mongolia and Poland (CCD/285), concerning the involvement of the United Nations Security Council in the investigation of cases of violation of the convention.

The measures embodied in the draft convention of the nine socialist States for ensuring the implementation of the convention are sufficiently strict and at the same time sufficiently flexible, and they enable the Governments themselves to choose such methods of control as, in their view, will most effectively guarantee implementation of the terms of the convention. Those measures do not limit the right of States, if they so wish and if they reach agreement on the matter, to have recourse to methods of an international character. That possibility is covered by the provisions of article 5.

5. A number of proposals put forward by members of the Disarmament Committee, including Sweden, Morocco and Yugoslavia, with a view to developing the system of control envisaged in the draft convention of the nine Socialist countries, are interesting and merit careful consideration and further elaboration.

Nevertheless, it is quite obviously necessary to maintain a balance in considering the political aspects of the problem of the prohibition of the development, production

and stockpiling of chemical and bacteriological weapons and the technical aspects of the problem of control over such prohibition. The attempts being made to base the work of the Committee on just the study of the technical features of the problem of control may hinder or in any case considerably delay the adoption of a political decision, which is necessarily the priority task in solving the problem of the prohibition of chemical and bacteriological weapons. Past experience, and in particular the activities of the League of Nations, shows that channelling disarmament discussions along the lines of technical expertise and deferment of political decisions resulted in failure to reach an agreement. This should not be lost sight of during consideration of the problem of the complete prohibition of chemical and bacteriological weapons.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/304
6 August 1970

Original: ENGLISH

ITALY

Additional Working Paper on the Problem of Controls Over Chemical Weapons

(1) In the working paper tabled by the Italian delegation on June 30, 1970 (CCD/289) the following concepts were, in particular, stressed: (a) the establishment of an effective system of controls is still the major problem among those that the Committee will have to solve with a view to achieving an agreement for the prohibition of chemical weapons; (b) the problem of controls presents some aspects that are predominantly scientific and a knowledge of which is essential before the various delegations can profitably embark on the discussion of a draft treaty; (c) for the purposes of such discussion, the technical studies which are already at the disposal of the Committee should be appropriately supplemented by a specific study on the problem of controls of chemical weapons to be undertaken by a special group of experts; (d) the Committee should itself guide the group on its labours deciding beforehand the lines on which it should work and the specific subjects with which it should deal.

(2) During the informal meeting held on August 5, 1970 and on other previous occasions, many delegations made valuable contributions to the discussions of the Committee by presenting their views and asking technical questions on the problem of controls over chemical weapons.

The Italian delegation wishes, on its part, to formulate a number of questions of technical nature, in the hope that this may help the work of the Committee:

(a) Assuming that, for the substances listed in the Japanese and Canadian papers (CCD/288 and CCD/300) a control problem arises only when considerable quantities are involved, is it possible to establish, by mutual consent, a listing of the large chemical industries which produce and practically control the products concerned?

(b) Taking for granted that such a possibility exists, does the fact that large quantities of these substances are mainly used by big industries involved in peaceful production make it easier to control any leak of such products towards non-peaceful uses?

(c) Granted the hypothesis that it is possible to exercise an overall control of the production and the flow of these substances, what is then the minimum percentage variation which, if not justified on economic grounds, could give rise to the suspicion that the final destination is not meant for peaceful uses?

(d) If a percentage variation of a specific factor in itself is not suitable as an indicator as to the destination of the product for warfare purposes, could this same factor acquire a decisive importance when combined with the percentage variation of another factor related to the former?

(e) Does an international organization exist which could contribute effectively to verifying the production and the flow of the substances concerned and, if it exists, could it include this task in its present structure or could it do so through minor structural and organizational changes?

(f) Taking for granted that such an organization exists, could its contribution be sufficient to establish a founded suspicion that a violation has been committed and thus justify a complaint?

(g) Could the present trend which aims at eliminating phosphates organic compounds as insecticides help the solution of the problem of controls?

(3) In the opinion of the Italian delegation, technical documents such as the ones mentioned above represent examples of the very contributions which, in working paper CCD/289, we suggested should be tabled by the various delegations to the C.C.D.

It will be recalled that in paragraph 5 (c) of the same working paper it was proposed that "each delegation should instruct the appropriate body in its own country to suggest a list of specific technical themes to be developed and studied in more detail".

We believe, however, that tabling such technical documents cannot be considered sufficient in itself. In our opinion, more appropriate methods should be envisaged so that contributions by individual countries could be fully utilized by the C.C.D.

To this end, we supported the idea of setting up a group of experts with a view to organizing the work that each competent national body would carry out. Moreover, in order to enable the group of experts to produce, within a relatively short time, a useful document for the specific purposes of the Committee, we also suggested under paragraph 5 b, c, d, e, of our working paper, a particular procedure according to which the group should be given appropriate guidance by the Committee itself.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/308
18 August 1970
Original: ENGLISH

UNITED KINGDOM

Working Paper on Verification of CW Arms Control Measures

1. Any consideration of the possibilities of verifying an arms control agreement in the field of C and BW must take account of all possibilities, both political and technical, by examining the feasibility of available technical methods in the light of existing political constraints.

2. The verification requirements can be simply stated in the form of a question: "What technically feasible, and politically acceptable, measures would be adequate to guarantee any international agreement for chemical and biological arms control at the present time?" This paper sets out to examine in this light and in a preliminary way a number of suggested techniques as a contribution to informal discussion of the subject.

3. In the case of BW which is not yet established as a military weapon, we have made it clear that we consider that no verification of production, testing and stockpiling is possible, but that the complaints procedures associated with the UK draft Convention on Biological Methods of Warfare, and designed to deter any would-be violators, would reduce the risk of accepting an unverified Convention to a level which would be acceptable at the present time.

4. Chemical weapons, on the other hand, were used extensively in the First World War, and stockpiles of vastly more lethal CW agents exist today and military doctrine openly envisages their use on an extensive scale in war. The fear of this is enough to lead a number of states to develop and deploy expensive definsive equipment. Verification of a CW agreement covering the production, testing and stockpiling, as well as use, of CW would therefore need to be extremely reliable before the risk of entering into such an agreement could be reduced to an acceptable level. This is the problem we must try to solve.

Requirements:

5. To ensure compliance with any CW agreement, one might need to verify, to an acceptable level of risk, all or any of the following:

(a) that existing weapons or their component parts have been destroyed and/or that no such weapons or component parts are held;

(b) absence (or cessation) of production of CW agents at declared facilities;

(c) absence of any undeclared production, testing and storage facilities.

Verification measures involving even a modest degree of intrusiveness appear to be unacceptable to a number of states. Direct confirmation that international agreements were not being broken might thus have to depend entirely on information obtained by external means, and the only such means so far suggested are observation satellites and remote sensors.

Observation Satellites:

6. This possibility has been carefully studied. In our view detection of CW field tests by this technique presents serious difficulties. First the possible test site itself must be detected (and it may not require fixed installations). Then the tests themselves must be detected, and differentiated from other possible types of field tests, including tests of CW defensive equipment. Additionally, one must assume that a state wishing to test in contravention of an agreement will attempt to conceal the fact - as, for example, by testing at night or in conditions of cloud cover. Altogether it would seem that the likelihood of detecting field tests by satellite observation would be very low. Identification by satellite photo-reconnaissance of a chemical agent plant (which might be part of a large industrial complex) would be even more difficult.

Atmospheric Sensors:

7. We have also looked into the possibility of identifying the minute atmospheric concentrations in which chemical agents resulting from field tests might reach extra-territorial detectors. Here we are faced with the problems of discriminating such concentrations from a background of normal industrial air pollution. An indication of the atmospheric concentrations in which agents might occur at various distances from a field test may be obtained by extrapolation of data published by the Swedish Defence Research Institute. This gives the concentration at various distances downwind of an initial airborne source of 10 kg of an involatile agent; by about 7 km the concentration is only 0.05 mg/cu. metre, and simple extrapolation gives a concentration at 50 km of the order of 10^{-12} mg/cu.m (a million millionth of a milligramme). This rough estimate is given to indicate the order of magnitude of the problem of remote detection - the exact values are not important.

8. At the far greater distances at which sensors would probably have to operate, the concentration would not only be much lower by reason of simple dilution, but important additional factors could reduce it still further: for example, wash-out by precipitation and horizontal separation of air masses, with subsequent differing wind directions at different levels. The effect of dilution could, in theory at least, be offset by the sampling and concentration of very large volumes of air, but even if this were practicabl it seems unlikely that it could compensate for extreme dilutions.

9. Because of the mass of other chemical and biological pollutants in concentrated air samples, highly specific and sophisticated analytical techniques would have to be developed. The only technique which currently appears feasible is the use of gas-liquid chromatography incorporating a phosphorus detector, followed by the examination of appropriate fractions by mass spectrometry to identify the actual nature of the phosphorus-containing material by comparison with the spectra of known compounds. However, it is not known whether the sensitivity of even such an advanced technique would be sufficient, and its practical application would pose many problems. For example, if the sensitivity of a technique were of the order of 10^{-9} mg (i.e. not less than a millionth of a milligramme could be detected) then in order to detect the field test quoted earlier, at only 50 km from the source a million cubic metres of air would have to be concentrated to give a detectable sample. This also assumes that the large quantities of other pollutants which would thereby be concentrated would not interfere with the detection process.

10. Positive results, assuming that sufficiently sensitive techniques were developed in the future, would also demand an assessment of the source of the material detected. This would certainly require the provision of extensive meteorological data (from within the suspected neighbouring country) and even then might prove impossible in the present state of the art.

Effluent Sensors:

11. The possibility of establishing the existence of a chemical agent production plant by the detection of unique indicators (if they exist) in rivers downstream of an effluent discharge has also been suggested, though this technique has yet to be fully evaluated.

12. Large scale production of nerve gases might be possible at only a relatively few riverside sites in any particular country. However, a factory in which these agents were made might also manufacture unobjectionable phosphorus compounds, resulting in an effluent discharge analogous to that from nerve gas manufacture. Thus, as well as having a high dilution in the effluent of nerve gas products or their intermediaries, there is also the likelihood of other waste products having similar chemical properties. Such a complication would be further exacerbated if the plant were situated in an industrial complex such as those found on major rivers. Similar considerations would apply to the detection of effluent discharged in the sea.

13. Should particular agents be made on a smaller scale, the effluent might be run to a sewage disposal system where its dilution would become enormous. Of course, as in the case of the US Newport Chemical Plant described in the US Working Paper CCD/293, a nerve gas plant could dispose of waste products into deep wells rather than by discharge into a river or the sea.

Defensive Measures:

14. If all the techniques discussed above were developed and applied, the almost insoluble problem would remain of attempting to prove a negative, especially from limited and uncertain indicators.

15. Where access to deployed military forces was not possible, confirmation of the absence of chemical weapons or of destruction of stocks could not be guaranteed. A consequence of this might well be the continued development and issue of defensive equipment, and its use in training exercises. Evidence of such defensive training alone provides no proof of the possession, or lack, of offensive C weapons; the use of chemical weapon simulants, for example, could either be a means of reinforcing defensive measures, or of providing practical training in the employment of actual chemical weapons.

16. On the other hand, the continued absence of chemical defensive equipment and associated training from the military forces of a state might well contribute, in conjunction with other factors, to confidence in the absence of a chemical weapon capability. However, the collection of such information would necessitate a reduction in the level of the political constraints implied in the preceding discussion, and one must accept that a CW agreement would need to take account of the degrees of access which differing political systems allow.

The Problem of Access:

17. Many of the verification suggestions already made in the Committee, for example the control of phosphorus production (suggested by the Delegation of Japan) a system of openness and reporting (outlined by the Swedish Delegation) and a variety of on-site inspection procedures (discussed by the USA, and included in the SIPRI Report Part IV), would either require a high degree of intrusiveness or depend to a considerable extent on the availability of detailed published information. This might involve, for example:

(a) budgetary and fiscal information on defence research, development and production;

(b) identification of likely targets for on-site inspection;

(c) examination of statistics of chemical industry production and distribution;

(d) access to, and monitoring of, national transportation networks;

(e) examination and sampling of effluent disposal systems at suspected sites;

(f) direct inspection of plant and equipment at suspected sites;

(g) examination and identification of raw materials entering suspected sites.

18. A number of these factors have already been examined, both in interventions and in working papers laid before the Committee. But to take the single example of (d), that of national transport networks, the size of the task involved - quite apart from the question of the political conditions in which close observation of trains and roads would be possible - can readily be illustrated. There were for example in the UK at the end of 1969, 12,098 miles of major rail routes, and 19,000 rail bulk liquid carriers (tank cars). On the roads, there were estimated to be upwards of 20,000 licensed road tankers.

19. A nation intending to contravene a ban on the production of Chemical Weapons need not, of course, move the necessary raw materials or finished agents by means of such obvious verification targets as tank cars or road tankers. Almost any road or rail vehicle, and many aircraft, could carry containers or such materials or agents.

20. Clearly some of the techniques listed above might have considerable relevance in certain circumstances, for example where a state wished to invite inspection of a particular facility in order to disprove allegations by others; but not all of them would be practicable. Equally, by no means all states would seem likely to accept the application of such techniques where they themselves are concerned.

21. We conclude, therefore, that considerable problems still lie ahead if the verification requirements for an acceptable CW agreement are to be met. It is, however, the intention of the United Kingdom to consider every approach, both technical and political, which might help to achieve the goal of an effective abolition of the possibility of chemicals as of biological warfare.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/310
25 August 1970
Original: ENGLISH

ARGENTINA, BRAZIL, BURMA, ETHIOPIA, INDIA, MEXICO, MOROCCO, NIGERIA, PAKISTAN, SWEDEN, UNITED ARAB REPUBLIC AND YUGOSLAVIA

Joint Memorandum on the question of Chemical and Bacteriological (Biological) Methods of Warfare

1. The international community has, during recent years, been increasingly concerned by developments in the field of chemical and bacteriological (biological) weapons and by the grave dangers posed by such weapons to humanity and the ecological balance of nature.

2. It is now universally recognized that prospects of international peace and security, as well as the achievement of the goal of general and complete disarmament under effective international control, would be enhanced if the development, production and stockpiling of chemical and bacteriological (biological) agents intended for purposes of war were to end and if they were eliminated from all military arsenals.

3. The Geneva Protocol of 1925 prohibits the use in war of all chemical and bacteriological (biological) agents. The General Assembly has, by resolution 2162 B(XXI), called for the strict observance by all States of the principles and objectives of the Geneva Protocol of 1925, condemned all actions contrary to those objectives and invited all States, which had not already done so, to accede to the Protocol. The General Assembly has, by resolution 2603 A(XXIV), also made a clear affirmation that the prohibition embodied in that Protocol was comprehensive and covered the use in international armed conflicts of all biological and chemical methods of warfare, regardless of any technical developments.

4. In addition to the existing parties to the Geneva Protocol of 1925 there are other States which are considering accession to or ratification of the Protocol. There are some who have unilaterally and unconditionally renounced one or both types of weapons. These are welcome developments.

5. The Report prepared by the United Nations Secretary-General, in accordance with the General Assembly resolution 2454 A(XXIII) with the assistance of consultant experts, on chemical and bacteriological (biological) weapons and the effects of their possible use, and the Report of the World Health Organization's group of consultants

on health aspects of chemical and biological weapons, and other studies on the subject, underline the immense importance and urgency universally felt in regard to reaching agreement to halt the development, production and stockpiling of all chemical and bacteriological (biological) agents for purposes of war and to achieve their effective elimination from the arsenals of weapons.

6. It is essential that both chemical and bacteriological (biological) weapons should continue to be dealt with together in taking steps towards the prohibition of their development, production and stockpiling and their effective elimination from the arsenals of all States. It is the conviction of the Group of Twelve that an effective solution of the problem should be sought on this basis.

7. The issue of verification is important in the field of chemical and bacteriological (biological) weapons, as indeed adequate verification is also essential in regard to the success of any measure in the field of disarmament. Reasonable guarantees and safeguards should, therefore, be devised to inspire confidence in the implementation of any agreement in the field of C and B weapons. Verification should be based on a combination of appropriate national and international measures, which would complement and supplement each other, thereby providing an acceptable system which would ensure effective implementation of the prohibition.

8. The Group expresses the hope that the basic approach, as outlined in the preceding paragraphs, concerning the task before the Conference of the Committee on Disarmament in the field of chemical and bacteriological (biological) weapons would receive general acceptance so that an early solution could be found in regard to the prohibition of the production, development and stockpiling of such weapons and their effective elimination from the arsenals of all States.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/311
25 August 1970
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UNITED STATES

Working Paper on Economic Data Monitoring as a Means of Verifying Compliance with a Ban on Chemical Weapons

This paper discusses the contribution which might be made by economic data monitoring to the verification of compliance with a treaty banning the production and stockpiling of chemical weapons. Over the past six years, the United States Arms Control and Disarmament Agency has investigated the potential of economic monitoring as applied to chemical weapons. The material in this paper is drawn very largely from the results of this research. In the interests of economy of presentation and because of their importance, the discussion will be restricted to organophosphorous nerve agents only. Most of the research was performed within the context of the US economy. Generalizations based largely on experience in one country only should be treated with reserve.

Operation of an Economic Monitoring System

Economic monitoring of a CW ban would aim at identifying changes or inconsistencies in economic data series that could indicate the development of a CW capability. While there is no pre-established method for utilizing economic data for arms control verification purposes, we have found it useful in the case of the organophosphorous nerve agents to consider how this technique might be used to monitor the production and consumption of materials which could be used to produce these agents. The analysis might proceed as follows.

The group of agents to be examined--in this case all nerve agents--is defined. Our analytical starting point is the molecular structure common to all nerve agents. The basic structure of organophosphorous poisons is that of a phosphorous atom bonded at four points to other chemical groups. These groups are joined to the phosphorous atom by some combination of four reaction processes: oxidation, esterification, alkylation, and either amination or flurination. Although the exact make-up of the attached chemical groups can vary, each must contain one of five elements: oxygen, either sulphur or selenium, nitrogen, fluorine or carbon. All known organophosphorous poisons conform to these general structural rules.

Given the five bonding elements and four bonding positions, the total number of combinations into which they can be arranged equals 625. About 20 of these possible structural combinations, or classes, have been found to be sufficiently toxic to be useful as poisons, and only six classes are considered toxic enough to be effective as nerve agents. (Discovery of additional highly toxic classes is possible).

Within those six classes of nerve agents, there is an almost infinite number of specific chemical compounds which could meet the common structural requirements. However, as with the agent classes, not all of these compounds would be sufficiently toxic to be useful as nerve agents. Also, the practicalities of the production processes involved reduce further the number of potential agents. These considerations refine the number of nerve agents we must consider from a theoretically immense number down to several thousand.

Our research determined that, with certain limiting assumptions concerning the state of the art of organophosphorous chemistry, all the potential agents could be manufactured using about 90 component materials (raw materials and intermediates). If, at this point, it were possible to say that, of the 90 materials only a few were required for the production of all nerve agents, our monitoring tasks could be greatly simplified. Such is not the case however; on the contrary, a rather low degree of "commonality" of materials was discovered. (The one exception to this statement relates to elemental phosphorous, which is the only material common to all nerve agents. Elemental phosphorous, however, is used throughout the world in a variety of commercial processes. To be conclusive alone, monitoring of the importation, production and consumption of elemental phosphorous would have to be completely foolproof). Thus, to make any useful statement about the manufacture of a given nerve agent, an economic monitoring system must consider simultaneously all, or almost all, of the 90 potential components.

There are several methods by which a nation can provide the component materials for agent production: (a) by increasing its own production of the required materials; (b) by diverting materials from existing uses or from stockpiles; (c) by importing the required materials; and (d) by a combination of the above. From the standpoint of a nation wishing to violate a ban on nerve agent production, the least detectable options would be to increase production, especially if excess production capacity is available, or to draw on stockpiles. Diversion from existing uses is more risky since it necessarily affects people and institutions downstream in the production cycle. Importing would be the least attractive option because the supply must be sought in other nations, making disclosure much more likely.

For statistical monitoring to be successful, the pattern of production and consumption of the various materials would have to be "visible" against the background of economic statistics of the country being monitored. This "visibility" would be affected by (1) the quantity of nerve agent to be produced, which in turn defines the quantities of materials required, (2) the ability of the country to supply the required materials from indigenous production, (3) the complexity of the economy, and (4) the amount, quality, precision and timeliness of the data supplied.

The actual monitoring process would call for detailed data, for each country monitored, on each potential component material in terms of (1) imports, (2) the process of its manufacture, working backwards to initial raw materials, and (3) its commercial end uses, including exports if any. Current data would need to be reported frequently and with minimum delay. Historical data would also be required comparable to current data to serve as a background against which to measure current trends and deviations.

The actual effort involved in gathering information would vary greatly from case to case. It would be least difficult in a small country with a simple economy, willing to co-operate freely, with fast, accurate statistical reporting, with many open sources of information, providing reliable consistent historical data, and which possessed and/or imported few of the materials used to produce nerve agents. As we move away from this example, the level of effort required would increase sharply and the reliability of the data being monitored would diminish.

Limitations and Problems of Economic Monitoring

Our research indicates that the success of an economic monitoring system depends on having a free flow of accurate, consistent, timely data, over a considerable span of time. Cross-checking with related statistics would be necessary.

Even assuming full compliance by all parties to a treaty involving economic monitoring, there are certain disadvantages and problems inherent in the method itself.

(1) With the best of intentions, the problem of honest error exists. In deriving statistics for non-arms-control purposes, problems such as in-process waste, variations in process yield or efficiency, changes in the nature of the product, and fluctuations in inventory can lead to significant error in the statistical results.

(2) A related problem, again not peculiar to arms control, is that statistical data are not always uniform or consistent in terms of terminology and coverage, and therefore, may not be strictly comparable.

(3) Statistical data are often published only after a considerable time lag, especially where the data are voluminous, complex or require considerable analysis.

(4) In some cases, the collection of data might become intrusive. If the data were detailed and extensive enough they might disclose more than just CW-related activities, perhaps even some of military significance. In some cases proprietary commercial processes and secrets might be disclosed to competitors.

(5) For purposes of verifying a CW treaty, some data which might be assumed to be useful in fact could be misleading. For example, statistics on chemical industry employment and investment are often hard to relate to figures in production, due to variations in factors such as classification terminology and labour productivity.

Apart from the problems, above, inherent in the method of economic monitoring, a second order of problems arises if one assumes that an economic monitoring system must be capable of identifying deliberate attempts at deception. Our studies on economic monitoring have been able to develop no effective way of dealing with the problem of existing stockpiles of CW agents. Also, they underline the problem of identifying small evasions. Should a nation not now possessing CW stockpiles so desire, it could possibly initiate CW agent production by gradually increasing production of raw materials and intermediates without altering its reported statistics, or by small diversions, or both. Such a gradual approach would be extremely difficult to detect by statistical methods, especially in a large complex economy.

Preliminary Conclusions and Comments

(1) The indirect nature of economic monitoring, which deals with records of events rather than the events themselvss, is both its strength and its weakness. On the one hand, such monitoring is non-instrusive and relies entirely on unilateral analysis of reported data. However, even at best, it can show only the symptons of a violation and not the violation itself.

(2) The role of economic monitoring will vary greatly with the characteristics of the country being monitored. It would be most effective when applied to small countries with open societies and non-autarchic economies. Large countries with closed societies and self-sufficient economies should face little difficulty in rendering it ineffective. Any nation capable of producing and stockpiling CW agents, and motivated to do so, would also be likely to be able to conceal this activity from the outside world, in terms of reported data.

(3) Although our investigation of the contribution of economic monitoring is still going on, our preliminary conclusions are that, under optimum conditions, economic monitoring could be of ancillary use, but alone would not provide an answer to the verification problem. It can serve as a precursor, guide, support and focusing technique, but not as a substitute for direct technical on-site inspection.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/314
1 September 1970
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UNITED ARAB REPUBLIC

Working Paper concerning suggestions on measures of verification of a ban on Chemical and Biological Weapons

1. When dealing with the issue of verification of CBW, the following points need to be taken into account:

(a) CW cannot be banned without adequate verification.

(b) Agreement on a procedure of verification, despite apparent difficulties, is not out of reach.

(c) Verification need not be 100 per cent effective. That would be both unnecessary and impossible to achieve.

(d) Verification has both a technical and a political aspect. These two aspects must be, as much as possible, reconciled.

(e) Aspects of verification must be considered in such a way as to produce a solution properly adjusted to present day facts and conditions.

(f) Procedures of verification should be both national and international. They should complement one another in the most suitable manner.

2. Procedures of verification should fulfill two purposes: a preventive one, seeking the non-occurance of a violation, and a curative one, to ascertain responsibilities in case a violation has been committed. These purposes could, perhaps, be best achieved by the following means:

(a) Each state party to the treaty is to undertake, within a certain period of time from the entry into force of the treaty, all necessary legal, administrative and otherwise practical measures, conducive to ensure the respect of the prohibitions and the elimination of stockpiles of the banned weapons. Furthermore, each party should inform the Security Council, or perhaps an impartial international body agreed to, on the steps it took in this regard, as well as on the completion of the elimination of its stockpiles. This procedure could be repeated whenever deemed necessary.

(b) Each state party is to undertake the forwarding of relevant and basic information to be agreed upon to the above mentioned impartial international body with a view to assist the technical process of verification. Furthermore, assistance of existing competent international organs such as WHO, FAO etc. ... could be called upon.

(c) In case of doubt arising concerning the activities of a state this would have to be reported to the Security Council which could take the necessary measures of investigation. A complaint could be, of course, directly lodged with the Security Council.

3. These procedures would notably increase in efficacity and credibility if there would be incorporated in the treaty a provision on withdrawal therefrom as well as another regarding a review conference. This would be a proper safeguard for ensuring the respect by all of the obligations entered upon.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/315
3 September 1970
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HUNGARY, MONGOLIA AND POLAND

Working document concerning the introduction of a safeguard clause - CCD/285 - to the draft convention prohibiting the development, production and stockpiling of chemical and bacteriological (biological) weapons and on the destruction of such weapons (Doc.A/7655) made by Mr. J. Winiewicz, Deputy-Minister for Foreign Affairs of the Polish People's Republic at the 464th plenary meeting of the Conference of the Committee on Disarmament

... After hearing the statements of practically all the Members of this Committee it has become obvious that its overwhelming majority definitely favours a joint treatment of chemical and bacteriological means of warfare.

I shall then proceed with few comments on our working paper (No.CCD/285) in connexion with certain articles of the draft Convention as contained in doc.A/7655.

The system of complaints embodied in our proposal, now before you, has been, to a large extent, inspired by the provisions in respect of verification formulated in the British draft Convention dealing with biological warfare. By referring all problems having a direct impact on the security of nations to the Security Council we are making use of the only organ of the United Nations which has the power to enforce necessary decisions and is authorized to undertake such forms of investigation as necessary and deriving from the character of the complaint.

In the second paragraph of the proposed new article we are stating the obligation of every State to the Convention to co-operate in carrying out any investigation, which might be decided upon by the Security Council. Should the Security Council decide for example on the need for an on site inspection, then, of course, the inspection should be carried out. In order to secure a speedy action in such a circumstance I think that a very interesting suggestion has been put forward here by the distinguished representative of Japan, Ambassador Abe in his statement of 10 March, when he proposed that a roster of experts on B and C warfare prepared by the Secretary-General of the United Nations to be used for on site inspection should such need arise. The Polish delegation will not fail to give this proposal a more thorough analysis.

When we speak of a system of verification and control our primary concern must be to ensure that it is within the scope of obligations assumed under the Treaty. Proposing the said addition to the draft convention we are fully aware of the fact, that any system of complaint and verification must be credible and has to inspire confidence in order to avert suspicion on the part of the signatories.

On the other hand we must always keep in mind that when exploring the most perfect methods of compliance with any measure of disarmament, political realism should remain our guide, if we really desire to make progress. Indeed, we fully share the view expressed by the distinguished representative of Sweden, Madame Myrdal when, in her statement of April 9, 1970, she said:

"The main objective of any verification procedure is that it should generate mutual trust".

We agree and accept this to be the very essential element and factor of co-operation; based on goodwill it may prove to be the most efficient if not the only way to solve differences that might originate in the future between parties to the Convention.

We also accept the view of the distinguished representative of Sweden, that complaint procedure does not secure full positive observance of the provisions of the Convention by all parties concerned. But we should like to draw the Committee's attention that in the last two preambular paragraphs of the draft resolution of the Security Council, proposed in our working paper, we are twice stressing the necessity to undertake proper steps as to ensure the strict adherence to the obligations stemming out of the Convention. It means that the Security Council, in accordance with its statutory function deriving from the Charter of the United Nations is in a position to take all appropriate steps resulting from the process of the investigation so as any would-be violator could have no chance to escape sanctions.

There are delegations hesitating in relying solely on the Security Council on questions related to the application of safeguard of measures of disarmament because of the veto power of its permanent Members. We would not argue that one could not theoretically conceive a more sophisticated and more efficient system of security than the one provided for in the Charter of the United Nations. No better system of security has been elaborated up till now, and we doubt whether the foreseeable future can bring changes in this field. We are convinced that the present system is valid and fully sufficient for the purpose of the Convention on CBW.

On the other hand we have to add, that many a painful problem in international relations remained and there are some which still remain unsolved not as the result of any shortcomings of the Charter but simply as the result of insidious disregard of its provisions and of the decisions of the Security Council.

The consideration of our working paper should in no way be separated from other provisions of the draft convention and in particular from its art. V and VI.

Article V is an important instrument safeguarding compliance with the provisions of the Convention. It provides for the early adoption and enforcement by States - in accordance with their constitutional procedure - of the necessary legislative and administrative measures pertaining to the prohibition of development, production and stockpiling of chemical and bacteriological (biological) weapons and to their destruction. One should not underestimate the importance of the subject matter and the enforcement power of its provisions. Like in other wellknown international instruments of that type, the draft Convention envisages the need of supplementing international obligations of States with corresponding national and administrative measures.

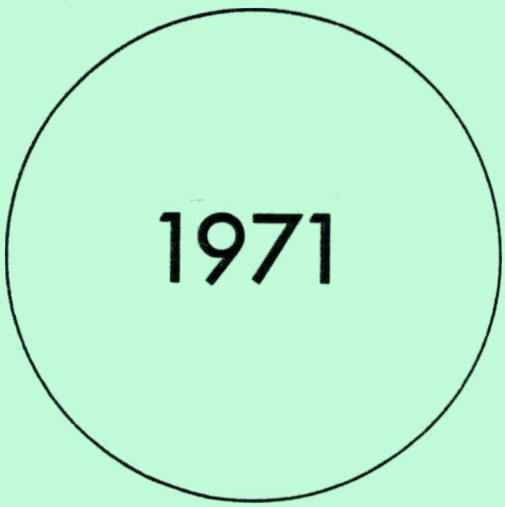
A pertinent interpretation of administrative measures that may be undertaken in the fulfilment of the provision of Art.V of the Draft has been spelled out by the distinguished representative of Yugoslavia, Minister Vratusa, in his statement of March 10 when he suggested that all States should place their institutions engaged in CBW research, development and production under civilian administration.

Another possible important administrative measure connected with the implementation of art.V of the Draft Convention could be the inclusion into textbooks dealing with chemistry and biology of a formula indicating that the use of any chemical formula or biological agent for any warlike purposes constitute a violation of international law and will be prosecuted in accordance with the appropriate national legislation. Every individual must become aware of the danger represented in CBW and has to be prepared for some form of participation in the enforcement of the Convention banning the development and production of those inhumane means warfare. I cannot abuse the patience of this Committee multiplying examples of possible measures in this field. We are ready to co-operate in spelling out other possible practical measures to this end. In these considerations of ours we are guided by our deep conviction on the necessity of mobilizing the masses of the peoples of the world against all the dangers of modern warfare. That they might be not taken by surprise out of ignorance of the lethal armory - sometimes compiled by their own governments. As Mr. Gomulka said in his speech at the United Nations General Assembly in 1960:

"It is of the utmost importance that mankind be fully aware of the dangers inherent in modern warfare. We have no right to conceal from the nations the truth about the real effects of nuclear arms and of weapons of mass destruction. On the contrary, we are in duty bound to spread this truth in order to make it easier for all nations to join their efforts in the struggle against the threat of war for general and complete disarmament".

The unfailing value of the safeguard provisions contained in art.V of the draft Convention is based on the consciousness and awareness of millions of peoples. Particularly those workers, farmers and technicians proud of their participation in the setting up of a better world and not of its utter destruction. Together with the scientists engaged in research, given the proper instrument of international law, their attitude can constitute a valuable guarantee that the Convention proposed now by the socialist States will not be violated.

The problem was raised as to how the national enforcement in different economic and social systems could be carried out. It does not seem to be a great problem. When the interests of entire populations are at stake, when we deal with crucial problems of peace and human survival - the feelings and actions of individuals are very much the same, irrespective of political systems under which they are living. As far as we are concerned, we firmly believe in their final judgement. ...


1971

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/320
2 March 1971
Original: ENGLISH

THE NETHERLANDS

Working paper concerning the prohibition of chemical warfare agents

One of the problems in the field of a prohibition of the development, production and stockpiling of chemical warfare agents and chemical weapons is the necessity for distinguishing between agents which have and agents which do not have legitimate uses for civilian purposes. Whereas the former category is likely to be suitable for conditional prohibition only, the latter category could, in principle, be prohibited unconditionally.

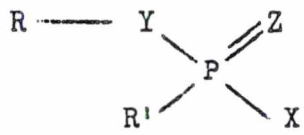
This paper intends to contribute to the formulation of a basis for delineating which chemical compounds should be included in such an unconditional prohibition. It concentrates on the nerve gases because, mainly as the result of their superior toxic properties, these gases constitute the most serious threat among chemical warfare agents. (See the reports of the Secretary-General of the United Nations and of the World Health Organization).

During the informal session of the CCD on April 22nd, 1970, the Swedish delegation circulated a tentative list comprising a number of agents which could be subject to an unconditional prohibition. In spite of the comprehensiveness of the list, which includes inter alia several nerve agents, it may well be incomplete as it limits itself to a restricted number of examples of the different types of agents.

In its working paper of August 6, 1970 (CCD/301) the Japanese delegation suggested to use the lethal dose as a criterion for the purpose of a reporting system on the statistics of certain chemical substances. This criterion seems to be a very useful approach to the problem of formulating a prohibition. In the opinion of the Netherlands delegation the proposed subcutaneous toxicity of 0.5 milligram per kilogram of body weight would be an acceptable level provided that the animal(s) referred to and the method of application are very well standardized. However, the fact that several compounds which find very useful and legitimate medical applications also show the proposed or a higher toxicity level, makes it difficult to use the lethal dose as the sole criterion for defining a range of agents that could be subject to an unconditional prohibition.

The lists of compounds forming part of the forementioned Swedish and Japanese proposals contain some representatives of the nerve gases. Rather than to present some well-known examples as a basis for prohibition purposes, the Netherlands delegation suggests to use a general chemical formula which (at least for the moment) covers as complete as possible the spectrum of organophosphorus compounds with suspected nerve agent properties.

This general formula may be represented by



in which

Y = O or S

Z = O or S

X = F, CN, N_3, SR'', $S(CH_2)_nSR''$, $S(CH_2)_nS^+(R'')_2$, $S(CH_2)_nN(R'')_2$, $S(CH_2)_nN^+(R'')_3$

R = (Substituted) alkyl, cycloalkyl or hydrogen

R' = Alkyl, dialkylamino

R'' = Alkyl

The formula should be handled in connexion with a toxicity level (LD_{50}) of 0.5 mg/kg determined subcutaneously (e.g. on rats), in such a way that compounds which are covered by the general formula should be subject to unconditional prohibition if they show a toxicity level of 0.5 milligram or less per kilogram of body weight.

It seems to be unlikely that compounds covered by the proposed criterion will be used for civilian purposes (e.g. as insecticides), at least for the time being. However in order to take account of future developments in the field of organophosphorus compounds, it is suggested that the criterion be reviewed periodically.

The Netherlands delegation is aware of the fact that the suggestion worked out in this paper shows some imperfections. In the first place it includes only one type of chemical warfare agents. If proven promising, the same approach might perhaps be extended to other types of chemical warfare agents in the near future. It is, however, recommended to consider organophosphorus compounds first because of the very serious threat originating from nerve agents.

Secondly the proposal does not incorporate chemical compounds which may be used for so-called "binary" nerve gas weapons, in which the nerve gas is formed by mixing two components during the delivery of the weapon to its target.

Nevertheless the Netherlands delegation hopes that the proposal may serve as a contribution to the formulation of a prohibition of the development, production and stockpiling of chemical warfare agents.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/322
16 March 1971
Original: ENGLISH

SWEDEN

Working Paper on a model for a comprehensive agreement concerning the prohibition of chemical and biological means of warfare

I. In the intervention by the Swedish delegation on 9 March, 1971 (CCD/PV.499) a model for a comprehensive convention prohibiting the development, testing, production and stockpiling of chemical and biological means of warfare was tentatively described in general terms. In order to make the suggestions contained therein more easily comprehensible, they are outlined in the following in an abbreviated form. A "skeleton" of our ideas is thus presented. It should be underlined that the presented model is not complete - it deals primarily with the thorny issues of the scope of the prohibitions and procedures for verification - and that some of the suggestions are still very tentative. As a matter of fact both the intervention itself and this abbreviated presentation should primarily be regarded as stages in the "mapping expedition", covering the whole field of CBW, in which the CCD has been engaged for more than a year.

II. Scope of the prohibition

1. No prohibitory rules should be included in the presently discussed treaty against use of CBW which is dealt with in a comprehensive way in the Geneva Protocol of 1925.

2. The treaty should contain a principal overriding regulation, indicating the undertaking by the Parties "not to develop, test, produce, stockpile or otherwise acquire chemical and biological weapons".

3. This general undertaking ought to be complemented with a prohibitory rule against all transfers of weapons between Parties.

4. Two corollary obligations to the general prohibition concerning weapons would follow:

(a) the first concerned with destruction or other disposal of existing stocks of chemical and biological means of warfare;

(b) the second concerned with the training of troops in offensive combat with CBW, instructions on such methods in military manuals etc.

5. There would follow a subsidiary set of prohibitions, concerned with the agents which constitute C and B weapons or are integral components of such weapons. These prohibitions would refer to production, testing and stockpiling, as well as transfers (export) of the agents.

6. The agents would be separated into two categories according to two technical criteria:

(a) Category (a) would compromise those agents, whether chemical, toxins or biological which have a practically exclusive use as potential means of warfare. They would, at the same time, be those agents which are super-toxic. In the chemical field this category would include all substances more toxic than 1 mg per kg body weight. It would thus i.a. comprise the chemical components of nerve gases and mustards, as well as all toxins;

(b) Category (b) would comprise all remaining chemical agents, less toxic than indicated by the above mentioned formula and which can be used as means of warfare but also have recognized peaceful uses. This would be the main category comprising such chemicals as hydrogen cyanide, phosgene, tear gases and defoliants. Also most biological agents would belong to this category in so far as they are produced for non-military purposes, e.g. for immunization.

7. There would, finally, be a third category, category (c), comprising ancillary equipment or vectors, specifically designed for using chemical and biological agents as means of warfare.

III. Verification

1. The verification procedures would probably have to be largely concentrated to the area of the agents. Suspicions of violations of the overall prohibition against CB weapons would have to be taken care of within the framework of a detailed complaints procedure. The same procedure would cover suspicions of violations against the corollary prohibitions against military training, army manuals etc.

2. The details of the complaints procedure will have to be worked out carefully. It should take the form of a system of successive steps, including consultations between the parties and other fact-finding measures. The final step would consist of a possibility of lodging a complaint with the UN Security Council.

3. Destruction and disposal of existing stocks of CBW would also have to be verified, preferably through an international procedure.

4. The more specific verification procedures would be concentrated on the agents. They would comprise a combination of national and international control measures.

The most rigorous methods of control would be those dealing with category (a) abo i.e. chemicals more toxic than 1 mg per kg body weight, toxins and biological agents without any recognized peaceful use.

The production of these compounds would in principle be prohibited. Any deviation from this general rule would have to be reported to an international agency, the report giving the reasons for the production (scientific use, protective measures etc). In case of any large-scale production (i.e. over one kg) or in case of suspected undeclared production, the international agency might be entitled to conduct an on-site inspection, either on the invitation of the producing or suspected party, or obligatory.

5. The compounds comprising category (b) as well as the ancillary equipment and vectors in category (c) would be controlled by national means only, such national control possibly in some cases complemented by statistical reporting by the parties to an international agency; they would further be subject, if suspicion was aroused, to the sequence of processes foreseen in the complaints procedure, i.e. through consultation and challenge and, in the final instance, by a reference of the dispute to the Security Council of the United Nations.

6. If and when new technical developments would allow more stringent verification procedures on the categories (b) and (c), agreement should be sought to shift them to category (a).

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/324
30 March 1971
Original: ENGLISH

SWEDEN

Working Paper on the destruction of chemical and biological means of warfare

The Secretary-General of the United Nations has called upon all states to reach agreement to halt the development, production and stockpiling of all chemical and bacteriological (biological) agents for purposes of war and to achieve their effective elimination from the arsenals of weapons. One aspect of this elimination is destruction of already existing chemical and biological means of warfare as foreseen both in the nine countries' revised draft convention on the prohibition of the development, production and stockpiling of chemical and bacteriological (biological) weapons and on the destruction of such weapons (A/8136) and in the revised text of the United Kingdom draft convention for the prohibition of biological methods of warfare (CCD/255/Rev.2).

Different attempts have been made to solve the problem of disposing of chemical and biological means of warfare. Recently, an operation whereby chemical munitions (rockets) containing nerve gas were sunk in the Atlantic became widely known and was extensively reported on (see "Hearings before the Sub-committee on Oceanography of the Committee on Merchant Marine and Fisheries; House of Representatives Aug 3, 4, 6 and 7, 1970, Washingon, D.C."). This report dealt thoroughly with several means of disposal and destruction and also provided the information that some types of equipment for destruction was under construction.

In the present working paper the principles of destruction of both chemical and biological means of warfare are outlined. An element of importance that has been taken into account is that the effectiveness of the destruction should be easily observed and verified.

CHEMICAL AGENTS

The following is applicable to nerve and mustard gases which are considered to be representative of the most dangerous compounds and, furthermore, are stockpiled in various parts of the world in great quantities. Such agents may be stockpiled in various ways which cause different technical problems when it comes to destruction.

They may, e.g., be stockpiled in

(a) containers in which the agents are easily accessible;

(b) munitions, containing explosives and perhaps propellants, from which the agents are accessible without prior defusing;

(c) munitions, the explosive part of which has to be defused before it can be emptied of the agent.

In the cases (b) and (c) the explosive part of the munitions causes special problems, particularly in the latter case where simultaneous destruction of the explosive part and the agents seems unavoidable. Thus, from the point of view of destruction, two alternatives can be anticipated:

(1) pure agents

(2) agents which are inseparable from munitions.

In the case of a pure agent two principally different methods for the destruction are conceivable.

One is by means of reactive chemicals (in a water solution) which detoxify the agent and the second, which is also more likely to be generally applicable, by thermal destruction (i.e., decomposition by heating/pyrolysis/or combustion).

The chemical method may involve use of alkali or oxidants (e.g., bleach). Chemical destruction generally gives nontoxic end-products, but the character of the products makes them an environmental hazard if introduced directly into the open, the ground, sea, lakes or rivers. The question of how to dispose of large quantities of the end-products, derived from the different chemical destruction methods, will have to be investigated further. Special facilities may have to be constructed.

Heating the agents themselves in autoclaves is technically feasible but may lead to some complex end-products about which relatively little is known.

Combustion, in combination with absorption of potential pollutants from the exhaust gases, appears to be the most promising method - technically and from the point of view of environmental pollution. A suitable combustion process would require specially constructed facilities.

The advantage of the thermal destruction methods would be that smaller destruction units might be used for a given amount of the agents and that the end-products are more easily handled. Actual experiments would have to be performed to evaluate the order of the most feasible technical steps.

In the case of munitions from which the agent cannot be separated easily, much more drastic procedures seem to be necessary. Use of underground nuclear explosions has been discussed and found technically feasible but were discarded in the earlier mentioned case for several reasons, among them the risks involved in handling the defective munitions (Hearings before the Sub-Committee on Oceanography of the Committee on Merchant Marine and Fisheries; House of Representatives Aug 3, 4, 5 and 7, Washington, D.C. 1970). Instead, the formerly widely used method of disposal by sinking the munitions in the sea was applied. The agents, when released from their containers, will be destroyed by chemical reactions with the sea water in due time. However, this method will be less attractive with regard to some of the nerve gases and the mustard gases, which need a considerably longer period to react with water. In addition, attention should be paid to the provisions of the recent Seabed Treaty which prohibit, i.a., the storing of chemical and biological weapons on the seabed.

Another less attractive alternative is treatment of the munitions with lime or bleach in old mines or underground in places chosen with great care.

Underwater detonation in closed-off water-filled pools together with facilities to take care of the toxic gases that may escape from the water surface might be feasible. Any of the mentioned methods are cumbersome. However, the greatest part of the existing chemical warfare agents can apparently be destroyed as such and according to the procedures suggested for pure agents.

BIOLOGICAL AGENTS

Biological agents may be destroyed by combustion, in autoclave or by means of disinfectants. Also, destruction of biological agents has its hazards, but offers in general smaller problems than chemical agents, especially since the quantities to be destroyed, and accordingly also the quantities of end-products, should be much smaller than is the case with the chemical warfare agents. Various destruction facilities intended for ordinary peaceful purposes already exist.

CONCLUSION

The destruction of munitions and agents intended for chemical and biological warfare is technically feasible. Because of the high toxicity and infectiousness of the agents, hazards may in certain cases cause considerable destruction costs due to the need for special technical facilities. The destruction methods recommended above may be subject to verification without major technical difficulties, but apparently only with inspectors present at the site of destruction.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/332
5 July 1971
Original: ENGLISH

UNITED STATES

Working Paper on CW verification

This paper examines three possible areas of CW verification: (1) safety features in plants producing nerve agents, (2) the sealing and monitoring of plants formerly producing nerve agents, and (3) sampling to detect possible nerve agent production.

A. Safety Features of Plants Manufacturing Nerve Agents

1. Safety features are a usual -- and often distinctive -- attribute of processing facilities which deal with toxic materials. The final stages of organophosphorus nerve agent manufacture, involving some of the most toxic known substances, demand especially stringent controls to safeguard operating personnel and surrounding areas. Many, although not necessarily all, of the following safety features might logically be expected in connexion with nerve agent production:

-- The building in which processing is conducted is likely to be unique in design. The specifications may call for it to be constructed with solid, airtight walls and roof, with all openings having tightly fitting closures with a minimum possibility for air leakage. A building designed and constructed in this manner would make it possible to have a continuous pressure differential between the exterior atmosphere, the work areas within the building and the toxic product production areas. The maintenance of lower atmospheric pressure in the production areas would help to prevent any accidental leakage of toxic materials from reaching other sections of the plant or its surroundings.

-- Intermediate products produced during agent manufacture are highly reactive with oxygen and moisture of the atmosphere. In many instances, the materials are pyrophoric, i.e., spontaneously flammable with the atmosphere or its components. Because of this, the equipment and process operations would be expected to have comprehensive vent control systems. They would be likely to include provisions for inert gas purge of all equipment as well as the maintenance of inert gas blankets over all process and storage vessels to prevent contact with the atmosphere. Vents from

all process equipment lines and storage vessels would probably lead to a central vent where the gases can either be "scrubbed," i.e., separated by chemical and mechanical means, from the atmosphere or "flared," i.e., burned under controlled conditions to prevent accidents.

-- Pumps used in nerve agent plants would probably be of a type which insure positive control of possible leaks of material to the atmosphere. Because of the problems of keeping pumps leakfree, process flows might be by gravity. Submerged pumps could be used in storage and supply vessels to minimize the likelihood that accidental leakage could spread.

-- Within the process building personnel areas would very probably be separated from the process areas by airtight construction. All normal production operations could be conducted by controls located in the personnel areas. For example, valves which may require manual operation for process control could be provided with reach rods which extend into the operating area through airtight packing glands, i.e., seals made of an impervious material, installed in the walls separating the process area from adjacent corridors. Windows would probably be provided in the walls between the safe corridors and the process area to permit observation of the process and of any personnel that are in the toxic area. There may also be closed-circuit television, with the receiver in the control room using a portable television camera which can be plugged in at various locations in order to permit visual observation of activities within the process area by control operators.

-- All personnel who work in the general area would probably be supplied with individual protective masks. There would be a number of gas alarms located throughout the building in order to give automatic warning of malfunctions creating a toxic situation. Test animals, such as rabbits, may also be kept in cages in critical areas to provide indications of leakage of toxic materials. All persons who enter the toxic area would normally wear full protective clothing. Portable radio receivers and transmitters may be provided for use inside such protective suits. This would allow standby safety operators in the corridor to communicate with personnel within the toxic area.

-- Doors into the toxic area may lack handles or other means of opening from within the toxic area, and exits from the process area would be through air locks, with self-closing doors. Each air lock would probably be equipped with sprays and with sufficient spray heads to thoroughly drench any person passing through the exit. The first or inner spray would likely be connected to a 5% caustic system and the outer spray connected to a service water system for rinsing. Waste from these showers would drain into the chemical waste system.

-- The process area may be equipped with overhead spray heads for spraying a caustic solution or water as controlled by valves in the corridor. Caustic spray is useful to detoxify equipment and to neutralize agent spilled within the area. Water sprays may be used to wash down the equipment and to wash away caustic contamination from the process area. These same sprays may be used in the event of fire in the toxic area.

-- There may be special arrangements in the plant and process design to reduce the hazards of sample taking. Special sample chambers may be provided which discharge a predetermined amount of material which will not overflow sample bottles. An interlock could be provided through the wall between the process area and the laboratory so that samples can be passed directly into a laboratory hood without the sample taker leaving the toxic area. Provisions may be made within the toxic area to decontaminate and dispose of returned samples.

-- Emergency facilities, to include air for instrument operation and power for lighting, operation of the air "scrubbers", and ventilation, may be provided as a backup in the event of normal power failure. This may include a system for automatic activation of the auxiliary power source in an emergency.

2. Any facility found to be equipped with many or all of these safety features would merit further investigation. The presence of these safety features would, however, not be determinative of nerve agent production. What is considered to be a necessary margin of safety may vary significantly from country to country, between civilian and military-run facilities and from one plant to another. There are also some kinds of commercial chemical production, including that involving

organophosphorous compounds, which are potentially very hazardous for plant personnel and, if not adequately controlled, damaging to the environment. Such considerations may justify maximum possible safety controls in commercial plants similar to what might be expected in nerve agent production. However, while safety features and environmental safeguards associated with nerve agent production may be found in some commercial manufacturing, they are nevertheless sufficiently unusual to merit serious attention in the broad study of CW verificiation.

B. Sealing and Monitoring of Production Facilities

1. One task facing a verification system for an agreement prohibiting production of chemical weapons is assuring that facilities which previously manufactured organophosphorous nerve agents refrain from proscribed activity.

2. There are several ways to dispose of former nerve agent plants. For instance, they might be converted for commercial manufacturing. This would raise one type of verification problem, which has been frequently discussed in the CCD, based on the need to assure that commercial manufacturing is not replaced or supplemented by agent production.

3. Former nerve agent facilities could also be dismantled and the sites used for activities unrelated to chemical processing. While offering verification advantages, dismantling would be expensive and deny future possible use of the facilities for some non-proscribed purpose.

4. A third approach would be to shut down agent facilities, but to defer the decision on their further disposition. This would preserve the option of converting a plant to other uses at some future date, or of eventually dismantling it.

5. Closing down former nerve agent plants would raise another type of verification question. Assuming the location were known, verification's major role would be assuring that activity was not resumed at the site. One way to gain this assurance would be through sealing the facility. This could involve placing some form of sealing devices on doors, fans associated with ventilation equipment, or on certain key valves in the process equipment. This would have to be done, however, in such a way that an inspector checking such seals would be able to tell whether they had been tampered with. This would depend on techniques involving tamper-resistant unattended safeguards. These have been studied in connexion with safeguarding power reactors and other nuclear facilities. A progress report on a joint Canada/USA

safeguards research and development project sponsored by the Atomic Energy Control Board of Canada and the US Arms Control and Disarmament Agency was presented at an IAEA symposium in Karlsruhe, FRG, in July 1970. The project's purpose was development of a practical system using unattended instruments, the integrity of which would be assured even though all design and operational details were known to participating governments.

6. While it is doubtful that any seal or other technical barrier could be made completely inviolable, there may be ways to give high assurance that an unattended system would show that it had or had not been tampered with. One possibility would be specially sealed containers around key valves or ventilation equipment controls. The containers might be made of heat resistant Pyrex glass with aluminized inner surfaces. They would need to be the proper shape to fit around the item to be sealed. Once placed around the object, the container might be locked by using a fiber-optic cable threaded through holes in the container. A fiber-optic cable consists of glass fibers, bonded together with epoxy. Random cross sections of such cables show distinctly differing fiber configurations, because of uncontrollable variables in aligning the fibers during manufacture. Each cable thus has its own unique "fingerprint", which cannot be duplicated, but which can be recorded by photographing the optically polished fiber ends. An attempt to pull such a sealing cable free or cut it would distort or destroy the unique "fingerprint". It would not be possible to reproduce an identical "fingerprint". An inspector equipped with a photograph of a cross section of the original sealing cable would be able to compare its configuration with that in the locking device and notice any differences. Efforts to penetrate the glass container without disturbing the sealing cable could be made discernible in a number of ways. For instance, the interior aluminium coating referred to above would help to make even small holes visually obvious.

7. Another way to ensure that a closed plant was not put into production again would be by the use of seismic sensors. Every production facility with mechanical equipment causes a vibration pattern in the structure, building or ground surrounding the plant. In theory a seismic device could be installed in or at a closed facility to determine the presence or absence of vibrations which accompany manufacturing activity.

8. There are a number of practical questions concerning the utility of sensing devices such as seismic detectors in monitoring a closed-down facility. For example:

1) How would the sensor function? Would it transmit continuously or only if vibrations exceeded a certain level?

2) To what degree could the sensors be made tamper-proof?

3) How frequently would a sensor require maintenance servicing or inspection to assure proper functioning?

4) At what distances and by what means could sensor signals be monitored?

5) Could seismic detectors distinguish between vibration patterns? Could they be developed to monitor a fully or partially converted plant to assure that it was not engaged in agent production?

9. There are other types of sensors which might be useful in monitoring a closed down plant if installed in or near the facility. For example, closed circuit television or heat detectors could be of help in determining that a facility was not being used. In addition, there are a number of sampling techniques -- some of which are discussed below -- that might be developed for use as remote alarms signalling resumption of activity possibly related to nerve agent production.

C. Sampling to detect possible nerve agent production.

1. Organophosphorous nerve agent production is characterized by the presence of distinctive chemical compounds in the later manufacturing stages. They are present to some degree in all materials, including wastes, which have come in contact with the final processes.

2. A number of analytical techniques, which are at various stages of development for other purposes, might have applicability in on-site sampling for nerve agent production. Japanese Working Paper CCD/301 described one such method, gas chromatography. Other techniques of possible interest include infrared spectrophotometry, thin-layer chromatography, nuclear magnetic resonance spectrometry, emission spectography, electron paramagnetic resonance, colorimetry, enzymatic analysis, and mass spectrometry.

3. It is probably necessary to concentrate CW compounds present in air, water, and soil samples before effective analyses can be carried out by any of these methods. Air and water samples might be concentrated by passing them over absorbent materials like charcoal or ion-exchange resins. Nerve agent compounds present in soil and vegetation samples could be extracted with a solvent. Some analytical procedures require samples with a very high degree of purity. With these procedures, it would be necessary to separate the target compounds from extraneous substances in the samples.

For example, only high-quality samples are satisfactory for use with nuclear magnetic resonance techniques. The following analytical techniques, in addition to gas chromatography, might be considered for possible roles in inspection sampling:

-- Infrared Spectrophotometry detects and identifies small quantities of substances by analyzing the structure of molecules. The infrared absorption spectrum of a compound acts as a sort of "signature" which can be compared with spectra of various possible substances.

-- Thin-Layer Chromatography (TLC) is a technique for separating the components of mixtures on a thin layer of finely divided solid absorbant. The resulting chromatogram shows a series of small deposits each, ideally, containing a single component of the analyzed mixture which can be visualized and compared to predeveloped signatures.

— Nuclear Magnetic Resonance (NMR) is the term applied to spectroscopy used to detect and distinguish between the nuclear particles present in a sample.

— Emission Spectrography is based on the principle of supplying additional energy to the electrons of molecules. Since there are definite energy states and since only certain changes are possible, there are a limited number of wave-lengths possible in the emission spectrum, which can be measured.

— Electron Paramagnetic Resonance (EPR) is based on the fact that atoms, ions, molecules, or molecule fragments having an odd number of electrons exhibit characteristic magnetic properties.

-- Colorimetry is a quantitative method of measuring the amount of a particular substance in solution by determining the intensity of its colour. Most colorimetric methods currently in use are photometric, where the colour intensity is measured by a photoelectric cell. Readings can be made in visible wavelengths as well as in ultraviolet and infrared.

-- Enzymatic Analysis. Substances which accelerate chemical reactions without being used up in the process are known as "catalysts"; those formed in living cells are called "enzymes". Organophosphorous nerve agents interfere with the action of an enzyme, cholinesterase, essential to the functions of the nervous system. An analytical system utilizing cholinesterase might be used to detect and measure organophosphorous compounds.

-- Mass Spectrometry uses an instrument that sorts out ions according to the ratio of mass to charge. Usually, the ionic species are brought successively to focus on a fine exit slit and collected on a device which can measure the intensity.

4. While all of these techniques are of proven value in analyzing organophosphorous compounds under laboratory conditions, their respective usefulness for on-site inspection has not yet been thoroughly examined. There are a number of factors that need to be taken into account, including sensitivity, expense, portability, and speed as well as simplicity of operation under actual sampling conditions. Further study of the technical aspects of inspection should include attention to the question of what kinds of sampling techniques might be most appropriate.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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S W E D E N

Working Paper on aspects of the definition of "toxins"

Introduction

According to the definitions given in the UN-report on chemical and biological weapons (A/7575) and the WHO-report on Health aspects of chemical and biological weapons (1967) toxins are to be considered as chemical warfare agents due to their (direct) toxic effects on living organisms and the fact that these effects are not depending on multiplication of the agent as is the characteristicum of B agents. However, nowhere has a comprehensive definition of toxins been given allowing a clearcut delimitation, although a useful description of toxins is to be found in the working paper CCD/286, April 1970, of the USA. In a comprehensive treaty covering prohibition of development, production and stockpiling of both B- and CW-agents a strict definition would not be necessary. For separate treaties, however, a definition seems indispensible.

The term "toxin" is often used in a vague sense. Some authorities consider any poisonous substance of biological origin or occurrence as a toxin, other authorities regard only macromolecules of microbial origin, lethal to man in microgramme amounts, as toxins. In addition there is the question of synthetic or semisynthetic toxins to be considered.

The toxic effects of toxins extend over a wide range, the weakest being comparable to the less toxic chemical warfare agents and the strongest to the most potent biological warfare agents. This is exemplified in the table annexed to this paper.

The fact that some very toxic compounds of biological origin have important use as medical drugs in small quantities must be recognized and provided for in a treaty.

The following is an attempt to discuss briefly the implications of different ways to define the concept toxins for use in a treaty dealing explicitly with toxins.

Possible criteria for the definition of toxins

Criteria, which can be used for the definition of "toxins", are of four main types:

(a) The natural origin or occurrence of the compounds;

Examples: Biological, microbial or microbiological, bacteriological.

(b) Degree of toxicity, type of toxic activity, and mode of action;

Examples: Highly toxic, toxic in amounts less than one mg, neurotoxic, incapacitating.

(c) The chemical nature of the compounds;

Examples: Proteins, macromolecules.

(d) Chemical operations producing toxins and poisonous substances related to toxins.

Examples: Synthetic, semisynthetic, chemically modified.

A definition of "toxins" will very likely have to include criteria of more than one of the above types. In the following, some criteria and possible combinations of criteria will be briefly discussed.

Natural origin of toxins

One of the more or less unspoken understandings with the hitherto presented concepts of toxins is that they are chemical substances resulting from metabolic processes of living organisms. Thus, in the above mentioned UN-report on chemical and bacteriological (biological) weapons, toxins are defined as "biologically produced chemical substances which are very highly toxic and may act by ingestion or inhalation" (paragraph 44). This definition will include not only the classical toxins of microbial origin (e.g., botulinum toxin A) but also toxic compounds of plant origin (e.g.,convallatoxin) and animal origin (e.g., tetrodotoxin and many snake venoms).

For warfare purposes, highly toxic compounds of microbial origin are presently of higher potential importance than compounds of other biological origins. One could therefore circumscribe the definition to include only compounds of microbial origin, if such a narrow definition is desired. It would still cover most of the natural toxins of potential warfare usefulness known today.

However, it may turn out that some highly toxic compounds of plant or animal origin are sufficiently stable and easily distributed to have a place in a potent weapon system. In order to anticipate such a situation, it may be advantageous to include toxic compounds of any biological origin in the toxin concept.

An interesting fact is that some toxic compounds arise from non-biological transformations occurring in nature, e.g.,hydrolysis and oxidation of substances of biological origin. In a strict sense, these toxic compounds are not "biologically produced", but ought to be covered by a definition of toxins.

Toxicity of toxins

The expression "very highly toxic" used in the above-mentioned UN report reference is somewhat inprecise. Some toxins merit special considerations as warfare agents because they are effective in doses smaller, sometimes several orders of magnitude smaller than one milligramme for a man. This dose is below the dose limits of today's most powerful synthetic agents.

If toxic compounds of any biological origin are considered, this interpretation of "very highly toxic" should include, e.g., botulinum toxin, staphylococcal enterotoxin, tetrodotoxin (fish, newt), and batrachotoxin (frog), see the table. Some of the naturally occurring toxic compounds, excluded by a definition of "very highly toxic", are monofluoroacetic acid (plant: Dichapetalum cymosum) and hydrogen cyanide (fungi).

If a minimum effective dose is specified in a prohibition, it would appear natural also to specify the mode of administration, since many compounds will differ considerably in toxicity, depending upon whether they are introduced, e.g., intravenously, orally, percutaneously or by inhalation. However, it is probably more convenient if the criterion of toxins is to be employed to regard all compounds that fulfil the minimum effective dose criterion by any means of administration, as toxins (provided that they also meet certain other criteria).

If the aim of a definition of the toxin concept for warfare purposes is to include only the macromolecular (see below) microbial toxins, criteria may be chosen from their immunological properties. In contrast to other toxic compounds, the macromolecular microbial toxins act as antigenes and stimulate antibody (antitoxin) production.

Chemical nature of toxins

Most of the highly toxic microbial compounds are proteins of high molecular weight. However, also other chemical types of compounds are represented, e.g., a highly fever-producing, non-protein macromolecule is known from E.coli (minimum effective dose for man 0.0001 mg). Many other types of chemical compounds are found among the highly toxic plant and animal constituents.

The only possible delimitations of the toxin concept by means of purely chemical criteria are by defining toxins as proteins and/or macromolecules. However, in either case, virtually all highly toxic compounds of plant and animal origin, as well as some of microbial origin would be excluded.

Synthesis and semi-synthesis of toxins and of chemically closely related compounds

The criterion based upon some type of biological occurrence or origin does not cover the possibilities of man-made, chemically wholly synthetised substances. Neither does it cover by chemical means modified substances of biological origin or occurrence. Thus, in many cases, slight chemical modifications of highly toxic molecules can be made without major alteration of their toxic properties, e.g., if an extra methyl group is introduced in a part of the naturally occurring batrachotoxin, the toxicity is somewhat

enhanced (LD_{50} for subcutanenous administration in mice changes from 0.002 to 0.001 mg/kg body weight). This semi-synthetic compound is best prepared from the relatively innocent frog constituent batrachotoxinin A. It would not qualify as a toxin, unless a proviso is made to the effect that compounds, closely related to naturally occurring, highly toxic compounds, will be regarded as toxins if they have similar toxic properties.

LSD (lysergic acid diethylamide), which is considered as a potential chemical warfare agent, constitutes another example. It has not been found in nature, but is very closely related to lysergamide (known from plants of the genera (Argyreia, Ipomea, and Rivea). Lysergamide exhibits psychotomimetic activity in doses below the milligramme level, and LSD is about ten times as potent. If only highly toxic compounds of biological origin are considered as toxins, lysergamide, but not its chemically produced derivative LSD, would be embraced by the definition.

Judging by the rapid advances of organic synthesis, it seems very likely that within a decade numerous highly toxic compounds can be prepared, modelled upon naturally occurring complex substances. A comprehensive toxin definition ought to include these probable synthetic or semi-synthetic compounds.

It is evident that it might be difficult to cover in definitions all the varieties that may arise in this respect from different chemical operations and an expression as "compounds chemically closely related to toxins" may be used although not totally adequate. It should be possible to overcome the imperfection by specifying the nature of the chemical modifications (e.g., substitution, change of an amino acid residue, homologation).

Summary

The concept of toxins must be clearly and unambiguously defined in a treaty obligation.

A definition for treaty purposes might be adopted by a selection from the different criteria listed hereabove, i.e., natural and synthetic origin, toxicity and chemical nature.

T A B L E

Examples of toxins and some of their properties

Toxin	LD_{50}, mouse, /ug/kg bodyweight	Biological origin	Molecular weight
Botulinum toxin A	0.001-0.00003	bacteria	900,000
Tetanus toxin	0.002-0.0001	bacteria	68,000
Staphylococcal enterotoxin B	0.1 (ED_{50} monkey)	bacteria	35,000
Ricin	0.6 (dog)	plant	80,000
Batrachotoxin	2	frog	399
Tetrodotoxin	8	fish, newt	319
Saxitoxin	9	dinoflagellate	370
Cobratoxin	50	snake	6,800
Convallatoxin	80 (cat)	plant	550
Curare	500	plant	696
Strychnine	500	plant	334
For comparison, two synthetic compounds are included:			
Sarin	100		140
Mustard gas	8,600		159

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CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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CANADA

Working Paper on atmospheric sensing and verification of a ban on development, production and stockpiling of chemical weapons

Over the past two years many proposals have been put forward for discussion at the meetings of the CCD on possible ways of verifying that an international agreement on the prohibition of the development, production and stockpiling of chemical weapons is being honoured by the signatories. These proposals have ranged from the employment of on-site inspection teams, to remote sensing by sophisticated technical gadgetry. The most reliable verification scheme is one where international inspection teams are permitted within a country. A discussion of such schemes is given in the SIPRI report. However, the degree of intrusion may not be acceptable and Canada, along with other countries, has been striving to find a method, which is both reliable and acceptable, and during the past six months has examined remote atmospheric sensing of field testing of CW agents.

First the various possibilities of monitoring the industrial and military activities of a country from a distance were considered. The SIPRI report suggested that economic monitoring of a country might provide a good indication of contravention of a chemical arms agreement, but the US reported in a paper last year (ref. CCD/311) that in the case of the nerve agents, economic monitoring in itself is not feasible - and the situation would be even more difficult with other known chemical agents.

We have looked into the possibilities of monitoring a country by means of satellites and while we have limited expertise in the field of military satellite reconnaissance, we are unable to visualize an agency working under the auspices of the UN utilizing such an approach. The British last year concluded that satellites would not likely prove to be very effective. Moreover it would be a very expensive and complex approach to verification which would be available to only a few wealthy nations and under present political structures, not the UN.

GE.71-14485

We concluded in our survey that the only approach which did not involve intrusion and was within the realms of feasibility was remote chemical sampling of chemical test areas. The SIPRI report expressed some confidence in monitoring chemical testing while the UK in their paper to CCD last year expressed doubt as to its value.

In our study on chemical sampling we assumed that in order for a nation to have a significant chemical warfare capability it must field-test the weapons that it has developed, The size of such a test could range from the detonation of a single artillery shell to the spraying of terrain by an aircraft. We have chosen the case of a large scale aircraft spray trial to illustrate the feasibility of detecting agents downwind of a test site; obviously the larger the experiment the easier would be the possibilities of detecting it. But it is not believed that tests would be carried out with live agent on a scale larger than this since much can be done with simulants: i.e., use of agents relatively non-toxic but which possess physical properties similar to toxic ones and as a result when detonated or sprayed behave in much the same way.

It was assumed that an aircraft could contaminate a strip of terrain of dimensions 1,000 metres cross-wind by 250 metres downwind to an agent density of between 5 and 20 g/m^2. Downwind concentration (mg/m^3) and total dosage ($mg. min/m^3$) profiles for the following agents: mustard, a representative persistent V-agent, and two volatile G-agents, sarin and soman, were calculated. Mustard was assumed to have been laid down to a contamination density of 20 gm/m^2 while the others were assumed to be laid down to a density of 5 g/m^2. These agents are representative of those which an industrial country with a CW capability might be expected to possess, i.e., a persistent vesicant, two volatile nerve agents and a persistent nerve agent.

Calculations of the downwind concentrations and the total dosages were made with the aid of a diffusion model which Canada has developed to assess downwind chemical agent hazard. This model is based on classical atmospheric diffusion models; it takes into account the nature of the terrain, the absorptive and evaporative characteristics of the agent, and the meteorological conditions that the programmer wishes to simulate. Since this model is a steady state model, all agent vapour concentrations.

Two extremes of meteorological stability were assumed, namely slight lapse and moderate inversion, and the criteria of detectability of agent used was the level of sensitivity of the various agent detection devices currently available to the Canadian Armed Forces.

Our studies have amplified the fact that certain agents, especially some persistent nerve agents, are readily absorbed on soil and vegetation over which the agent cloud passes. For example, we do not believe, given the sensitivity of the existing detection equipment, that a persistent V-agent could be detected at distances of more than approximately 10 Kms downwind of our simulated source. And, in our opinion this distance would tend to be optimistic. On the other hand, there is some chance of detecting a large sarin gas source at distances in hundreds of kilometres. And mustard laid down in the contamination density mentioned might be detectable at distances in the tens of kilometres. Again we wish to emphasize that these are theoretical calculations and if anything are overestimates. Obviously if the test involved the detonation of a single chemical artillery shell, the problem of detection would be much more acute.

No clear statement can be made concerning the feasibility of remote chemical detection of CW agent field testing since we would require knowledge of the characteristics of the agents which we are attempting to detect. But from our studies we find that whilst it may be possible to detect some CW agents at considerable distances downwind of their source, it is virtually impossible to detect others at very short distances. Therefore, it is believed that remote atmospheric sensoring, by chemical sampling techniques, is not a practical approach to verification unless sampling sensitivities are greatly increased and some form of intrusion is allowed.

It is reasonable to assume that chemical sampling capabilities could be increased, say a thousand fold, and used to identify a nerve agent at an air concentration level of approximately 2.5×10^{-5} mg/m^3. Such a level of sensitivity would greatly increase the downwind distance at which detection and identification of agents could take place. However, it is improbable that chemical samplers, even if they had such a capability, could be used on their own and outside a country to verify adherence to a chemical test ban: some countries are just too large, also there is the chance of agent being washed out by moisture and dispersed by natural barriers such as mountains. It is unrealistic to suppose that an agent cloud after travelling for thousands of miles could be detected by the presently available sampling equipments. Thus any country with a large land mass could ensure if it wished to carry out a test, that its activities could not be monitored by a neighbouring country by careful selection of the location of the site and undertaking testing when prevailing winds were in the appropriate direction.

There is another problem. What countries are willing to have such instrumentation, controlled by foreign nationals, within the confines of their national boundaries? Perhaps one might be restricted to placing them on the borders of a remote country because the country in question may in turn be surrounded by an adjoining country which is again opposed to this intrusion. Under such circumstances one would be forced either to sample from the nearest country willing to permit this intrusion, or from international waters, which might easily be thousands of miles away.

In most studies on possible approaches to verification the constraining factor has been the problem of getting close enough to the source of possible clandestine activities to verify adherence to the international agreement. We believe that remote chemical sampling of the atmosphere to monitor the testing of chemical weapons with the existing, or improved, equipment is not feasible. It might be applicable to small countries but in the case of countries that are thousands of miles in one direction, dilution of the agent cloud over such distances would greatly decrease the possibilities of detection. Then also, as we have pointed out, some agents because of their absorptive characteristics are virtually undetectable a few kilometres downwind of their source.

So far this has all been rather negative. We can suggest, however, a way of using chemical samplers in a verification scheme, which while involving a degree of intrusion might be acceptable to those nations seriously interested in resolving this problem. The effects of industrial pollution on our environment have caused increasing concern within the last few years, as the industrial development of the world has outstripped industry's efforts to dispose of its waste products. In the world today many government agencies have been set up to control pollution and to attempt to make industry operate within strict anti-pollution guidelines. It is now normal to see in the daily newspapers of large industrial cities in the North American continent the measured atmospheric concentrations of sulphur and nitrogen oxides above these cities. We would suggest that since trace quantities of nerve agents from field tests could conceivably be considered as other pollutants in the atmosphere, they could be detected by a national pollution monitoring system which has an international exchange of information.

There would be problems, but the war gases of primary concern, the nerve agents, have their own distinctive signatures. They are organophosphorous compounds, and as such are not easily confused with common industrial pollutants. It might be feasible to develop a "national" monitoring system if nations would agree to collect concentration levels, for example, of organophosphorous compounds within their country. The collection of the data could be carried out by a national network of meteorological stations, whilst transmission and summary analysis of the data could be carried out within the framework of international exchanges such as now exist through the World Meteorological Organization.

In conclusion we can summarize by stating that in our opinion remote (extraterritorial) chemical sampling for the verification of an adherence to a chemical disarmament agreement does not appear to be feasible. However, in addition to any economic monitoring, considered in other working papers, employed in connection with the control of pollution, the use of samplers for verification by national means and surveyed by an international organization merits further examination. It may be within this context that techniques might be established that would assist in the development of a verification mechanism for a ban on the development, production and stockpiling of chemical weapons.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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ITALY

Working Paper on some problems concerning the prohibition of chemical weapons

During the informal meeting held on July 7, 1971 with experts present, the delegation of Italy dealt with three major technical problems which, in its view, should be tackled with a view to a solution of the question of the prohibition of chemical weapons, namely: (1) the compiling of a complete list of agents to be banned; (2) the control of production of such agents; (3) the destruction of stockpiles of chemical agents.

For the Committee's further consideration the views of the Italian delegation are set forth in this working paper.

(1) With regard to the first problem - compiling of a complete list of agents to be banned - our delegation has studied with keen interest the various proposals that have already been submitted by other delegations. We note, however, that the Committee has so far been unable to undertake a thorough comparative analysis of the proposals and to draw, where possible, useful conclusions for our further work. In this connexion we should like to stress once again the desirability of the Committee itself taking steps to establish a group of experts with the task of studying such proposals. It will be recalled that on 30 June of last year we submitted a working paper (CCD/289) on this procedural matter.

Among the various suggestions for the compilation of a list, those submitted by the delegation of the Netherlands and of Japan deserve particular attention. The Dutch proposal contained in document CCD/320 of 2 March last, has the advantage of covering in a single general formula all the organophosphorus compounds recognized today as chemical agents or as very similar to them; and it includes therefore, by its very comprehensiveness, all those which are or will be synthetically produced, e.g. Sarin, Soman, Tabun, V Agents, Tammelin Esters, insecticides, etc. Even if this general formula leaves out a number of substances officially defined as warfare agents (e.g. mustard gas, cyanogen chloride, phosgene, etc.) it does cover all the agents that actually constitute the most dangerous and lethal weapons of chemical warfare. It should not be difficult, however, to reach agreement on a complete list of agents not covered by the formula.

(2) Concerning the second problem - control of substances to be prohibited - here again we note that the Committee has no suitable body to study and co-ordinate the various proposals in order that the Committee itself may undertake a proper assessment of this problem.

Some of the working papers and statements of other delegations on the control question have received careful consideration because of the specific data they contain. In his statement of 18 March last the distinguished representative of the United States discussed the percentage distribution of raw material flows in respect of its overall utilization in the economy of a given country. According to this statement, the percentage to be diverted in order to obtain 10,000 tons of phosphorus agents annually was only about one per cent of raw material produced and therefore too insignificant a variation to arouse suspicion and justify a complaint. This conclusion would appear at first glance to rule out any possibility of pursuing this list of inquiry.

If, however, we look more closely into the implications of the United States representative's argument, the question can be seen in less negative terms. It is true that the percentage variation required for the production of 10,000 tons of phosphorus agents is small in the case where the quantity of raw material is quite considerable. But, by taking into account smaller quantities of raw material, we find that the percentage variation assumes significant values. Let us assume, for example, an economically advanced country processing in one year three million tons of phosphate rock; its raw material production is assumed to be about one-tenth the amount postulated in the American example but well above that of the great majority of countries in the world. It must be considered that this hypothetical country in case of war (and perhaps particularly in such a case) could not avoid devoting very important quantities of raw material to vital economic sectors (fertilizers, fuels, lubricant etc.). It is therefore reasonable to estimate that the amount of phosphorus still available, from which the quantities necessary for the production of chemical agents could be drawn, would be about 50,000 tons; which means that in order to produce 10,000 tons of warfare agents the country would have to divert 2,000 tons (4% of the 50,000 tons) which is quite a significant variation.

The objection that to take a smaller parameter for phosphate rock mined or available could imply a smaller production of chemical agents does not seem convincing. The quantity of agents produced or to be produced does not depend on the availability of raw material, but essentially on military requirements. The latter necessitate that production of chemical agents cannot be kept below a certain level without its becoming of no military significance.

From these considerations it seems clear that, if only one parameter is used for our analysis, controls are not feasible for the generality of countries, but it is equally clear that the number of countries for which controls do not seem feasible would be small. On the one hand, there are a very few countries whose production of phosphate rock is so large that the percentage variation in respect of raw material that might be diverted to weapons production would seem insignificant. On the other, if we examine the geographical distribution of sources of phosphate rock, we find that in the great majority of countries the quantity which can be mined is quite small and seldom such as to allow them to be self-sufficient in respect of its uses for solely peaceful purposes. Thus the method of using only one parameter, because it is not universally applicable, could be only envisaged as a first approach.

In our working paper CCD/304 of 6 August, 1970 concerning indirect controls we formulated a number of questions for a group of experts to work on. One of the questions was related to the use of percentage variation as a first step toward identification of signs to be deemed suspicious in the monitoring of economic data on phosphorus production and flows. We further asked whether in the event of variation in a single parameter not being significant in itself, it might become significant when associated with a variation in one or more other parameters to be found.

In order to clarify better what we had in mind when we posed these questions, the example mentioned above may be further considered with particular reference to the production of phosphorus trichloride and phosphorus oxychloride as intermediates in the production of agents. The annual production of these intermediates, estimated on the basis of the data already used in this example, would come to 5,000 tons which would be completely absorbed in the production of 10,000 tons of agents and yet would be insufficient. The shifting of a parameter concerning the production of phosphorus trichloride and phosphorus oxychloride would be therefore of very great importance. A further question to be elucidated is whether it will also be sufficiently indicative when applied to those few countries producing large quantities of phosphate rock.

To sum up, it seems to us that on the basis of reliable data for a single parameter a significant number of countries can, even now, be effectively monitored. Additional parameters based on monitoring of percentage variations in respect of phosphorus and organophosphorus substances would enable the range of controls to be extended. For this purpose other parameters could be found and taken into account, and their correlation would progressively enable us to establish a model for use in an appropriate computer and thereby create an effective system of controls applicable to the whole world. We feel justified therefore in urging that researchers make a determined effort to identify one or more parameters which, linked to the first, could close all loopholes.

We are well aware that the problem bristles with difficulties. Its solution will necessitate the collection and processing by powerful computers of large quantities of statistical data for the construction of complex models which must be tested out and improved until a definitive model is worked out and proved valid for all cases.

We share in this respect the views expressed by the Japanese delegation in CCD/301 of August 1970 concerning the collection of statistical data. We appreciate the ingenious method proposed in the Japanese paper for the selection of substances for statistical monitoring. It would be very useful to compare this method with other methods and procedures which experts from other countries may wish to propose. It should be noted that a proposal similar to the Japanese is to be found in the Swedish working paper CCD/322 of 16 March 1971. Moreover, it seems to us that useful suggestions are contained in the "inspection questionnaire" circulated on July 6, 1971 by the American delegation.

Working paper CCD/332 submitted on the same day by the United States delegation, highlights factors which can be utilized by means of on-site inspection to determine whether a plant is producing prohibited chemical substances, taking into account the characteristics of the plant and the chemical nature of the waste materials released by the plant. The most refined and up-to-date methods have been indicated for the analysis of these waste products. The American paper, which assumes that there will be on-site inspection, is a valuable contribution to a solution of the control problem. It is reasonable to suppose, however, that this type of inspection cannot be of a permanent and general character. It seems desirable therefore to seek a method whereby a suspicion can be formulated as a basis for a complaint. This in turn could be followed by on-site inspection using, among others, the factors and methods suggested by the United States delegation.

In making these remarks of a methodological character we cannot of course foresee whether the search for a solution, such as the one we have outlined, will produce positive or negative results. We are convinced, however, that the problem must be tackled so that we may know with certainty what is the answer concerning the feasibility of controls. If the results are positive the Committee will have a suitable gauge for the detection of a dangerous situation. If they are negative we shall at least be able to draw the logical inference for the final elaboration of a political instrument.

(3) Lastly, very careful consideration, in our opinion, should be paid to the question of the destruction of stockpiles of chemical weapons and agents. The Committee has already received a valuable contribution from the Swedish delegation (working paper CCD/324 of March 30, 1971) drawing attention to this grave problem at an early stage. Since destruction of large stocks by dumping into the ocean depths is unthinkable, and combustion is not readily practicable, a more logical course would appear to be that of chemical transformation, which implies a timely study of chemical processes and methods to be applied.

A closely related problem is that of controlling the destruction of chemical weapons. Once again we reiterate the necessity of having available the contribution of a group of experts who should be given a precise mandate and asked to report back to the Committee itself. The problem is much too grave and the risks involved are too great.

In joining the other delegations that requested the convening of this meeting the Italian delegation shared the hope that a careful study on the technical level would lead to further progress in our consideration of the problems outlined above.

This meeting may open up prospects for fruitful future contacts between experts along the lines which we have indicated. The interesting new data and information that the Committee has received will require further detailed analysis whose conclusions should be compared and discussed together in another exercise of this kind in order to trace the guidelines for constructive work before the next UN General Assembly.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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JAPAN

Working paper on a biological approach to the question of verification on the prohibition of chemical weapons

- Organophosphorus chemical agents -

As the SIPRI Report "The Problem of Chemical and Biological Warfare, Part IV Verification (February 1970)" has described, nerve agent plants are usually kept air tight and operated at a negative pressure. Furthermore, critical chemical reaction equipment is handled by remote control devices, and so forth, then plants are designed to avoid exposure of the chemical agent to workers. Thus, the safety facilities are presumably completely organized. It is no doubt that continuous and periodical health examinations are executed for the ideal labour management.

Here, we should like to make an attempt on a biological approach to the question of verification on the prohibition of chemical weapons from the viewpoint of workers' health control.

The biological effects of organophosphorus compounds depend mainly on their inhibitory effect on the activity of cholinesterase in man, and the inhibition rate is said to run parallel to the dose. It is also known that a change in the activity of cholinesterase in the body takes place by the presence of an organophosphorus compound in a quantity which is too small to produce any clinical symptom, either subjective or objective, in man. Consequently, the measurement of the change is regarded as a useful indicator for checking whether or not the body has been exposed to an organophosphorus compound.

It is to be noted further that the measurement of the activity of cholinesterase in the blood requires relatively simple techniques, since the cholinesterase in the plasma, which is the amorphous part of blood, is more easily affected than that in the other organs or tissues; and moreover the activity level of the cholinesterase in the red cells, which are the solid part of the blood, undergoes an irreversible change. Therefore, the measurement of the change in the activity of the cholinesterase in both plasma and red cells could be used as an effective and practicable method in protecting those who are engaged in activities which have a possibility of exposure to chemical compounds of the organophosphorus family.

It might be worthwhile mentioning in this context the governmental guideline adopted in Japan for the purpose of maintaining the health of workers in factories producing or using organophosphorus compounds. Under this policy, the diagnosis of such symptoms as a decline in the level of activity of the cholinesterase in the blood, sudoresis or excessive perspiration, miosis or the contraction of the pupil and muscular fibrillation of the eyelids and the face are suggested as criteria for the periodical medical examinations. As mentioned above, among the four criteria of the examinations, a decline in the level of activity of the cholinesterase is the most sensitive. Therefore it becomes the best parameter for the biological change by the effect of organophosphorus compounds. Based on the above guidance, in a case where the activity level of the cholinesterase in the plasma of a worker is found to have dropped by thirty percent or more, he should be transferred to another post or given a certain period of rest for the purpose of natural physical recovery.

According to the above guidance, organophosphorus compound producing plants in our country have made great efforts for the maintenance of workers' health. For example, in the case of workers in organophosphorus pesticide producing plants, the level of activity of the cholinesterase in workers' plasma is measured three or five times before workers start to work in the plant, and therefore, the mean value of the level calculated as before-mentioned is recorded as the individual normal level of activity. The workers' level of activity of the cholinesterase is examined regularly, which varies from every two weeks to two months according to the toxicity of the pesticide which is being produced. We have not had any significant incidents for over ten years up to the present, including the period of producing even parathion which has a high toxicity on mammals. In a general observation, however, under similar conditions of labour management, the decline in the level of activity of the cholinesterase among workers who are engaged in the production of organophosphorus compounds compared with that among workers who are engaged in the production of other chemical compounds is remarkable.

Of course, even when a change is detected in the level of activity of the cholinesterase in the blood, it would be almost impossible to draw from that fact an inference as to the type or the amount of production of the chemical compound. On the other hand, considering the fact that some of the organophosphorus compounds now used for peaceful purposes could be employed as chemical weapons and the plants now producing such compounds could change the nature of production as the need arises, a means of verification which covers a wide range of organophosphorus compounds might be useful.

It should be natural that the facilities of a factory vary according to the degree of the workers' exposure to organophosphorus compounds. However, even in the case of a plant with ideal equipment where the possibility of exposure to organophosphorou organophosphorus compounds might be completely eliminated, it would still be necessary from the medical point of view, as long as there are workers engaged in the production, to conduct a medical examination to completely ensure the safety. In the case of a factory where precaution measures are being taken to such an extent as would completely eliminate the possibility of exposure, no biological change is detected in man. Such special precaution measures themselves would provide useful data for verification purposes.

In accordance with the above considerations, we should like to suggest that this Committee explore the possibility of establishing a method of verification based on the examination of the level of activity of the cholinesterase in the blood of people working in chemical plants engaged in the production of organophosphorus compounds and whether extraordinary safety measures are being taken in such plants.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/344
24 August 1971
Original: ENGLISH

JAPAN

Working paper containing remarks of Prof. Shunichi Yamada, the University of Tokyo, concerning the question of verification on the prohibition of chemical weapons, presented at the informal meeting on 7 July 1971

The question of verification of compliance with the prohibition of chemical weapons is considered to be extremely difficult because of the close interrelationship between the production of such weapons and industry for peaceful purposes and also because such production requires only comparatively simple techniques. We have made a careful study with a view to finding technical methods which would enable us to conduct more or less effective verification, which, as we have just mentioned, will involve many complexities, and our past study has made it possible for us to come up with some suggestions in this regard. We believe that a suitable combination of these suggestions, though it may be far from perfect as a method of verification of chemical weapons, will provide us with some clue in our present efforts. This paper tries to examine in more detail our past suggestions and attempt to present them in somewhat more precise manner.

Since the question of verification of chemical weapons in general is much too wide a subject, we have concentrated on the question of verification specifically relating to the production of nerve agents, which are, of course, organophosphorus compounds. Organophosphorus compounds are widely used in industry for peaceful purposes in the production of pesticides and it was from the research in pesticides that the discovery of nerve agents originated. However, unlike in the field of pesticides where efforts have been made to lower their toxic effects on mammals, the development efforts in the field of nerve agents have been directed towards increasing their toxic effect. At the present time the toxic level of nerve agents is reported to be between 1,000 and 10,000 times greater than that of pesticides. It is to be noted that the difference in chemical structure between nerve agents and pesticides lies in the fact that, while sarin, soman, V agents and all other new types of nerve agents, with a few exceptions, contain methyl-phosphorus bonds, no chemical compounds with such bonds are used as pesticides. Therefore, should we be able to establish a highly sensitive method of microanalyzing a methyl-phosphorus bond, it would greatly facilitate the detection of nerve agents.

Last summer we submitted to this Committee a working paper (CCD/301) in which we stated: "If an emission electrode for a flame thermionic detector is attached to the nozzle of a flame ionization detector in gaschromatography, a high sensitivity will be shown by phosphorus compounds and the minimum amount detectable will be 1×10^{-12} gram." We noted further that, by using this method, it would be possible to detect and identify such known nerve agents as sarin, soman and V agents or their decomposed products which might exist in very small quantities in liquid wastes from the chemical plant concerned, the soil and dust in and around the producing plant, or on the production equipment or the workers' clothes, by checking their retention times.

Generally speaking, nerve agents are methylphosphonic ester halogenides and they are converted to methylphosphonic acid by hydrolysis, with their methyl-phosphorus bond remaining unsevered. If, therefore, we apply the method of gaschromatography mentioned above to such methylphosphonic acid itself or to its methyl or ethyl ester, which has a low boiling point, we might be able to analyse them both qualitatively and quantitatively. Since this method would enable us to verify the presence or absence of known nerve agents as well as those derivatives which have methyl-phosphorus bonds and which cannot be used for purposes other than the production of nerve agents, it would be a useful means of verification of nerve agents, irrespective of whether or not they are already known.

It will hardly be necessary to add that further detailed study of various factors affecting hydrolysis or conditions in applying gaschromatography such as the type of columns to be used, temperature, sensitivity of the instruments, etc., would be required.

If we could establish the method of microanalysis of chemical compounds with a methyl-phosphorus bond, it would be possible to verify whether or not nerve agents are being produced by checking liquid wastes from the suspected plant or even from the atmosphere or river water at a considerable distance from the plant. It goes without saying that the same method, if applied in the case of an investigation with direct access to the suspected plant, would be even more effective. Although we have at present no such data based on actual experiments, we believe that the method we have suggested can be a possible means of verification and if we could visit, together with representatives from other countries, facilities where nerve agents are actually handled and investigate them, it would provide us with valuable information to prove the effectiveness of our concept.

We put forward another suggestion in the same working paper dealing with necessary data which would contribute indirectly, if not directly, to the detection of production of nerve agents. To that end, we suggested the establishment of a system under which countries would report on the statistics for certain phosphorus compounds, giving the

amounts produced, exported and imported and figures for consumption for different purposes. If such a system worked properly, it would contribute to the prevention of the use of those su stances for the production of nerve agents. We should now like to attempt to explain this approach in rather more detail.

Nerve agents are organo phosphorus compounds and their manufacture requires phosphorus compounds as the principal raw material as well as many kinds of auxiliary materials or solvents, and the lack of any of them would make production impossible. However, since the auxiliary materials or solvents used in the production of phosphorus compounds are also widely used in the production of many other industrial goods and it would be extremely difficult to trace the flow of these materials, it would be practical to leave them aside for the moment and focus our attention on the flow of the principal raw material, that is, phosphorus compounds. Thus, if we check statistically the amount of production and consumption of yellow phosphorus, which is the starting material, and other various important intermediates in the production of nerve agents, we should be able to ascertain whether or not chemical compounds of the organophosphorus family are being used for the production of nerve agents. Although there are various methods for the production of such agents, which are already known or could conceivable be developed, it would suffice for us to concentrate on some of them from the viewpoint of the possibility of industrial mass production. Important intermediates which are common in those several practicable methods are yellow phosphorus, phosphorus trichloride, phosphorus oxychloride, phosphorus pentachloride and phosphorus pentasulfide, which are all inorganic phosphorus compounds, as well as such organophosphorus compounds as dimethyl or diethyl phosphite, trimethyl or triethyl phosphite and methylphosphonic dichloride or difluoride. With the exceptions of methylphosphonic dihalogenides, those compounds are all used in great quantities as materials or solvents in the manufacturing of agricultural chemicals, pharmaceuticals, perfumes, dyestuffs, vinyl chloride stabilizer or plasticizer. Methylphosphonic acid dichloride or difluoride contains a methyl-phosphorus bond, and belongs to a special group of chemical compounds. It is also considered to be an important final intermediate in the production process of nerve agents and is reported as possessing itself a high toxic effect. Although it is reported that it can be used as a material for the production of polymers containing phosphorus, we do not have any detailed information on it.

In Japan, the statistics on the amounts of the production and consumption of the inorganic phosphorus compounds mentioned above are systematized and made public. Recently a survey has been conducted on the flow of those intermediate materials in Japan. For the information of each delegation, the tables on the amount of consumption of

phosphorus trichloride and phosphorus oxychloride in Japan are attached to this working paper. However, there are not sufficient statistics on organophosphorus compounds other than agricultural chemicals. Furthermore, methylphosphonic dihalogenides, which have no peaceful uses, are, of course, not industrially produced or used in Japan. Accordingly, we believe that, if countries do their best to gather reliable statistics in a more systematic way on the phosphorus compounds and clarify the flow of such compounds, it would make it possible to some extent to check the possibility of their being diverted to the production of nerve agents. Considering the possibility of other methods of manufacturing nerve agents and of the isolation of intermediates, those chemical compounds which we have dealt with might not be the best ones as check points. Also, the question of the relationship between the extent of statistical errors and the amounts of intermediates required for the production of nerve agents might throw some doubts on the usefulness of preparing such statistics. However, if we try to minimize the weakness in the system for the preparation of statistics, and countries concerned are persuaded to make them public, it would result in a situation favouring the prevention of the production of nerve agents and would help to build up mutual confidence among states.

We should like now to deal with a matter which is not necessarily related to any concrete means of verification but designed to prevent the secret development of or research on new types of highly toxic chemical weapons in the future. Last summer, in this Committee, we proposed that the existing chemical compounds with toxic effects above a certain level should be listed as items to be reported upon and that a system should be established so that, when new chemical substances whose toxic effects equal or exceed that level were discovered, they might be tested by an appropriate international research institute and, if they were found to have toxic effects equal to or above that level, this would be announced. We further suggested as the toxic level to be used as the criterion for this purpose a lethal dose (LD_{50}) of 0.5 milligramme per kilogramme of body weight by hypodermic injection. The basis for this suggestion is that we can safely assume that no chemical substance with a toxic effect equal to or above that level can be used for peaceful purposes.

There are more than ten kinds of chemical compounds with toxic effects equal to or exceeding the suggested level: namely, tabun, soman, sarin, VX, a few organophosphorus compounds which were mentioned in our working paper submitted last summer (CCD/301) and in the Netherlands working paper submitted this spring (CCD/320), such toxins as

botulinus toxin and tetrodotoxin, alkaloids such as accnitine and plant heart poisons such as scillaren. If these substances need to be manufactured as pharmaceuticals or for other peaceful purposes, we would be able to agree to report on the purpose, amount and place of the production.

The criterion lethal dose (LD_{50}) of 0.5 milligramme per kilogramme of body weight would be based on hypodermic injection, the method by which most of our available data have been obtained. However, there still exist such questions as whether the criterion should be based on the same route of absorption as in the case of use as a chemical weapon, that is, inhalation or percutaneous absorption, and whether we should use a uniform method of testing on animals, specifying the kind of animals to be used, their weight and number. On these problems we should like to hear the opinion of pharmacology experts. It would also be desirable to hold further discussions on the question of choosing an appropriate international body which would carry out authoritative tests in this regard.

Table 1

Amount of Consumption of Phosphorus Trichloride (PCl_3) by Purpose in Japan
(tons)

Year / Purpose	1965	1966	1967	1968	1969	1970 (est.)
Agricultural Chemicals	785 (32.4)	1.182 (40.3)	1.761 (46.0)	2.343 (51.2)	2.714 (53.9)	3.120 (55.7)
Vinyl Chloride Stabilizer	689 (38.4)	877 (29.9)	1.112 (29.0)	1.063 (23.1)	1.229 (24.4)	1.280 (22.9)
Dyestuffs	622 (25.7)	507 (17.3)	677 (17.7)	801 (17.5)	642 (12.7)	493 (8.8)
Pharmaceuticals	77 (3.2)	115 (4.0)	80 (3.1)	122 (2.7)	99 (2.0)	175 (3.1)
Others	249 (10.3)	250 (8.5)	200 (5.2)	250 (5.5)	353 (7.0)	532 (9.5)
Total	2.422 (100)	2.931 (100)	3.830 (100)	4.579 (100)	5.037 (100)	5.600 (100)

Percentage values are given in parentheses.

Table 2

Amount of Consumption of Phosphorus Oxychloride ($POCl_3$) by Purpose in Japan
(tons)

Year / Purpose	1965	1966	1967	1968	1969	1970 (est.)
Plasticizers	1.263 (41.6)	1.460 (42.2)	1.963 (47.6)	2.376 (48.1)	2.498 (48.5)	2.882 (53.9)
Pharmaceuticals	1.037 (34.2)	800 (23.1)	790 (19.2)	1.017 (20.6)	1.288 (25.0)	1.164 (21.8)
Perfumes	49 (1.6)	45 (1.3)	97 (2.4)	141 (2.9)	134 (2.6)	107 (2.0)
Others	684 (22.6)	1.157 (33.4)	1.270 (30.8)	1.405 (28.4)	1.233 (23.9)	1.199 (22.4)
Total	3.033 (100)	3.462 (100)	4.120 (100)	4.939 (100)	5.153 (100)	5.351 (100)

Percentage values are given in parentheses.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/352
28 September 1971
Original: ENGLISH

ARGENTINA, BRAZIL, BURMA, EGYPT, ETHIOPIA, INDIA
MEXICO, MOROCCO, NIGERIA, PAKISTAN, SWEDEN AND YUGOSLAVIA

Joint memorandum on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction

In the Joint memorandum of the group of twelve members of the Conference of the Committee on Disarmament on the question of chemical and bacteriological (biological) methods of warfare (CCD/310), the group had expressed the following views:

(i) It is urgent and important to reach agreement on the problem of chemical and bacteriological (biological) methods of warfare;

(ii) Both chemical and bacteriological (biological) weapons should continue to be dealt with together in taking steps towards the prohibition of their development, production and stockpiling and their effective elimination from the arsenals of States;

(iii) The issue of verification is important in the field of chemical and bacteriological (biological) weapons, as indeed adequate verification is also essential in regard to the success of any measures in the field of disarmament. Reasonable guarantees and safeguards should, therefore, be devised to inspire confidence in the implementation of any agreement in the field of C and B weapons. Verification should be based on a combination of appropriate national and international measures, which would complement and supplement each other, thereby providing an acceptable system which would ensure effective implementation of the prohibition.

This basic approach was commended by the General Assembly of the United Nations in its resolution 2662 (XXV).

The group of twelve members of the Conference of the Committee on Disarmament have taken note of the evolution of negotations which has since taken place, whereby only the elaboration of a Convention on the prohibition of bacteriological (biological) and toxin weapons and on their destruction seems possible at the present stage. However, the group wishes to emphasize the immense importance and urgency of reaching agreement on the elimination of chemical weapons also.

Bearing in mind the recognized principle of the elimination of chemical weapons as well as the firmly expressed commitment to continue negotiations in good faith until early agreement is reached on effective measures for the prohibition of the development, production and stockpiling of chemical weapons and on their destruction, the group offers the following elements on which such negotiations should be based:

1. An obligation to prohibit the development, production, stockpiling, acquisition and retention of chemical agents of types and in quantities that will be defined in future agreed provisions, and weapons using such chemical agents as well as equipment or means of delivery designed to facilitate the use of such agents or weapons.

2. An undertaking not to assist, receive, encourage or induce any State, group of States or international organizations in the above mentioned prohibited activities.

3. An undertaking to destroy or convert to peaceful uses, taking all necessary safety precautions, all chemical agents, weapons, equipment or means of delivery and facilities, specially meant for the development, production and stockpiling or for using such agents or weapons.

4. An undertaking to disband and not to establish anew special military or other forces for using chemical agents or weapons.

5. The problem of verification should be treated in accordance with the suggestions contained in the Joint memorandum of the group of twelve members of the Conference of the Committee on Disarmament (CCD/310).

6. A clear understanding whereby future agreed provisions for the prohibition of the development, production and stockpiling of chemical weapons are not to be interpreted as in any way limiting or detracting from the obligations assumed by the Parties under the Geneva Protocol of 1925.

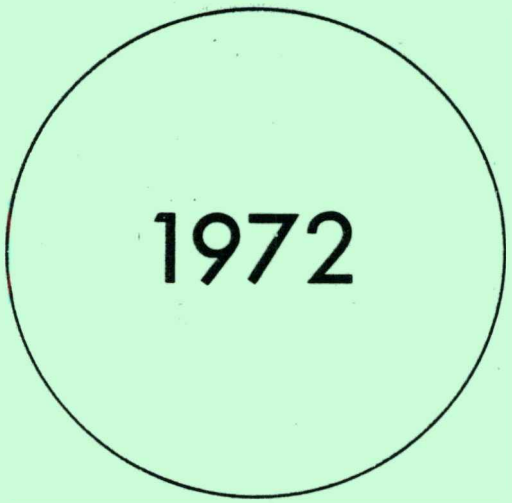
7. Future agreed provisions should be implemented in a manner designed to avoid hampering the research, development, production, possession and application of chemical agents for peaceful purposes or hindering the economic or technological development of States Parties.

8. An undertaking to facilitate the fullest possible exchange of chemical agents, equipment, material and scientific and technological information for the use of such chemical agents for peaceful purposes.

9. A recognition of the principle that a substantial portion of the savings derived from measures in the field of disarmament should be devoted to promoting economic and social development, particularly in the developing countries.

The group is firmly convinced that the CCD should proceed with the task of elaborating, as a high priority item, agreed provisions for the prohibition of the development, production and stockpiling of chemical weapons.

The Group finally expresses the hope that the elements suggested in the preceding paragraphs would receive general acceptance so that early agreement could be reached on the complete prohibition of the development, production and stockpiling of chemical weapons and on their effective elimination from the arsenals of States.


1972

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/360
20 March 1972
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UNITED STATES OF AMERICA

Work Program regarding negotiations on prohibition of chemical weapons

I. INTRODUCTION

This paper sets forth some of the considerations that are relevant to the question of prohibition of chemical weapons. It deals primarily with lethal chemical warfare agents. The paper does not attempt to treat all of the many factors which we or others may feel are important with respect to these agents or offer final judgements on those questions that are discussed. The delegation hopes that the material presented will stimulate further discussion and assist the Committee towards reaching a consensus regarding those considerations that are important to successful negotiations

II. SCOPE

This section (A) sets forth major categories of types of agents and precursors describing a number of factors which appear to the US delegation relevant to their consideration in the context of arms limitation, (B) describes possible ways of defining substances that might be controlled, and (C) sets forth and discusses classes of activities pertaining to chemical weapons programs together with relevant arms limitation considerations.

A. Major categories of substances related to chemical warfare include the following:

1. Single-purpose agents. These agents have no large-scale uses except in chemical warfare. Modern agents in this category, such as organophosphorus compounds, are extremely toxic. Some older agents, which caused a number of deaths in World War I, also fall into the "single-purpose" category.

2. "Dual-purpose" agents are chemicals which are commonly used for civilian purposes, but which might also be used as CW agents. Phosgene, chlorine, and hydrogen cyanide are well-known examples of substances in this category and were

utilized widely in the first World War. The extent of the civilian uses of these agents was described in a working paper (CCD/283) submitted earlier by the US delegation.

3. Precursors. Intermediates of modern agents may or may not have civilian applications. Phosphorus trichloride, for example, a key precursor in the production of organophosphorus nerve agents, is widely used as an intermediate in the manufacture of pesticides and plasticizers. Under present conditions, agent intermediates do not assume immediate military significance until processed further into an agent, but binary devices, by using agent intermediates as weapons components, could blur this distinction.

B. Definitions of Controlled Substances

The following general criteria offer various possibilities for defining chemical substances which might be used for chemical warfare:

1. General Toxicity Standard. Modern lethal agents are in general much more toxic to humans than are pesticides or other chemicals used in the civilian sector. A standard related to the toxicity of present-day nerve agents would exclude, for all practical purposes, chemicals which have civilian uses. However, allowance should be made for the fact that a number of super-toxic compounds have legitimate medical applications. If a toxicity standard were adopted it might be necessary to provide for a uniform laboratory method of determining the toxicity of a compound. The kind of animals to be used, their number and weight, the method of application of the chemical, and extrapolation of effects to humans, are among the factors which would have to be dealt with. Questions regarding the application of a toxicity standard might be referred to an international consultative body or some other appropriate international body.

2. Identification of Specific Agents. Many chemical substances which have been used in warfare or developed for weapons purposes are generally known. Although a comprehensive list of these known agents by name and specific structural formula might include the majority of agents in current arsenals, there is no way at present to know whether such a list would include all the major agents in the arsenals of states or under development.

3. General Structural Formula. All presently identified nerve agents are organophosphorus compounds which exert their toxic effect by inhibition of the enzyme acetylcholinesterase. Considerable information is available on the relationship between chemical structure and ability to inhibit acetylcholinesterase. A general structural formula might be developed which would describe the spectrum of organophosphorus compounds which could be used as lethal agents but would not include compounds used as pesticides. One possibility is the formula presented in CCD/320 by the delegation of the Netherlands.

4. Criterion Based on Purpose. The Biological Weapons Convention relies on a general formulation which prohibits agents "of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes". This definition is both comprehensive and simple. Such a definition by itself, however, could be insufficiently precise for effective application to chemicals which are produced in extremely large quantities for peaceful purposes.

5. Combination of Methods. Having various possible prohibitions in mind, the Committee might consider what combination or combinations of criteria could be appropriate. The advantages might be weighed of using a purpose criterion, accompanied by one or more of the other forms of definition described above. If differing prohibitions were to be considered for various categories of agents, definitions would be needed which could distinguish such categories from one another. For example, with respect to prohibitions covering the most lethal types of agents, a definition might include, in addition to a purpose criterion, reference to structural formulas of known agents and specification of toxicity levels. Binary components, however, may not be readily distinguishable from many industrial chemicals either by their structural formula or toxicity. If such intermediates were to be considered, because of their potential military importance, for specific prohibitions, it might be desirable to consider a definition that was based on the

purpose criterion and a list of known substances. There are, of course, advantages and disadvantages to all of the various possible definitions and their combinations, which should be carefully considered by the Committee as it moves forward in its work on questions concerning CW prohibitions.

6. Maintaining Effective Definitions. The Committee might consider ways in which definitions could be kept current. Examples of possible technological developments which could affect the adequacy of definitions in future circumstances are:

(a) Development of very toxic chemicals with non-military uses;

(b) Development of binary weapons with "dual-purpose" chemical components;

(c) Development of non-military uses for substances similar to present nerve agents;

(d) Development of chemical compounds which have potential military utility but which do not clearly meet traditional criteria for determining controlled substances. In view of these possibilities, consideration might be given to the most appropriate means for continuing or periodic future consultations to help insure that the scope of substances to be controlled remains effectively defined, with updating as necessary.

C. Scope of Activities Which Might Be Controlled

The Committee should give consideration to the various classes of activities pertaining to chemical weapons programs together with relevant arms limitation factors.

1. Production of Agents is a key element in acquiring and, over the long run, in maintaining a chemical warfare capability. The current process of manufacture of modern lethal agents is a sophisticated one carried out in highly specialized facilities. These characteristics give rise to important considerations bearing on the question of nerve agent production controls:

(a) Initiating nerve agent production is a complex task. Considerable time is required to construct a new agent plant, convert another chemical facility to agent production, or even to reactivate an agent plant which has been shut down for more than a short period. The engineering difficulties which must be overcome are considerable. The cost of establishing a nerve agent manufacturing facility of the type used in the past is many times greater than for a production facility for commercial chemicals. These considerations may not be fully applicable in the case of production of components for binary weapons.

(b) While it may be reasonable to assume that there are relatively few chemical facilities which might be used at the present time to make organophosphorus chemical warfare agents, information is insufficient to determine which facilities in fact have this capability and have been engaged in agent production.

In the case of nerve agent production facilities, possibilities for demilitarization range from closing or "mothballing" plants to conversion or destruction. Measures which might be useful in ensuring that required actions were taken are discussed below in the verification section.

2. Production of Weapons

(a) Chemical munitions manufacture uses substantially the same type of metal-processing facilities used to make casings for conventional weapons. Filling of munitions with agent, on the other hand, characteristically is a highly specialized process carried out under stringent safety and security controls. The filling of chemical munitions with nerve agent would normally be carried out at or near the agent production facility, where appropriate conditions for handling highly toxic materials would already exist. This would be a lesser consideration in the filling of munitions using less toxic materials such as chlorine, phosgene or possible components of binary weapons.

(b) In considering possible approaches to prohibiting production of chemical weapons, the question of munitions might assume varying importance depending on the nature of the agents being utilized:

(i) Dual-Purpose Agents. A great many countries would, of course, continue to possess production facilities for, and large quantities of, such chemicals as chlorine and phosgene for peaceful industrial uses after any chemical weapons agreement. Such production facilities, or, current stocks, could be utilized at anytime for making weapons. Thus the activity which it seems most relevant to restrict in this area would be production of munitions rather than production of agents.

(ii) Nerve Agents. On the other hand, in the case of known nerve agent munitions, the agents themselves do not have large-scale peaceful uses, and their possession in any quantity, even when not filled in munitions, has military significance. Thus, controls affecting production of agents would appear to be of particular importance in connexion with such weapons as those using nerve agents.

3. Stockpiling. Possession of stocks of chemical weapons is essential to maintenance of an immediate chemical capability. While there is evidence which suggests the existence of substantial quantities of chemical arms in present day arsenals of several nations, storage of chemical weapons by its nature is not a readily identifiable activity. Several considerations seem pertinent in relation to stockpiling:

(a) There is general uncertainty over the size and composition of chemical weapons stocks in existence.

(b) A capability to retaliate promptly in kind to a chemical attack is one deterrent against initiation of chemical warfare.

(c) Destruction or demilitarization of stocks, given the toxic nature of modern agents, requires time-consuming and carefully controlled processing under stringent safety precautions. To ensure that none of the toxic agent escapes into the invironment, a destruction facility must be operated under the principle of "total containment". Another major concern is the disposal of the end-products of the agent destruction. These end-products, while relatively non-toxic in themselves, might have a serious adverse effect if introduced into the environment in large quantities.

4. Research and Development

(a) Research. Certain lethal agents were an accidental by-product of industrial insecticide research conducted in civilian laboratories. It may be difficult to tell from the nature of research on toxic substances whether or not such research is part of a military programme. It may also be difficult to distinguish many aspects of research for offensive purposes from research for defensive or prophylactic purposes. At the same time, it is possible that a number of countries will attach importance to the continuation of research for defensive purposes.

(b) Development of promising CW agents and of means for disseminating them are explicitly military activities and go beyond the stage necessary for design of defensive measures. However, development, like research, is an activity of low visibility.

III. VERIFICATION

The Committee faces a number of important questions with respect to possible means of verification, both national and international. This section sets forth a number of considerations (A) on the relationship between the scope of prohibitions and verification, and (B) regarding the feasibility of possible specific verification elements such as (1) seals and monitoring devices, (2) information exchange, (3) declarations, (4) remote sensing devices, (5) inspection visits, and (6) monitoring of imports and shipments of certain specific materials.

A. Relationship Between Verification and Scope

Various possible combinations of CW prohibitions would be likely, in order to be effective, to require various measures of verification. Comprehensive prohibitions would, by definition, most completely limit chemical warfare capabilities. Moreover, comprehensive prohibitions, by covering many aspects of CW activities, would tend to reinforce each other. On the other hand, there may be some factors which would warrant the Committee's consideration of the relative merits of a phased approach in which some activities are prohibited initially and other activities at subsequent stages. For example, a simultaneous prohibition of production of certain agents or weapons, together with a requirement for complete destruction of any existing stocks of those agents or weapons, might require a higher degree of

assurance of compliance than if prohibitions were placed initially on production alone. As indicated earlier, possession of a retaliatory CW capability has been generally considered to provide one deterrent to the first-use of chemical weapons by others. A state possessing chemical weapons could feel that it required a very high degree of assurance that others would be taking the same steps it was to take, before agreeing to prohibitions which, when implemented, would leave it with no ability to retaliate promptly. Thus, one possible way some states might be satisfied with a somewhat lower level of initial assurance would be if the disarmament process took place in stages, that is, in the example under discussion, if production of certain classes of agents or weapons were prohibited initially while destruction of stockpiles were to take place in a subsequent stage.

B. Verification Elements

1. Seals and Monitoring Devices. The possibility exists of assuring that CW activity does not take place at "mothballed" facilities through the use of seals or monitoring devices of the types which have been studied in connexion with nuclear safeguards. This possibility has particular relevance with respect to a phased process in which CW production facilities are shut down but not initially dismantled. During the last session of the CCD, the delegation of the United States submitted a working paper (CCD/332) which describes the nature and possible utility of sealing and monitoring devices.

2. Information Exchange. Given the complexity, and the prospects for growth and change in the chemical industry throughout the world, provisions for information exchange might play a useful role in verifying chemical weapons limitations. Consideration might be given in the Committee to the types of information which would be helpful. Possibilities might include information regarding: (a) quantity, types,and uses of organophosphorus products; (b) quantity, types, and uses of dual purpose chemicals; and (c) intended use of major new chemical production facilities.

3. Declarations. Two types of declarations which might be considered in connexion with chemical weapons prohibitions are:

(a) Declarations Regarding Activities. The Committee might examine the utility of periodic declarations regarding activities relevant to an agreement as one means to help reinforce implementation of an agreement. For example, annual statements by parties, having the effect of affirming their compliance with an agreement, might be considered. The Committee might examine whether declarations which set forth annual national production figures for substances limited by an agreement would offer to parties an additional degree of assurance of continuing observance of an agreement. In the case of a prohibition of nerve-agent production, for example, it would be expected that parties would register zero production or a very small amount destined for scientific research. To emphasize a party's continuing commitment to an agreement, such declarations might be endorsed or issued at the highest governmental level.

(b) Declarations of Facilities. Declarations might also be considered that could be helpful in increasing the effectiveness of various means of verification. For example, submission by parties of lists identifying and locating facilities capable of handling highly toxic materials would be of help in verifying prohibitions of production. What types of facilities might be included in such lists, and whether the lists should contain supplemental information regarding past and present activity at particular installations, could be a subject to be examined within the Committee.

4. Remote Sensing Devices. The question of possible utility of remote sensing devices to detect evidence of CW activity is being studied in various countries. The present level of sensor technology, however, does not appear to offer significant prospects, in the near future, for the development of long-range sensors that could detect evidence of the manufacture or storage of chemical agents. The two principal problems in this respect are the difficulty of achieving sufficiently great sensitivity over large distances and the fact that substances resulting from prohibited and non-prohibited activities may give closely similar readings.

5. Inspection Visits. The Committee should consider possibilities for on-the-scene verification, including such questions as how locations to be visited are chosen and what might be expected to take place during a visit. An on-the-scene inspection by technically qualified personnel may be the most efficient and direct way of resolving a serious question concerning implementation of chemical prohibitions at a given site.

6. Monitoring of Imports and Shipments. Certain chemical substances have limited commercial application. A disproportionate increase in imports or shipments of these materials might be significant in verifying observance of an agreement.

IV. INTERNATIONAL ORGANIZATIONAL CONSIDERATIONS

A number of questions pertaining to international organizational considerations could have possible relation to measures containing prohibitions on chemical weapons. This section discusses (A) possible consultative arrangements, (B) relationship to the Security Council of the United Nations, and (C) the usefulness of provisions for periodic review. The consideration of these questions, as well as those in part V below, would of course be significantly affected by the manner in which questions in the preceding sections, pertaining to scope and to verification, were handled.

A. Consultative Body

In assessing which approaches to the achievement of restraints on chemical weapons are promising and which are not, consideration might be given, at an appropriate stage in the work of the Committee, to whether establishment of a standing consultative body would be helpful and, if so, what its role might be. While recent multilateral arms control agreements have not established or defined special roles for a body of this sort, a consultative group might be able to perform constructive functions in connexion with an agreement on chemical weapons. Given the complexities and difficulties of CW verification problems, provision for a consultative body might offer some additional element of assurance to potential parties to an agreement. Participation in the consultative body of appropriate governmental, military, and scientific representatives might in itself establish increased international confidence, understanding, and co-operation in dealing with problems inherent in the implementation of restraints on CW.

1. Possible Functions.

(a) One function of a consultative body might be to keep abreast, through the participation of appropriate military and scientific experts, with the military potential of various advances in chemistry. Such a function on the part of a consultative body might be particularly relevant if a chemical weapons agreement defined controlled substances using such criteria as a general toxicity standard and/or identification of specific agents. A consultative body might perform the function of reviewing questions regarding new chemical substances and of making such determinations as whether a particular commercially produced substance (i) fell within an agreed toxicity or formula criteria, (ii) should be classified as single-purpose or as dual-purpose, (iii) should be considered a precursor; and whether in light of these assessments the substance should be classified as one controlled or proscribed by the relevant definitions.

(b) Another possible role which might be considered for a consultative body could be in helping to assure parties to a treaty that its provisions were being carried out. Such a body might, for example, be the recipient of reports from parties to a treaty regarding their compliance with its provisions for destruction of existing stocks of lethal chemical agents and chemical weapons. It might also receive information reports on the intended use of organophosphorus substances produced by parties and on the use of certain categories of existing and new chemical production facilities. A consultative body might also receive questions from parties regarding implementation or observance of the CW agreement. In this connexion the consultative body might be the locus for arranging inspection visits to clarify an ambiguous situation and to restore confidence that an agreement was being observed.

2. Organizational Considerations.

(a) Operations. It would be necessary to consider in advance of determining whether to establish a consultative body the way in which it might perform the functions expected of it. Attention would need to be devoted to questions such as the powers that a consultative body might have to initiate actions, to make recommendations, and to solicit the co-operation of parties in the resolution of any problems that might arise. It would also be necessary to consider such practical questions as funding, headquarters, staff, and types of services to be provided. Parties to an agreement would naturally wish to avoid unnecessary costs in implementing any agreements in the CW area and would not wish to establish a new international organization or assign new functions to an existing organization unless substantial benefits could be expected in the solution of problems involved in implementing the agreement.

(b) Membership. The question of membership and participation in such a consultative body would be an important one for potential parties to an agreement. One possibility might be to agree that representatives of all parties to a CW agreement would be entitled to participate in any consultative body concerned with the implementation of that agreement. However, a consultative body might itself determine how experts would be selected for participation in its various activities.

(c) Relationship to Existing Organizations. Since a consultative body might be concerned with a range of issues varying from use of chemical substances for agricultural purposes to questions involving security and political issues, the relationship of such a body to existing international organizations might also be

considered. It might be useful to consider what ties a consultative body would need to have with such offices as the United Nations Secretary-General or with the United Nations Security Council, the United Nations General Assembly, or United Nations specialized agencies, and how these might best be provided for.

B. Relationship to the Security Council

A number of recent arms limitation treaties have contained provisions which specifically recognize the pre-eminent role of the United Nations Security Council in dealing with matters affecting international peace and security. In view of the important security implications any new agreement restricting chemical weapons would have, members of the Committee may wish to consider whether it would be of value to reaffirm in an appropriate manner the right of parties to submit complaints of violation to the Security Council together with all possible evidence, and to set forth an undertaking by parties to co-operate in carrying out any investigations the Security Council might initiate.

C. Review Conference

The Committee might weigh the advantages of a periodic review conference as an additional means of assuring the continued effectiveness of a CW agreement. A review conference could conduct a broad examination of whether the purposes and principles of the agreement were being realized, taking into account particularly any new scientific and technological developments relevant to the agreement. The discussion of issues and problems at a review conference could be of assistance to the subsequent work of any consultative body. Preparations for a review conference could be entrusted to a consultative body, if one had been established.

V. OTHER QUESTIONS

A number of other questions could arise in the course of consideration of possible prohibitions relating to chemical weapons. These might include (A) relationship to the Geneva Protocol, (B) facilitation of international co-operation in the field of peaceful applications, (C) prohibitions of assistance to third parties with respect to proscribed activities, (D) entry into force, (E) duration and withdrawal, and (F) amendments.

A. Relationship to the Geneva Protocol

In connexion with the achievement of any new restrictions on chemical weapons a question will naturally arise as to the relationship between these restrictions and existing restraints in the Geneva Protocol. Committee members may therefore wish to

consider whether any new agreement on chemical weapons should contain provisions noting the importance of the Geneva Protocol and ensuring that nothing in the agreement could be interpreted as in any way limiting or detracting from obligations assumed under the Geneva Protocol.

B. Facilitation of International Co-operation

In view of the fact that restraints on chemical weapons will have an important bearing, directly or indirectly, on activities in peaceful scientific and industrial areas, the Committee may wish to consider whether it would be practical and desirable for any new prohibitions to be accompanied by provisions that make clear the intention of parties to co-operate with other states or international organizations in the further development and peaceful application of science in fields relating to the agreement. Provisions along these lines are contained in both the Biological Weapons Convention and the Treaty on the Non-Proliferation of Nuclear Weapons. It would, therefore, seem logical to consider the desirability of appropriate provisions in the case of restraints on chemical weapons.

C. Assistance to Third Parties

Since parties to any new agreement would be accepting restrictions on their activities, it would seem logical to consider the possibility of appropriate provisions pursuant to which parties would agree not to assist or encourage any others to carry out activities limited by the new agreement. Such provisions, which have been included in recent multilateral arms control agreements, would reinforce the achievement of the broad purposes of any new agreement.

D. Entry Into Force

The question of how additional limitations on chemical weapons enter into force is important because a new agreement would affect weapons of established military significance. The Committee could consider whether a relatively large or a relatively limited number of ratifications ought to be necessary before a new agreement would enter into force. This question could have relationship not only to the possible scope of a new agreement but also to the manner in which questions such as duration and withdrawal are handled.

E. Duration and Withdrawal

The manner in which the questions of duration and withdrawal are handled in any new chemical weapons agreement will have a relationship to the possible scope of any new prohibitions and the extent of reassurance provided to parties through agreed means

of verification. These issues are in turn related to such questions as the overall stability of any new agreement and the extent of capability remaining in the hands of any nation to deter the initiation of chemical warfare by others. Approaches to the question of duration could range from consideration of an agreement limited to a fixed number of years (with possibilities of continuation or renewal), to an agreement of indefinite duration. Intermediate approaches might also be envisioned. Procedures for withdrawal could also vary, in part depending upon whether duration was limited or indefinite.

F. Amendment

Procedures for amendments could assume particular significance in the case of chemical weapons prohibitions. Chemical weapons and agents relate to a field of science and technology which is rapidly expanding and which may undergo basic changes in the future. Thus, technical aspects of prohibitions formulated in the light of technology existing in one decade could be significantly different in another decade. Whether amendments should be relatively easier or more difficult to adopt could also be related to the manner in which the issue of duration was handled.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/361
28 March 1972

ENGLISH
Original: RUSSIAN

BULGARIA, CZECHOSLOVAKIA, HUNGARY, MONGOLIA, POLAND, ROMANIA, UNION OF SOVIET SOCIALIST REPUBLICS

Draft Convention on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction

by

Bulgaria, the Byelorussian Soviet Socialist Republic, Czechoslovakia, Hungary, Mongolia, Poland, Romania, the Ukrainian Soviet Socialist Republic and the Union of Soviet Socialist Republics

The States Parties to this Convention,

Determined to act with a view to achieving effective progress towards general and complete disarmament including first of all the prohibition and elimination of all types of weapons of mass destruction -- nuclear, chemical and bacteriological,

Convinced that the prohibition of the development, production and stockpiling of chemical weapons and their elimination, through effective measures, will facilitate the achievement of general and complete disarmament under strict and effective international control,

Convinced of the importance and urgency of eliminating from the arsenals of States, through effective measures, such dangerous weapons of mass destruction as those using chemical agents,

Recalling that the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction affirms the recognized objective of effective prohibition of chemical weapons,

Recognizing the important significance of the Geneva Protocol of 17 June 1925 for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, and also the contribution which the said Protocol has already made, and continues to make, to mitigating the horrors of war,

Reaffirming their adherence to the principles and objectives of that Protocol and calling upon all States to comply strictly with them,

Recalling that the General Assembly of the United Nations has repeatedly, and particularly in resolution 2827A(XXVI) of 16 December 1971, condemned all actions contrary to the principles and objectives of the Geneva Protocol of 17 June 1925,

Desiring to contribute to the strengthening of confidence between peoples and the general improvement of the international atmosphere,

Desiring also to contribute to the realization of the purposes and principles of the Charter of the United Nations,

Determined, for the sake of all mankind, to exclude completely the possibility of chemical agents being used as weapons,

Convinced that such use would be repugnant to the conscience of mankind and that no effort should be spared to minimize this risk,

Have agreed as follows:

ARTICLE I

Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

(1) Chemical agents of types and in quantities that have no justification for peaceful purposes;

(2) Weapons, equipment or means of delivery designed to use such agents for hostile purposes or in armed conflict.

ARTICLE II

Each State Party to this Convention undertakes to destroy, or to divert to peaceful purposes, as soon as possible but not later than ..... months after the entry into force of the Convention, all chemical agents, weapons, equipment and means of delivery specified in Article I of the Convention which are in its possession or under its jurisdiction or control. In implementing the provisions of this Article all necessary safety precautions shall be observed to protect populations and the environment.

ARTICLE III

Each State Party to this Convention undertakes not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, weapons, equipment or means of delivery specified in Article I of the Convention.

ARTICLE IV

Each State Party to this Convention shall, in accordance with its constitutional processes, take any necessary measures to prohibit and prevent development, production, stockpiling, acquisition or retention of the agents, weapons, equipment and means of delivery specified in Article I of the Convention, within the territory of such State, under its jurisdiction or under its control anywhere.

ARTICLE V

The States Parties to the Convention undertake to consult one another and to co-operate in solving any problems which may arise in relation to the objective of, or in the application of the provisions of, this Convention. Consultation and co-operation pursuant to this Article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its Charter.

ARTICLE VI

(1) Any State Party to the Convention which finds that any other State Party is acting in breach of obligations deriving from the provisions of this Convention may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all possible evidence confirming its validity, as well as a request for its consideration by the Security Council.

(2) Each State Party to the Convention undertakes to co-operate in carrying out any investigation which the Security Council may initiate, in accordance with the provisions of the United Nations Charter, on the basis of the complaint received by the Council. The Security Council shall inform the States Parties to the Convention of the results of the investigation.

ARTICLE VII

Each State Party to the Convention undertakes to provide or support assistance, in accordance with the United Nations Charter, to any Party to the Convention which so requests, if the Security Council decides that such Party has been exposed to danger as a result of violation of this Convention.

ARTICLE VIII

Nothing in this Convention shall be interpreted as in any way limiting or detracting from the obligations assumed by any State under the Geneva Protocol of 17 June 1925 for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, as well as under the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction.

ARTICLE IX

(1) The States Parties to the Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the use of chemical agents for peaceful purposes. Parties to the Convention in a position to do so shall also co-operate in contributing individually or together with other States or international organizations to the further development and application of scientific discoveries in the field of chemistry for peaceful purposes.

(2) This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of States Parties to the Convention or international co-operation in the field of peaceful chemical activities, including the international exchange of chemical agents and equipment for the processing, use or production of chemical agents for peaceful purposes in accordance with the provisions of this Convention.

ARTICLE X

Any State Party may propose amendments to this Convention. Amendments shall enter into force for each State Party accepting the amendments upon their acceptance by a majority of the States Parties to the Convention and thereafter for each remaining State Party on the date of acceptance by it of the amendments.

ARTICLE XI

Five years after the entry into force of this Convention, or earlier if it is requested by a majority of Parties to the Convention by submitting a proposal to this effect to the Depositary Governments, a conference of States Parties to the Convention shall be held at Geneva, Switzerland, to review the operation of this Convention, with a view to assuring that the purposes of the preamble and the provisions of the Convention are being realized. Such review shall take into account any new scientific and technological developments relevant to this Convention.

ARTICLE XII

(1) This Convention shall be of unlimited duration.

(2) Each State Party to this Convention shall in exercising its national sovereignty have the right to withdraw from the Convention if it decides that extraordinary events, related to the subject matter of this Convention, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other States Parties to the Convention and to the United Nations Security Council three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.

ARTICLE XIII

(1) This Convention shall be open to all States for signature. Any State which does not sign the Convention before its entry into force in accordance with paragraph (3) of this Article may accede to it at any time.

(2) This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of _____ which are hereby designated the Depositary Governments.

(3) This Convention shall enter into force after the deposit of the instruments of ratification by _____ Governments, including the Governments designated as Depositaries of the Convention.

(4) For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

(5) The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or of accession and the date of the entry into force of this Convention, and of the receipt of other notices.

(6) This Convention shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

ARTICLE XIV

This Convention, the Chinese, English, French, Russian and Spanish texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Convention shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

In witness whereof the undersigned, duly authorized, have signed this Convention.

Done in _____ copies at _____,

this _____ day of _____ , _____ .

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/365*
26 June 1972
Original: ENGLISH

UNITED STATES OF AMERICA

Working Paper on definitions of controlled substances

In the "Work Programme regarding negotiations on prohibition of chemical weapons" (CCD/360) the United States delegation set forth several general criteria which might be useful in defining substances that could be used for chemical warfare. This paper presents more detailed information on these criteria and discusses some of the advantages and disadvantages of each. It deals specifically with the principal known single- and dual-purpose lethal agents, their mode of action, and how they might be defined.

SINGLE-PURPOSE AGENTS

The super-toxic single-purpose chemical agents commonly discussed, such as VX and GB, are organophosphorus compounds. Another class of compounds which includes super-toxic chemicals with potential utility as chemical warfare agents is the carbamates. These two types of chemicals are commonly called nerve agents because they act by disrupting the nervous system. Compounds related to "mustard gas", although less toxic in general than the organophosphorus and carbamate compounds, comprise a third group of potential single-purpose agents.

NERVE AGENTS

Mechanism of action of nerve agents

The very high toxicity of many organophosphorus and carbamate compounds is due to their ability to interfere with certain enzymes of the nervous system, giving rise to the term "nerve agents". An enzyme is a substance which acts in the body as a catalyst in promoting specific chemical reactions. One of the most important enzymes affected by nerve agents is acetylcholinesterase, which plays an important role in controlling muscle movements.

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*Reissued for technical reasons

At certain points in the nervous system there are gaps in the electrical pathway along which signals travel. A chemical, acetylcholine, is used to transmit the signals across the junction. When an electrical signal reaches one side of the junction, acetylcholine is released. This substance moves across the junction and activates muscle or nerve cells on the other side. After sufficient activation has taken place, the acetylcholinesterase present nearby in the body destroys the built-up acetylcholine.

When nerve agents enter the body, they react with enzyme molecules, thereby blocking the catalytic action of the enzyme. Acetylcholine then begins to build up in all the muscles because the supply of effective enzyme has been depleted. Since the body provides no other means for stopping the activation process, the muscles remain "switched on" and cannot be "switched off". All the muscles - even those pulling in opposite directions - try to contract. The result is that all co-ordinated action is lost and the muscles go into a state of vibration (fibrillation) and then become paralyzed. This applies not only to the muscles of the arms and legs, for instance, but also to those that control respiration. The cause of death is usually asphyxiation following paralysis of the respiratory muscles.

Structural formulas for nerve agents

Since organophosphorus and carbamate nerve agents exert their toxic effect by blocking the action of acetylcholinesterase, there is a strong correlation between the toxicity of a nerve agent and its inhibitory effect on this enzyme. As a result of studies of the functioning of acetylcholinesterase, there is considerable information available on the structural features which would make a compound an effective nerve agent and therefore of potential utility as a lethal chemical warfare agent. This information can be summarized in structural formulas which describe the spectrum of organophosphorus and carbamate compounds which are most likely to be developed as lethal agents (see Annex A).

All super-toxic organophosphorus and carbamate compounds known to us could be described by two general structural formulas. This definition would be relatively simple and yet would cover the two classes of compounds which currently appear to have the greatest potential for use as lethal agents. However, the structural formulas would not be applicable to all super-toxic compounds, especially those which may be discovered in the future. Using this broad criterion, it would not be possible to separate completely compounds which have peaceful uses from those useful only in warfare. Finally, the chemical components of binary weapons would not be covered under this criterion.

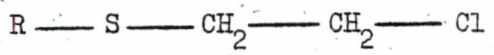
MUSTARD-TYPE COMPOUNDS

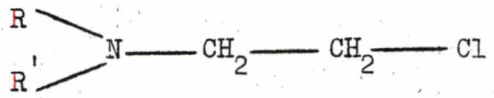
Mechanism of action

β-halogenated sulphides (sulphur mustards) and β-halogenated amines (nitrogen mustards) form a third category of potential single-purpose lethal agents. A typical representative of this group is bis-(2-chloroethyl) sulphide, the "mustard gas" which was used in large quantities in World War I. The mustards act first as a cell irritant and then as a cell poison on all tissue surfaces contacted. The exact mechanism of the toxic action is not well understood. However, mustard-type compounds are known to react with certain nitrogen atoms present in nucleic acids. The physiological action of mustard compounds resembles to some extent the action of ionizing radiation in changing the function and structure of cells. For this reason some nitrogen mustards have been used in cancer treatment.

Structural formulae for mustard-type compounds

The formulas shown below might be used to describe the sulphur and nitrogen mustards:

sulphur mustards: 

nitrogen mustards: 

R and R' = substituted or unsubstituted aliphatic and aromatic groups

As already noted, many of the nitrogen mustards have small-scale medical and peaceful research uses. It does not appear possible to develop a structural formula which would refer only to those mustards which would be useful only as chemical warfare agents.

TOXICITY LIMIT

A key feature of modern agents is their extraordinarily high toxicity to humans and other mammals. Chemicals used widely in the civilian sector are much less toxic in general. As several delegations have suggested, a toxicity limit might be useful as one criterion for defining chemical substances which are potential chemical warfare agents.

A criterion based on a toxicity limit would have the advantage of being directly related to the potential danger from a particular substance. Furthermore, determinations of toxicity are already routinely conducted in laboratories in many countries. This technique is used especially in connexion with development of new drugs and insecticides.

However, laboratory procedures for toxicity determination are not uniform from country to country - or even within a single country. Accurate, reproducible toxicity values can be obtained only if the testing procedure and form of presentation of results are very carefully specified in advance.

A toxicity standard would be applicable to known super-toxic substances or any super-toxic substance discovered in the future. However, it would probably not apply to mustard-type compounds, dual-purpose agents, and components of binary weapons since these substances are comparable in toxicity to many chemicals used exclusively for peaceful industrial purposes.

LIST OF KNOWN AGENTS AND PRECURSORS

A comprehensive list of known single-purpose agents and precursors by name and structural formula is likely to include most of the agents currently in national arsenals and their precursors. Chemicals which are likely to be significant components of binary weapons might also be placed on such a list. The names and formulas of a number of known single-purpose agents and precursors are given in Annex B. Those that are presently stockpiled by the United States are marked with an asterisk.

At present it is not possible to be certain if all the major agents in the arsenals of States or under development would appear in a list of this type. Furthermore, a definition based solely on a list of known agents could be circumvented by a slight modification of the structure of an agent on the list or by development of a new type of super-toxic agent.

PURPOSE CRITERION

A general criterion, such as that in the Biological Weapons Convention, which prohibits agents "of types and in quantities that have no justification for prophylactic, protective or other peaceful purposes", would provide the simplest and most comprehensive definition. In contrast to definitions based on structural formulas or toxicity, a purpose criterion would be applicable to binary-weapon components. Without some specific technical guidelines, however, difficulties could arise in applying such a criterion in some situations.

DUAL-PURPOSE AGENTS

The most widely discussed lethal agents which are also used on a large scale for peaceful purposes are chlorine, phosgene, hydrogen cyanide and cyanogen chloride. Each of these dual-purpose chemicals was used as a lethal chemical agent in World War I.

Mechanism of action

Chlorine and phosgene are lung irritants which exert their toxic effect by damaging the breathing mechanism. Phosgene, for example, injures the capillaries in the lungs and leads to seepage of watery fluid into the air sacs. When a lethal amount of agent is received, the air sacks become so flooded that air is excluded and the victim dies from lack of sufficient oxygen.

Hydrogen cyanide and cyanogen chloride affect bodily functions by inhibiting the enzyme cytochrome oxidase, thus preventing the normal utilization of oxygen by the body tissues. Oxygen starvation occurs in the cells and tissues very quickly. Death occurs as a result of paralysis of the respiratory centre in the brain which controls the nerves involved in breathing and through circulatory failure.

Possible definitions

The agents in the dual-purpose category are relatively few in number and possess diverse chemical structures. Neither a toxicity limit nor a structural formula would appear to be useful in delimiting possible dual-purpose agents.

However, the dual-purpose agents which were used in World War I or have been developed since then are generally well known. For this reason a list of known dual-purpose agents would most probably include all which are now or have been in the arsenals of States.

Among the compounds which might be included in such a list are those given below:

Potential dual-purpose agents

chlorine	Cl_2
phosgene	$Cl-\overset{\overset{O}{\|}}{C}-Cl$
hydrogen cyanide	HCN
chloropicrin	Cl_3C-NO_2
cyanogen chloride	Cl-CN
trichloromethyl chloroformate	$Cl_3C-O-\overset{\overset{O}{\|}}{C}-Cl$
diisopropyl fluorophosphate	$F-\overset{\overset{O}{\|}}{P}-(O\text{-iso-}C_3H_7)_2$

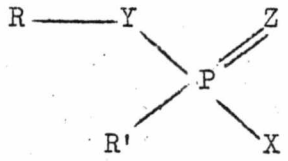
In the area of dual-purpose agents it might be desirable to consider a definition based on a purpose criterion and a list of known dual-purpose agents.

United States Working Paper on
Definitions of Controlled Substances

ANNEX A: Possible Structural Formulae for Nerve Agents

1. Organophosphorus Compounds

The general structural formula for potential organophosphorus agents proposed by the Netherlands in CCD/320 (shown below)



in which

Y = O or S

Z = O or S

X = F, CN, N_3, SR'', $S(CH_2)_nSR''$, $S(CH_2)_nS^+(R'')_2$, $S(CH_2)_nN(R'')_2$, $S(CH_2)_nN^+(R'')_3$

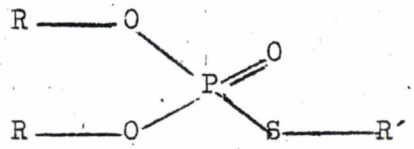
R = (Substituted) alkyl, cycloalkyl or hydrogen

R' = Alkyl, dialkylamino

R'' = Alkyl

would describe the great majority of organophosphorus compounds known to be potent inhibitors of acetylcholinesterase and at the same time would exclude compounds which currently have important peaceful uses.

This definition appears at first to be very broad, but on review it is apparent that at least one type of super-toxic organophosphorus compound, O,O-dialkyl S-alkyl phosphorothiolates (shown below)

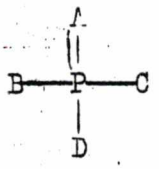


in which R, R' = (substituted) alkyl, cycloalkyl would not be covered. Included in this group are 2-(diethoxyphosphinylthio)-thiocholine salts, 2-(diethoxyphosphinylthio) ethyldiethylsulfonium salts and analogous compounds.

This type of compound would be accommodated if the definition of R' (in the formula in CCD/320) were changed so that R' = alkyl, dialkylamino, alkoxy.

Another feature of the formula in CCD/320 is that it would describe only those types of organophosphorus compounds whose toxicity has already been determined.

A more general expression for potential organophosphorus nerve agents can be provided by the general formula:



A = O, S, Se

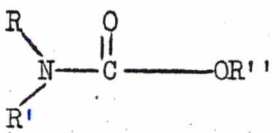
B, C, D may be any atom or group of atoms.

This definition would include all compounds covered by the Netherlands general formula, O,O-dialkyl S-alkyl phosphorothiolates and all super-toxic organophosphorus compounds which may be developed in the future. However, many of the compounds included under the second formula above would not be super-toxic; some would have important civilian uses.

2. Carbamates

The carbamates are another class of chemicals from which extraordinarily toxic compounds with potential utility as chemical warfare agents might be developed. Although carbamates do not contain a phosphorus atom, they function as nerve agents in much the same fashion as organophosphorus compounds. The carbamate group (-O-C(=O)-N<), which is the characteristic structural feature of this class of compounds, contains the very common elements carbon, nitrogen, oxygen, and (often) hydrogen.

A separate formula, in addition to the one for organophosphorus compounds, would be needed to cover carbamates. The general formula below would describe as complete as possible a spectrum of super-toxic carbamate compounds:



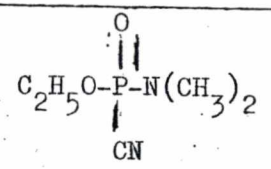
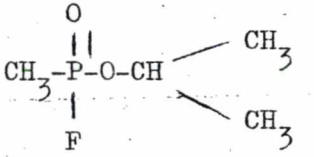
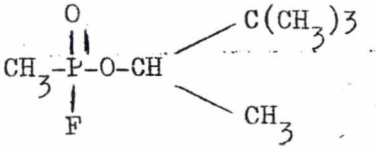
R = hydrogen, alkyl R'=alkyl

R'' = any alkyl or aryl group

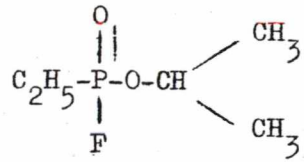
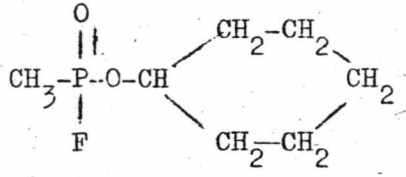
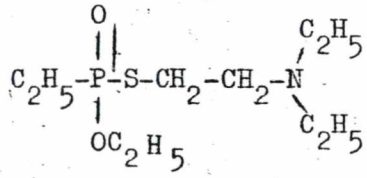
Here again, many compounds not sufficiently toxic to be potential chemical warfare agents would be included, among them some compounds used in the civilian sector. It does not appear possible to design a general structural formula for carbamates which would include only the super-toxic carbamates.

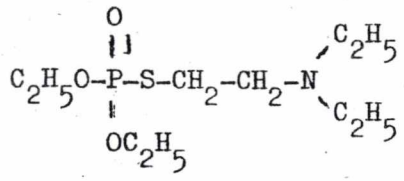
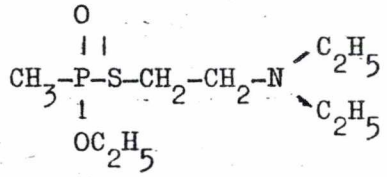
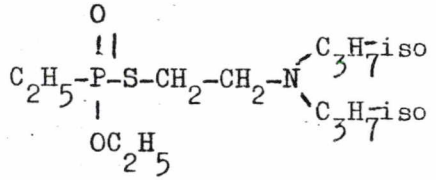
UNITED STATES WORKING PAPER ON DEFINITIONS OF CONTROLLED SUBSTANCES

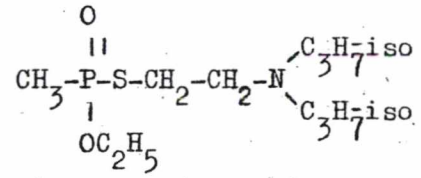
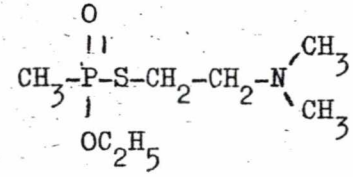
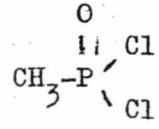
ANNEX B. SINGLE-PURPOSE LETHAL AGENTS AND PRECURSORS

Common Name	Chemical Name	Structural Formula
A. Nerve agents:		
1. Tabun, GA	Ethyl N,N-dimethylphosphoramidocyanidate	
2. Sarin, GB*/	Isopropyl methylphosphonofluoridate	
3. Soman, GD	1,2,2-Trimethylpropyl methylphosphono-fluoridate	

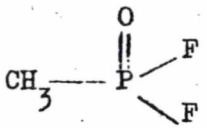
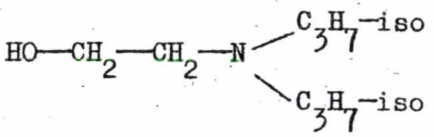
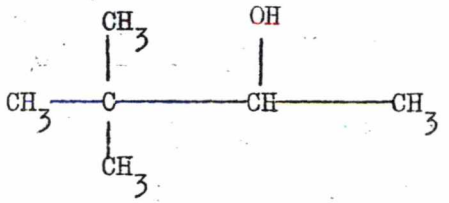
*/ US standard agent

	Common Name	Chemical Name	Structural Formula
4.	Ethyl Sarin, GE	Isopropyl ethylphosphonofluoridate	
5.	GF	Cyclohexyl methylphosphonofluoridate	
6.	VE	O-Ethyl S-2 diethylaminoethyl ethylphosphonothiolate	

	Common Name	Chemical Name	Structural Formula
7.	Amiton, VG	O,O-Diethyl S-2-diethylaminoethyl phosphorothiolate	
8.	Edemo, VM	O-Ethyl S-2-diethylaminoethyl methylphosphonothiolate	
9.	VS	O-Ethyl S-2-diisopropylaminoethyl ethylphosphonothiolate	

	Common Name	Chemical Name	Structural Formula
10.	VX *	O-Ethyl S-2-diisopropylaminoethyl methylphosphonothiolate	
11.	33 SN	O-Ethyl S-2-dimethylaminoethyl methylphosphonothiolate	
B.	Nerve Agent Precursors		
1.	Dichlor	Methylphosphonic dichloride	

* US standard agent

Common Name	Chemical Name	Structural Formula
2. Difluor	Methylphosphonic difluoride	
3. None	N,N-diisopropylethanolamine, 2-Diisopropylaminoethanol	
4. Pinacolyl alcohol	3,3-Dimethyl-2-propanol	

Common Name	Chemical Name	Structural Formula
B. Mustard-type Agents		
1. Mustard gas*	Bis(2-chloroethyl)sulfide	$S(CH_2\ CH_2\ Cl)_2$
2. HN-1	Ethyl-bis(2-chloroethyl)amine	$C_2H_5\text{-}N(CH_2CH_2Cl)_2$
3. HN-2	Methyl-bis(2-chloroethyl)amine	$CH_3\text{-}N(CH_2CH_2Cl)_2$
4. HN-3	Tris(2-chloroethyl)amine	$N(CH_2CH_2Cl)_3$
5. Sesquimustard	1,2-bis(2-chloroethylthio)ethane	$(CH_2\ SCH_2CH_2Cl)_2$
6. T	Bis(2-chloroethylthioethyl)ether	$O(CH_2\ CH_2\ SCH_2CH_2Cl)_2$
7. Lewisiite	2-chlorovinyl dichloroarsine	$CHClCH — AsCl_2$

* United States standard agent.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/366
20 June 1972
Original: ENGLISH

UNITED STATES OF AMERICA

Working Paper on storage of chemical agents and weapons

Introduction

The US work programme on CW (CCD/360) pointed out that "while there is evidence which suggests the existence of substantial quantities of chemical arms in present day arsenals of several nations, storage of chemical weapons by its nature is not a readily identifiable activity." This paper examines the storage of toxic chemical agents and weapons and the extent to which storage may be observable. The paper discusses overall configuration of storage areas, as well as features of storage, such as security, maintenance, and safety. The US Delegation believes that an examination of these questions is relevant in considering verification questions connected with possible prohibitions regarding possession and stockpiling of chemical weapons (CW) and CW agents.

The information set forth below is drawn largely from US experience. While similar features could be expected to apply to CW storage elsewhere, it is not known whether all states possessing CW stocks employ analogous methods to cope with such problems as security and personal safety. By making available information concerning US storage methods and some possible alternatives, this paper is intended to contribute to the establishment of a factual basis for examining verification in relation to stockpiling.

1. General Considerations

Storage of chemical agents and weapons involves providing for: the physical security of stocks, the maintenance of such stocks to prevent and minimize the problems of deterioration, and the protection and treatment of personnel who may accidentally come in contact with the agent. Physical security may be provided by maintaining strict perimeter controls to prevent unauthorized access. Maintenance can be facilitated by arranging munitions or other chemical containers so they can be easily and completely inspected, by using leak detection and alarm systems, and by having

decontamination supplies and equipment available. Personnel can be protected by regulating access, by providing protective clothing and decontamination facilities, and by ensuring quick access to specialized medical services in the event of exposure to a chemical agent.

2. Perimeter Security

Chemical agents and weapons can be stored both within restricted areas of conventional munitions depots and at separate locations. Like military storage depots in general, the perimeters of areas containing chemical agents or weapons are characteristically protected by security fencing. They may also be guarded by roving patrols and monitored by mechanical sensing devices. Access is limited to controlled checkpoints and normally requires a special pass or documents. However, none of these physical security precautions are unique to CW storage.

Perimeter safety measures to protect personnel against possible leakage, on the other hand, may be indicative of CW storage. Regular sampling of the air around the perimeter is one measure common to CW storage areas and not normally found elsewhere. Meteorological and air sampling/recording stations housed in small sheds along the perimeter have been used for this purpose. Portable sampling equipment has also been shown to be effective. Another method of checking for leakage is to place cages containing test animals at selected points on the periphery as well as inside the storage area.

The most readily visible indication of storage, assuming no effort to withhold knowledge from persons in the immediate area, might be warning signs. Such signs could be posted along perimeters of CW depot areas alerting personnel to the presence of hazardous or toxic materials. While they might not be visible to persons entering a general military storage area in which chemicals were also stored, special signs could warn those approaching the chemical section of the hazard involved and of what protective equipment may be necessary to gain admittance. Perimeter guards patrolling areas where chemicals are stored might be expected to carry - or have readily available - protective masks. Persons entering the immediate area of toxic materials storage might be expected to wear impermeable clothing and to carry protective masks.

3. Considerations Relating to Types of Materials Being Stored

Storage problems differ according to the type of agent that is being stored. Some of the agents used in World War I, such as chlorine, phosgene and hydrogen cyanide, require less stringent storage precautions than do mustard or nerve agents, although such basic requirements as monitoring of stocks for leakage and precautions for safety

are similar. Air-sampling equipment might be used to warn of leaks; emergency protection for personnel could be assured by having available protective masks.

Effective protection, on the other hand, against mustard agents and some nerve agents (such as the V agents) requires impermeable protective clothing as well as masks. It might be expected that such equipment would be worn by persons servicing stocks of these agents. Medical facilities for treating organophosphorus nerve agent casualties would have available a supply of antidote, such as atropine and 2-PAM chloride, as well as equipment for rapid blood analysis. Such supplies and equipment would not be found at medical facilities connected with storage areas containing only conventional weapons. Also available in the immediate storage area would be decontamination equipment, such as vehicles with pressurized spray tanks and decontamination chemicals such as super tropical bleach for use in neutralizing agents from leaking containers or accidental spills.

In addition to perimeter warnings, signs may be used within a chemical storage area to alert personnel to the exact nature of the hazard they would face in the event of an accident. Under US practice this has been done by posting large signs with symbols indicating the type of material being stored. In the interests of ensuring maximum safety of personnel, hazard indicators might warn if "special hazard" materials (such as nerve agents) are present, and if so, whether they are volatile (GB), requiring masks, or less volatile (VX), requiring protective suits as well as masks.

4. Storage of Bulk Agent and Filled Munitions

Chemical agents are stored in bulk containers or in filled munitions. Filled chemical munitions would normally be kept in military storage depots. Bulk agent might be stored either at munitions storage depots, or at locations associated with production or with facilities for the filling of munitions.

For bulk storage the US has used "one-ton" cylindrical steel drums. Bulk containers offer the advantages of limiting the number of units that need to be inspected, and, because they are designed specifically for storage purposes, of minimizing long-term dangers of leakage. They are also suitable for compact storage under a variety of conditions - in the open, in buildings, or underground.

Storage of agent in filled munitions entails more complex maintenance problems over the long run because of the increased number of items to be monitored and the somewhat greater rate of deterioration. If munitions are stored with their explosive

components, they would need to be maintained also in accordance with procedures for storage of high explosives. (Under US practices, high explosives are kept in widely-spaced, revetted and reinforced concrete bunkers.)

5. Storage Area Size and Configuration

A variety of configurations are possible within a chemical storage area. Bulk storage of agents can be carried out in the open, in various types of shelters, or underground. Open-air storage of containers in rows is perhaps most convenient for systematic maintenance purposes. However, other possibilities range from stacking containers in compact tiers under sheds at military depots to warehousing bulk agent at or near production facilities. In either example the structures used might physically resemble standard storage sheds or buildings - at least externally - and could be large or small, closed or open, or high or low.

Large volume storage at one location offers more efficient use of equipment and facilities. The convenience offered by concentrating storage at one location might, however, be offset by other factors such as a desire to make storage less visible and less vulnerable by dispersing stocks. Filled munitions might be expected to occupy larger storage areas than would similar quantities of agent in bulk containers.

Filled munitions have tended to be placed in widely-separated magazines which were built to store conventional weapons as well. Other structures offering suitable protection against weather damage and meeting appropriate standards for chemical and explosive hazards could also be used. Some munitions may be stored outside, under canvas or similar covers. If warning signs are used on bunkers or other storage structures, it would be expected that they would indicate not only a chemical hazard but whether explosive components are also present. Such signs could offer the only ready external means of distinguishing bunkers containing conventional munitions from bunkers storing chemical munitions.

6. Alternative Patterns of Storage

While the preceding descriptions are representative of some actual storage practices, they do not exhaust the many possible alternative ways to handle the problems connected with storage of chemical agents and munitions. Other methods might cost more, or sacrifice some degree of personnel safety. They might, however, be considered worth the possible extra costs and safety risks by a country placing particular emphasis on concealing its stockpiles.

Evidence of chemical weapons storage activity offered by the storage methods discussed is of low visibility, even to observers near a storage facility. These indications might be almost completely eliminated through the use of alternative methods of sampling for leakage and by doing away with or hiding safety features. For example, removal of warning markers from perimeter fencing, entry points, and within storage areas would eliminate the most obvious sign of chemical storage. Use of small, hidden air sampling stations in place of permanent, fixed meteorological facilities would remove another indicator. Material and related equipment, such as bulk storage containers and decontamination equipment, normally stored in the open, could be kept out of sight in buildings or in below-ground storage.

Safety measures, which might be necessary or highly desirable in connection with storage of substances such as nerve agents, would not, however, be equally necessary for storage of binary chemical weapon components. Any accidental leakage from binary munitions would not present a hazard substantially greater than that posed by many chemicals in industrial use.

In general, there would appear to be only very limited opportunities to distinguish chemical agents and weapons storage from other munitions or military storage. These opportunities would seem particularly limited at any significant distance from the immediate storage area. Furthermore, such indications of chemical storage activity as may be available to persons near or at a storage facility are largely of a type which could be relatively easily altered. Thus, while some indications of CW storage may be visible under certain conditions, it is questionable whether these will be significantly helpful in formulating a reliable and negotiable system of verification of possible CW stockpiling.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/367
20 June 1972
Original: ENGLISH

UNITED STATES OF AMERICA

Working Paper on the destruction of chemical weapons

This paper describes environmental protection and safety procedures used in current United States operations for demilitarizing limited quantities of chemical weapons. Such a description will, it is hoped, be helpful in gaining an understanding of practical considerations involved in the objective of destruction of chemical weapons stockpiles.

The example provided below involves the demilitarization and disposal of nerve agent cluster bombs. The current United States plan for destruction of these munitions offers an opportunity to examine practical factors relating to the disposition of weapons containing one of the most toxic types of chemical agents.

Growing concern for environmental safeguards has been reflected in the United States by an increasing body of laws and regulations controlling governmental as well as private actions affecting the environment. The major United States legislation affecting destruction of toxic materials is the National Environmental Policy Act of 1969. This Act requires that every proposed Federal Government action significantly affecting the quality of the environment include a detailed public statement on its environmental impact. The Act creates in the Office of the President a Council on Environmental Quality with responsibility for reviewing and appraising such proposed actions. While directed primarily at non-military activities, the Act also applies to destruction of chemical weapons.

In 1969 the Department of the Army initiated plans to dispose of approximately 2,500 tons of nerve agent in munitions of a type considered obsolete, stored at Rocky Mountain Arsenal in Colorado. Under the National Environmental Protection Act, before proceeding with demilitarization of these munitions, the Army was required to prepare a statement detailing its destruction plans. Comments on the Army's proposals were requested in February 1971 from interested Federal, State and local agencies, including

the United States Department of Health, Education and Welfare, the State of Colorado, and the Denver Regional Council of Governments. A revised statement was made available to the Council on Environmental Quality and the public in December 1971. It is anticipated that destruction will begin in 1973 and require approximately eighteen months to complete.

The environmental impact statement in this case, with attached plan for demilitarization and disposal of waste products, includes over 850 pages of discussion and supporting data. As required by the Act, it contains a detailed discussion concerning possible adverse environmental effects of destruction, and relates these effects to various alternative methods of destruction. The plan for destruction offers full relevant background information on all aspects of demilitarization. This includes technical descriptions, with appropriate photographs, charts, and diagrams concerning the munitions to be destroyed, the site at which destruction is to be carried out, and the proposed destruction and disposal process. The description of proposed demilitarization operations covers methods of transporting the munitions from the storage area to the holding and demilitarization building, removal of inert parts and their decontamination, draining of agent from munitions through a chemical pipeline to agent deactivation facilities, detoxification of agent, and processing of waste residue in a centrifuge/spray dryer system prior to final disposal. Safety controls, including provisions to prevent any release of agent during normal destruction operations or as a result of an accident, measures to control by-products released during detoxification processes, and alarms and equipment to protect personnel, are described. The results of pilot tests (using simulated agent) are also provided.

The following excerpts from the summary portion of the statement are illustrative of the types of information necessary in order that responsible agencies may consider whether a given plan for destruction of toxic substances provides adequate environmental safeguards. These excerpts also offer an indication of the rigorous procedures that must be followed in carrying out destruction of chemical weapons.

"Background

This environmental impact statement presents the programme for the demilitarization of the M34 cluster stockpile at Rocky Mountain Arsenal. This programme encompasses about 21,000 M34 gas bomb clusters containing approximately 454,000 gallons of agent GB (volatile liquid 'nerve gas') which will be disposed of by chemical neutralization.

The M34 demilitarization effort was initiated in August 1969 by a special group designated Task Force Eagle ... Instructions and guidelines for the Task Force placed particular emphasis on safety and security rather than cost or time.

"The Cluster, Gas Bomb, Nonpersistent, GB 1000-pound M34 is an air deliverable munition containing 76 individual M125 bombs filled with 2.6 pounds of GB nerve agent (methylisopropoxy-fluoro-phosphine oxide) and a 0.55 pound tetryl central burster. The M34 clusters were manufactured in the mid 1950's, are stored at Rocky Mountain Arsenal, are now obsolete and therefore must be disposed of.

"Small quantities of M34 clusters had been demilitarized in the past under field conditions at Rocky Mountain Arsenal. Review of the procedures and safety for such outdoor demilitarization indicated their inadequacy to meet the current emphasis and guidance on maximum safety, particularly where many thousands of clusters are involved. Accordingly, Task Force Eagle was established to plan and conduct a programme for indoor demilitarization in an explosion-proof, gas-tight facility, using remote control and automated equipment to the maximum extent. The objective was to reduce or eliminate the use of personnel in direct proximity to the declustering operation and to provide complete safety to the surrounding environment and population during normal operations or in the event of accidental munition functioning.

"It is currently planned to demilitarize 60 M34 clusters per day in two 8-hour shifts. This will permit completing the entire demilitarization about 18 months after start of live operations....

"Environmental Impact of the Proposed Action

The M34 cluster demilitarization programme has been developed with the specific purpose of insuring that there will be no deleterious impact to the environment as a result of this effort. It is possible that extremely small amounts of undetoxified GB nerve agent will be emitted to the atmosphere during the demilitarization process. However, the emission level will not exceed the concentration limit prescribed by the Surgeon General of the Public Health Service for the general population and unmasked workers .... Other air pollutants (hydrogen fluoride, HF; nitrogen dioxide, NO_2) may be emitted to the atmosphere intermittently during the demilitarization process. NO_2 emission will be controlled not to exceed the level set in latest Federal Standards .... The waste products from the chemical detoxification will be processed through a centrifuge/spray dryer system to remove the solids and evaporate the water. The solids will be packaged in drums and stored temporarily in a warehouse at Rocky

Mountain Arsenal pending ultimate disposition. All pipe and sewer lines transporting agent and/or waste products will be verified to be leaktight prior to start of operations.

"As noted above, ... the munitions declustering will be carried out in a facility which will physically contain any explosion that may accidentally occur. The facility has explosion-proof doors and automatic blast valves that will insure that the facility is gastight in the remote event of an accidental munition functioning and will prohibit any deleterious leakage of agent to the atmosphere. Any liquid agent then will be decontaminated by a special spray system and any residual agent vapor subsequently will be bled to the scrubbers (cleansing devices). During normal operations the area will be continously ventilated (under negative pressure relative to the outside) and any agent that may evaporate will pass through ventilation ducts to scrubbers where it will be captured and chemically neutralized. Operating personnel are experienced in the handling of nerve agents. They will be given preplacement physicals and subjected to periodic followup clinical examination, to ensure the adequacy of the detection and protective measures provided. In addition, they also will be given special training in the conduct of this programme ...."

These examples of planning for an actual CW destruction operation involving a limited quantity of weapons indicate that destruction of chemical weapons is a complex and time-consuming task which requires the most detailed preparations. Comprehensive destruction of all lethal CW stocks in arsenals everywhere would involve major environmental and safety considerations which would affect both the methods that might be appropriate for large-scale destruction, as well as the time required.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/368
20 June 1972
Original: ENGLISH

UNITED STATES OF AMERICA

Working Paper: Statistics relating to production and trade of certain chemical substances in the US

The Canadian and Japanese delegations (CCD/300, 301, 344) have suggested that it would be useful to review the possibility of compiling production and trade data on certain chemical substances used in preparation of lethal chemical agents. In response to this suggestion, the US wishes to share with other members of the Committee the following information regarding the production and trade of chemical substances in the US.

US Production Statistics

The United States presently releases considerable data on chemical production. Annual production figures for eight of the sixteen chemicals listed in the Canadian and Japanese papers are available in US Census Bureau or US Tariff Commission publications.

Statistics on the eight other chemicals on the Canadian and Japanese lists are not published by the US Government either because production is minute or nil or because US law restricts the publication of figures which might disclose the output of individual producing firms and thus restrain competition by placing them at a possible competitive disadvantage. Methylphosphonic dichloride and difluoride, and pinacolyl alcohol fall into the first category of extremely limited or nil production. Production data for phosphorus pentachloride, dimethylphosphite, sulphur dichloride, thiodiglycol, cyanogen chloride, and diethylamino ethyl alcohol are reported to the US Government but not released publicly because of legal limitations on disclosure.

Production data for the other eight chemicals on the Canadian and Japanese lists are capsuled in Table 1. Included also are data on chlorine because of its extensive use in World War I and data on organophosphorus insecticides because of the similarity of their chemical structure and mode of action to nerve agents.

Production figures cover all chemicals produced in the US during the year, whether sold or devoted to "captive" uses. The term "captive" refers to use of a chemical by a single manufacturing firm for production of another chemical.

Production Trends

Production trends of the chemicals listed vary considerably. Most of the listed chemicals require further processing to become usable end products. Demand is therefore determined by the user-industries (which may build up or draw down inventories in any given year), and ultimately by the final consumers. Production is accordingly affected by:

1. The general level of business activity;

2. Relative price and cost levels, which among other factors are influenced by changes in technology, by shortages, and by availability of alternative chemicals or means of processing;

3. Changes in consumer preferences. For example, production of elemental phosphorus declined more than 13 per cent between 1969 and 1971 because of concern that the use of phosphates in detergents caused environmental damage to waterways receiving sewage from homes.

Regional Production

Table 2 indicates the geographic distribution of plants where these chemicals are manufactured in the US*. Almost half of the plants are located in the South Central region, although all the chemicals listed except hydrogen cyanide are produced in at least three of the five broad regions designated in the table.

Plant location is based on the availability of raw materials and inexpensive transportation as well as proximity to direct users and final markets. Plant location over time does vary as older plants become obsolete. Frequently older plants are replaced by ones located nearer areas of expanding population.

Foreign Trade

The US requires customs declarations of both quantities and values for all commercial exports and imports, but does not at present publish trade data on all individual commodities. The only chemicals with potential utility for CW purposes

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* Not listed in the table are ethylene and organophosphorus insecticides. The former is produced by 23 firms and the latter by 15 firms. Since some firms have several plants, the number of producing plants involved is considerably larger.

for which data are published separately are those listed in Table 3. Many chemicals are traded in such small quantities that they are classified into broader categories for reporting purposes. The trade in phosphorus trichloride, however, is reported even though that trade is virtually infinitesimal.

Generally speaking US imports and exports of chemicals with a potential for CW use are very small. The exception is organophosphorus insecticides for which exports represented 30 per cent of US production in 1970. The only other chemical for which separately published trade statistics can be compared with production is chlorine. Exports as a percent of production varied from between one half of one per cent in 1967 to one sixth of one per cent in 1970. Imports represent one per cent or less of US production.

The significant feature of these trade statistics, aside from the small quantities relative to production, is their erratic variation from year to year.

TABLE 1

Production of Selected Chemicals in the US (in Metric Tons)

	1966	1967	1968	1969	1970	1971*
Elemental Phosphorus	513,067	532,532	556,425	570,590	548,918	494,486
Phosphorus Trichloride	39,987	46,391	49,470	51,993	41,760	50,091
Phosphorus Oxychloride	27,724	28,860	30,445	28,490	29,833	28,069
Phosphorus Pentasulfide	48,788	44,170	46,844	50,585	60,763	63,466
Ethylene Oxide	1,055,482	1,046,832	1,190,805	1,545,748	1,753,058	1,637,644
Phosgene	149,575	168,759	202,571	229,078	280,085	---
Hydrogen Cyanide	146,557	114,421	138,090	167,690	145,625	---
Ethylene	5,098,956	5,377,208	5,965,116	7,455,500	8,205,209	8,302,705
Chlorine	6,535,806	6,967,176	7,660,813	8,505,822	8,854,441	8,473,983
Organophosphorus Insecticides	54,397	28,996**	34,414**	41,939**	60,100	---

*Based on preliminary monthly reports, subject to revision. Those chemicals for which no data are available for 1971 are not reported monthly.

**Cyclic only. In 1967-1969, figures for acyclics were not published because figures for individual firms would have been disclosed. In 1966, acyclic production was 21,129 tons, and in 1970 it was 25,066 tons.

TABLE 2

Number and Location of US Plants Producing Selected Chemicals

Location/ Chemical	Elemental Phosphorus	Phosphorus Trichloride	Phosphorus Oxychloride	Phosphorus Pentasulfide	Ethylene Oxide	Phosgene	Hydrogen Cyanide	Cyanogen Chloride	Chlorine
Northeast (North Atlantic)	2	3	2	1	1	2	-	2	10
Southeast (South Atlantic)	4	2	1	-	3	4	-	1	12
North Central	-	1	1	1	-	4	1	1	11
South Central	5	1	-	4	13	6	8	2	28
West (Pacific)	3	-	-	-	1	-	-	1	7
Total Plants	14	7	4	6	18*/	16	9	7	68

*/ There is also one plant in Puerto Rico

TABLE 3

US Trade in Selected Chemicals (in Metric Tons)

	1966	1967	1968	1969	1970	1971
Exports						
Chlorine	19,334	32,896	32,935	23,924	14,801	10,412
Organophosphorus Insecticides*/	15,490	21,765	25,468	25,926	17,753	22,811
Imports						
Chlorine	65,699	53,108	38,056	20,530	22,618	31,875
Ethylene Oxide	117	598	264	21	25	28
Phosphorus	341	284	380	409	279	285
Phosphorus Trichloride	**/	.014	.004	.007	***/	.004

*/ In Addition, during 1966-1971, US exports of formulations of pesticides for agricultural use containing small proportions of organophosphorus pesticide ingredients amounted to approximately three eighths of the export volume of organophosphorus insecticides categorized in this table.

**/ Not reported separately.

***/ Less than half a kilogram.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/369
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UNITED STATES OF AMERICA

Working Paper on US domestic legislation regarding chemical substances

This paper describes relevant provisions of domestic US legislation with respect to the use, production and handling of chemical substances. The delegation of Sweden has already pointed out that a review of the situation with respect to national and international regulations in this area would be useful and desirable (CCD/PV.556, p.18). The following description may be helpful in the Committee's consideration of the extent to which existing legal restraints might be relevant in reinforcing the observance of chemical weapons prohibitions.

The provisions of US domestic legislation described below are illustrative, not comprehensive. They have been condensed from voluminous and detailed material and are described only in brief, essential terms. Some material of special interest, such as that relating to definitions, has been included in footnotes. Special attention has been given to the possible relevance of these provisions with respect to the control of the use, production and handling of toxic chemical substances which can be used for weapons purposes.

The United States is a federal state. Consequently there exist parallel systems of legislation, respectively within the domain of the Federal Government and of the various states. States do not have the authority to legislate in some areas where the US Congress has acted. State laws vary widely. In some jurisdictions, for instance where there has been extensive industrial development, there is likely to be far more legal regulation than will be found in other jurisdictions, where this has not been the case.

It will be noted that some provisions of Federal legislation deal specifically with chemical warfare agents and govern the importation, exportation, handling, use and disposal of these substances. Most Federal legislation affecting chemical warfare agents, however, applies to them because they are chemical substances and not specifically because they are chemical warfare agents. Legislation in this category relates to such matters as production, sale, transportation and disposal of chemical substances. Parallel provisions may be found in State legislation.

An effort has been made to arrange relevant legislation in such a way as to facilitate a review of the legislative provisions described below.

I. Federal Laws Directly Applicable to Chemical Warfare Agents

Most of the Federal legislation affecting chemical warfare agents applies generally to chemical substances. Some statutes, however, do limit the importation, exportation, handling, use and disposal specifically of chemical warfare agents. Accordingly, these statutes deserve special treatment.

A. Importation and Exportation of Chemical Warfare Agents

The Mutual Security Act of 1954[1/] authorizes the President "to control, in furtherance of world peace and security and foreign policy of the United States, the export and import of arms, ammunition, and implements of war, including technical data relating thereto". The President may designate particular items falling within the above categories. All persons engaged "in the business of manufacturing, exporting or importing" such items must register with the Government. Penalty for willful violation is $25,000, two years in prison, or both. The powers of the President under this section have been delegated to the Secretary of the Treasury for import and the Secretary of State for export.[2/]

Among the "implements of war" designated by regulation are "chemical agents",[3/] "nerve gases and incapacitating agents".

B. Handling, Use and Disposal of Chemical Warfare Agents

Several sections of Title 50 of the United States Code regulate the transportation, open-air testing, deployment, storage, disposal of, and procurement of delivery systems for "lethal chemical warfare agents" by the US Government. Section 1511 requires that the Secretary of Defense submit semi-annual reports to Congress setting forth the amounts spent during the preceding six-month period for research, development, testing and evaluation and procurement of all lethal and non-lethal chemical agents. Section 1512 prohibits the transportation, open-air testing and disposal of chemical warfare agents unless the proposed action can be accomplished without endangering the

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1/ 22 USC 1934 (1970).

2/ Exec. Order No. 11432, 3 CFR 751 (Comp. 1966-1970).

3/ The term "chemical agents" is defined as substances "useful in war which, by (their) ordinary and direct chemical action, produce a powerful physiological effect". 22 CFR 121.08.

public health and safety. Section 1513 prohibits the deployment, storage or disposal outside of the United States of any lethal chemical warfare agents or their associated delivery systems without the giving of prior notice of the proposed action to the country exercising jurisdiction over the area in question. Section 1516 prohibits the procurement of delivery systems for lethal chemical warfare agents unless the President certifies to Congress that the delivery systems are vital to the safety and security of the United States. Finally, sections 1517 and 1518 prohibit the disposal of chemical warfare agents unless the agents have been det xified or made harmless to man and his environment, unless immediate disposal is clearly necessary to safeguard human life or in a emergency.

II. Federal Legislation Applicable to Chemical Substances Generally

Although there are only a few laws directly affecting chemical warfare agents per se, there are many Federal laws affecting them as chemical substances. These laws generally regulate the production and sale, the interstate transportation and the disposal of various chemical substances. The most pertinent legislation is set out below.

A. Federal Legislation Regulating the Production and Sale of Various Chemical Substances

1. Federal Hazardous Substances Labeling Act.

The Federal Hazardous Substances Labeling Act[4/] prohibits the introduction into interstate commerce of any misbranded hazardous substance or banned hazardous substance. The Act defines "misbranded hazardous substance" as a hazardous substance which, inter alia, fails to bear a label which states conspicuously the word "poison" for any

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4/ 15 USC 1261 et seq. (1970).

hazardous substance which is highly toxic.[5] The Act also bans hazardous substances which might otherwise be used in the household but which cannot be made safe by cautionary labelling.

2. Federal Insecticide, Fungicide and Rodenticide Act

The Federal Insecticide, Fungicide and Rodenticide Act[6] prohibits the distribution in interstate commerce and the exportation of pesticides not properly registered and pesticides containing improperly labelled substances which are highly toxic to man.[7] The Federal Environmental Protection Agency (EPA) administers the Act's provisions for registration, packaging and labelling of such pesticides. The EPA has the authority to inspect the records of the manufacturer to determine whether the provisions of the Act are being met. Furthermore, agents of the Department of Agriculture are authorized to physically inspect shipments of pesticides to ensure that the provisions of this Act are enforced. Finally, in cases where the safety of the pesticides is challenged by the EPA, the manufacturer of the challenged pesticide must establish the safety of the product.

5/ An example of an extremely specific statutory definition is found in the following definition of the term "highly toxic": "any substance which falls within any of the following categories: (a) Produces death within fourteen days in half or more than half of a group of ten or more laboratory white rats each weighing between two hundred and three hundred grams, at a single dose of fifty milligrams or less per kilogram of body weight, when orally administered; or (b) produces death within fourteen days in half or more than half of a group of ten or more laboratory white rats each weighing between two hundred and three hundred grams, when inhaled continuously for a period of one hour or less at an atmospheric concentration of two hundred parts per million by volume or less of gas or vapor or two milligrams per liter by volume or less of mist or dust provided such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner; or (c) produces death within fourteen days in half or more than half of a group of ten or more rabbits tested in a dosage of two hundred milligrams or less per kilogram of body weight, when administered by continuous contact with the bare skin for twenty-four hours or less". 15 USC 1261 (h)(1) (1970).

6/ 7 USC 135 (1970).

7/ This Act prohibits the sale of pesticides containing the arsenate, arsenite, fluoride and fluosilicate compounds listed below unless these compounds are distinctively colored to identify their presence in the pesticide. A pesticide containing such an uncolored compound would be per se mislabelled and therefore could not be introduced into interstate commerce. The compounds specifically covered by this Act are standard lead arsenate, basic lead arsenate, calcium arsenate, magnesium arsenate, zinc arsenate, zinc arsenite, sodium fluoride, sodium fluosilicate and barium fluosilicate.

Under proposals presently before the Congress, the power of the EPA to regulate the marketing of pesticides would be extended to include the application or use of such substances as well.

3. Federal Food, Drug and Cosmetic Act

A great deal of domestic legislation affects the production and sale of various chemical substances.[8/] The Federal Food, Drug and Cosmetic Act,[9/] for example, extensively regulates the production and sale of drugs. A "drug" is defined as an article (other than food) intended to affect the structure of any function of the body of man or other animals. The Act also prohibits the adulteration of any drug in interstate commerce.[10/] In order to enforce the prohibitions of the Act, Federal agents have the authority under section 374(a) to enter and to inspect any factory, warehouse or establishment in which drugs are manufactured, processed, parked or held for introduction into interstate commerce or any vehicle being used to transport such drugs in interstate commerce. These inspections extend to all records, files, papers, processes, contracts and facilities bearing on whether adulterated drugs are being manufactured, processed, parked or transported in such places.

B. Federal Legislation Regulating the Transportation of Various Chemical Substances

There is fairly extensive Federal regulation of the transportation of chemical substances within the United States. Section 832 of Title 18 of the United States Code prohibits the transportation, carriage or conveyance within the US of etiologic (disease causing) agents unless authorized by the Secretary of Transportation. The

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8/ Under the Occupational Safety and Health Act (29 USC 650 et seq. (1970)), the Secretary of Health, Education and Welfare is authorized to establish and administer standards protecting the safety and health of workers employed in business engaged in interstate commerce. The Secretary of HEW is required to take action in cases where "employees are exposed to grave danger from exposure to substances or agents determined to be toxic or physically harmful ...".

9/ 21 USC 301 et seq. (1970).

10/ An example of a general statutory definition is by 21 USC 351 (1970) which defines adulterated drugs as drugs which (1) contain filthy, putrid or decomposed substances, (2) were manufactured under conditions not conforming to current good manufacturing processes, and (3) do not conform to standards of strength, quality, or purity as set forth in either the United States Pharmacopeia or the Homeopathic Pharmacopeia of the United States, if the drug purports to be one listed in either of these publications.

Secretary is authorized to promulgate rules and regulations covering the transportation of these agents in order to ensure their safe transportation. These regulations apply to all land carriers engaged in interstate or foreign commerce and contain the designations of routes over which etiologic agents may be transported.

Section 834 of Title 18 of the United States Code authorizes the Secretary of Transportation to regulate the transportation within the US of "dangerous articles" including etiologic agents, corrosive liquids, compressed gases and poisonous substances. The Secretary's regulations are binding on all land carriers engaged in interstate and foreign commerce and on all shippers making shipments of "dangerous articles" in interstate and foreign commerce.[11/] Under this section the Secretary is authorized to require carriers to adhere to the best-known practicable means for parking, marking, loading, handling while in transit, and inspecting such articles in order to insure their safe transit.

Section 170 of Title 46 of the United States Code prohibits the marine transportation of explosives and other dangerous articles or substances, including "inflammable liquids and solids, oxidizing materials, corrosive liquids, compressed gases, poisonous articles or substances, hazardous articles ..." except in accordance with the regulations of the Coast Guard. These regulations cover the marking, packaging, handling, storage, stowage and labelling of dangerous articles and substances.

Under Section 1716 of Title 18 of the United States Code the transmission through the mails of poisonous drugs and materials which may kill or injure another is prohibited.

Finally, the Anti-Smuggling Act[12/] regulates the transportation and distribution of merchandise into the customs jurisdiction of the United States. Another section of the US Code contains a list of the controlled merchandise.[13/] Various chemical substances are enumerated in this listing. There are specific regulations relating to viruses, serums, toxins and analogous products for use in the treatment of human beings and domestic animals.[14/]

11/ The regulations promulgated by the Secretary of Transportation list many chemical agents; see 49 CFR 172.5.

12/ 19 USC 1701 et seq. (1970).

13/ 19 USC 1202 (Sub-chapter 4) (1970).

14/ 19 CFR 12.17, 12.21.

C. Federal Laws Controlling the Disposal of Chemical Substances

Under Federal water pollution legislation[15/] the Federal Environmental Protection Agency (EPA) has the authority to establish methods and means for preventing "hazardous substances" from entering the navigable waters of the United States. In this legislation the term "hazardous substances" is defined as "such elements and compounds which, when discharged in any quantity into or upon the navigable waters of the United States or adjoining shorelines or the waters of the contiguous zone, present an imminent and substantial danger to the public health or welfare, including, but not limited to, fish, shellfish, wildlife, shorelines and beaches".

Analogous authority is given to the EPA with respect to certain hazardous air pollutants.[16/]

When the destruction or disposal of any chemical substance by a Federal agency may have a significantly adverse effect on the quality of the human environment, the National Environmental Policy Act[17/] requires that the Federal agency undertaking such an action file an environmental impact statement assessing the possible threat to the environment posed by the proposed Federal action.

III. State Laws Applicable to Chemical Substances

State legislation regulating the production, sale, transportation and disposal of chemical substances generally shows considerable diversity and is in many cases not as comprehensive as Federal regulation. In some areas where the US Congress has enacted legislation the States are without authority to do so. In other cases, parallel Federal and State legislation exists.

A. Diversity of State Regulation

One characteristic of the body of State regulation governing chemical substances is the diversity from one jurisdiction to another. For example, Maine, New Jersey and New York have one type of legislation -- in virtually identical terms -- regulating the sale and distribution of pesticides. Under this legislation pesticides must be registered prior to sale and there are provisions governing the handling of pesticides

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15/ 33 USC 1162 (1970) hazardous.

16/ 42 USC 1857 (1970). An air pollutant is defined to be "an air pollutant to which no ambient air quality standard is applicable and which in the judgment of the Administrator (of EPA) may cause, or contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness".

17/ 42 USC 4321 (1970).

in commercial transactions. The legislation also contains provisions designed to prevent injuries arising out of the dissemination of pesticides. California, however, has a very different type of legislation not only pertaining to sale and use, but also to manufacture of pesticides, which is illegal without a licence. Provision is made also for inspection of manufacturing facilities by competent State authorities.[18/]

B. Scope of State Regulation

Even though the most heavily industrialized states, like California, New Jersey and New York, have extensive industrial marketing and pollution legislation, the scope of legislation with respect to the production, sale, transportation and disposal of chemical substances often is not as comprehensive as Federal legislation. A case in point is California, which has extensive legislation embracing the manufacture and sale of drugs, pesticides and injurious or hazardous chemical substances,[19/] and which has pollution legislation which prohibits the discharge of chemical substances into the waters of the State if such discharge is likely to be detrimental to wild life.[20/] California, however, does not have specific legislation regulating the transportation of chemical substances within the State, nor does it have the equivalent of the Federal Occupational Safety and Health Act, which sets safety standards for production facilities that manufacture hazardous chemical substances.

The scope of legislation in other States is in some cases even less comprehensive. New York, for example, has legislation governing the manufacture and sale of drugs, the distribution and sale of pesticides and the disposal of chemical pollutants.[21/] It does

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18/ The basic legislation regulating pesticides in New York may be found at N.Y. AGRICULTURE AND MARKETING LAW Sec.149 (McKinney 1954); analogous New Jersey legislation may be found at N.J. STAT. Sec.4:8A-2 (1960); in Maine the relevant legislation may be found at 7 M.R.S.A.Sec.581 et seq.; in California the relevant provisions may be found at CAL. AGRIC. CODE Sec.12751 et seq. (West 1954).

19/ The manufacture and sale of drugs are controlled in general by CAL. HEALTH AND SAFETY CODE Sec.11000 et seq. and Sec.26310 et seq. (West 1954); pesticides by CAL. AGRIC. CODE Sec.12751 et seq. (West 1954); injurious materials by CAL. AGRIC. CODE Sec.14001 et seq. (West 1954); and hazardous substances by CAL. HEALTH AND SAFETY CODE Sec.28740 et seq. (West 1954).

20/ See CAL. FISH AND GAME CODE Sec.5650 (West 1954); for general prohibitions on the discharge of chemicals which degrade water quality standards, see CAL. WATER CODE Sec.13000 et seq. (West 1954).

21/ The manufacture and sale of drugs is governed by N.Y. EDUCATION LAW Sec.6808 et seq. (McKinney 1954); pesticides by N.Y. AGRICULTURE AND MARKETS LAW Sec.149 (McKinney 1954); chemical pollution of water by N.Y. PUBLIC HEALTH LAW Sec.1200 et seq. (McKinney 1954).

not, however, have a Hazardous Substances Act or regulations governing the manufacture of pesticides or other injurious substances. Moreover, New York, like California, does not have a comprehensive State Code regulating transportation of chemical substances within the State. Unlike California, however, New York regulates the routes over which vehicles carrying dangerous chemical substances may travel.22/

22/ N.Y. VEHICLE AND TRAFFIC LAW Sec.1630 (McKinney 1954) authorizes certain localities to regulate the transportation of dangerous chemical substances.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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UNITED KINGDOM

Working Paper on remote detection of chemical weapon field tests

A 1. In an earlier Working Paper (CCD 308) the requirements for verification of chemical weapon arms control measures were reviewed in broad terms in order to put the overall problem of verification into perspective. Subsequently a number of Working Papers have continued this process with varying degrees of elaboration of detailed aspects of the problem. It is appropriate, now that the Committee has a general understanding of the problem, for consideration to be given in detail to some of the verification techniques which have been suggested, so that positive action can be focussed on those which show real promise of practical application.

2. One technique which requires further examination since it has been suggested as one which would not involve on-site inspection is the use of satellite-mounted sensors designed to detect field tests of chemical weapons. This paper seeks to examine in detail:

i) whether such a system would be feasible in terms of sensitivity requirements and equipment performance; and

ii) what would be the probability of detection of field tests on the basis of certain assumptions.

3. A fundamental assumption is that field tests of chemical weapons would be essential as part of the development process culminating in production and stockpiling of the weapons. It is important to note that while this

may be true for any new development, for example by a state previously lacking a chemical weapon capability it is not necessarily a valid assumption for countries which have previously had such a capability, unless perhaps development of a new type were initiated.

B The characteristics and sensitivity requirements of sensors

4. The remote detection of a chemical agent liberated during a field test necessitates the transmission of a signal from the chemical to a sensor, and in order to differentiate such tests from tests of weapons such as high explosive or smoke shells, the transmitted signal must allow identification of the chemical. This need to transmit a signal indicates the use of electromagnetic radiation of some form and only those frequencies of the electromagnetic spectrum need be considered which are transmitted by the earth's atmosphere and capable of giving chemical information. Absorption by the atmosphere limits the useable frequencies to "windows" in the near ultraviolet, visible light, infrared, microwave and radio-frequency regions. Of these regions only the infrared will produce chemical data on all molecules and of the available windows in the infrared region, that from 8 - 15 μ is preferred because:

a. it is a region in which many characteristic infrared absorption bands are found

b. the black body radiation from the earth peaks at about 10 μ

Consideration will therefore be limited in this paper to a remote detection device working in the 8 - 15 μ window.

5. For the purpose of examining the capabilities of a typical satellite-mounted sensor, the orbit of the earth resources satellite (ERS) will be considered as the sensor requirements for this have been extensively reported. The ERS will be placed in a circular sun synchronous orbit at a height of

880 Km with an orbit inclination of approximately 99°. This produces a ground point shift of 2860 Km per orbit and a westerly shift of 170 Km each day. The sensors have a field of view of almost 190 Km producing a 10% overlap on successive days. The ground velocity of the satellite is 6.7 Km sec^{-1} which imposes severe constraints on the infrared sensor.

6. Two types of sensor which are available are a suitable photoconductive detector, such as cadmium-mercury-tellurium (CdHgTe), and a pyroelectric detector such as triglycine sulphate. The former will require cooling to 77°K, the latter will operate at ambient temperature. The photoconductive sensor is usually used in a linescanning system, similar to the line scanning of a television screen, without interlacing, whereas the triglycine sulphate can be used in a pyroelectric vidicon detector in which the whole image is formed on the detector surface, which is ruled to give a number of discrete point detectors and the charge on these points is subsequently scanned by an electron beam. In normal systems working in the visible and photographic infrared regions of the spectrum, the different spectral ranges are each monitored by a separate vidicon using a filter to isolate the respective wavelength regions.

7. The choice of which system to use for surveillance of chemical weapon tests from a satellite will be governed by the degree of spectral resolution required. If the identity of a chemical agent can be established using a small number of wavelengths then either system could be used. If a large number of wavelengths are required then the consequent multiplicity of vidicons would be prohibitive.

8. In remote sensing of nerve agents from the ground using infrared absorption, detection can be based on the 9.7 μ band common to most nerve agents. However, this band cannot be used for satellite-based observation because of the atmospheric ozone absorption band at this wavelength.

When the spectra of the atmosphere and a selection of nerve agents are examined together, it is apparent that since it is impossible to use the 9.7 μ region for identification, no simple combination of bands will allow agents to be detected. Identification will then have to depend on summing all the information available in the 8 - 9.4 and 9.8 - 12 μ regions, the individual agents being identified by pattern recognition techniques. This will require a spectral resolution of 0.1 μ or better which would require a minimum of 38 vidicons. It therefore appears that the line scanning approach would be preferable.

9. When using scanning techniques based on passive infrared it is essential that the spectrum scan should be complete in the time interval in which a single target is being viewed. Since the sensor detects the absorption by a vapour cloud of infrared radiation from the earth's surface, a changing pattern of absorption at different wavelengths would result if this background surface radiation varied during the course of a single scan. Relation of the data to the pattern for individual agents would then not be possible. If the spectral scan covers areas of different emissivity then false signals can result. The highest resolution of a linescan instrument yet achieved is 0.5 milliradians with 0.25 milliradians as the practical limit. This gives a minimum line width of about 250 m for the ERS system, but the value is of course dependent on altitude. Taking the instantaneous target being scanned as a square of this size then there will be roughly 800 such target dots in the 190 km line scan or $(800)^2$ dots in the square frame. This frame is completed in 28 secs giving a 'dot' time of 40 μs. In that time it would be necessary to measure absorption at at least 38 wavelengths - requiring a detector response of 1 μs or better. This is within the capabilities of a cooled CdHgTe photoconductive detector. The fastest scanning system yet described would scan the 8 - 12 μ region

in 3 μs at a resolution of 0.50 μ, so that the required scan rate of 40 μs is feasible. This data would need to be digitised for transmission to earth and commercial converters have speeds up to 15MHz. Allowing 4 bits per wavelength interval (intensity scale of 16 : 1) and using the position of the intensity bits in the bit string to denote wavelength, the data transmission rate would be 4MHz. It appears then that it would be technologically feasible to design a satellite based system with adequate speed.

10. Considering now the sensitivity of an infrared line scan system, the limiting discriminating power of the present CdHgTe detector is 0.08 per cent, the noise level limitation of the scanning system is 0.1 per cent. The corresponding detection sensitivity for an average nerve agent is about 0.1 mg $\bar{m}^2$ based on its strongest band. For identification several bands will have to be used which could degrade this sensitivity by a factor of 2 - 4. It is possible that more sensitive detectors may become available and that more efficient means of suppressing the system noise may be found. However, measurements at ground level indicate that atmospheric turbulence itself sets a noise limitation of 0.04 per cent on the discrimination sensitivity. These terrestrial measurements were made with an instrument having a low time constant, but still one significantly higher than that of the satellite system. It therefore appears unlikely that a discrimination level better than 0.1 per cent is likely to be achieved, so that a sensitivity of 0.1 mg $\bar{m}^2$ is the most that appears practicable. Essentially, it appears that the intrinsic sensitivity of existing infrared detectors is adequate, but that the limiting factor is likely to be the random noise level of the overall system.

11. Before the practical value of such a detection sensitivity is examined, it should be noted that such a detection system as that discussed above could only recognize known agents as the patterns for recognition would have to be stored within the system. The detection of tests with a new agent would be outside the capabilities of such a system as the necessary spectrum analysis, at a rate of the order of 2,500 spectra per second, would involve an extremely large computer organization. Even comparison of the limited range of wavelengths with a limited library of known chemical agents at this rate is at the limits of current computer capabilities.

12. So far sensor sensitivity has been discussed in terms of the rapid response necessary for a satellite giving wide coverage by tracking over a large proportion of the earth's surface. With a satellite geo-stationary orbit covering a fixed area, there would be a possibility of improving the sensor sensitivity by using integrating techniques as explained in paragraph 21 below.

C. The probability of detection by satellite-mounted sensors

13. In assessing the probability of successful detection of chemical weapon field tests from a sensor-satellite system, a number of assumptions have to be made in order to provide quantitative data inputs. Two necessary assumptions have already arisen from the discussion of appropriate sensors, viz that the sensor is an infrared spectrophotometer designed to detect vapours of chemical agents (aerosols would not be as readily detected by this type of instrument); and that tests are carried out with known agents.

14. Two more assumptions of particular importance are made in the following assessment. Firstly that tests are carried out at known fixed locations and secondly that tests are random with respect to time. Arguments can easily be raised against both these assumptions. While some tests would probably involve complex support facilities which could not easily be moved, undoubtedly much testing could be carried out without such facilities. The choice of random test times was dictated by the need to employ numerical values in this quantitative assessment. Although it is

reasonable to examine the performance of a detection system under these assumptions, one must consider later the factors bearing upon detection possibilities in the case of a deliberate attempt at concealment.

15. A logic diagram showing the interactions of the various components which affect the separate probabilities involved in the overall surveillance system is given in Figure 1 attached. In addition to the satellite-sensor system which would scan the test area in a systematic manner the other main components are a source (munition/agent) which releases a "puff" of agent vapour, and the environment which determines the dispersion of the puff and also has a large influence on its detectability. The probability of successful surveillance of field tests (Ps) is calculated as the product of the following four terms:

Pc the probability of a clear sky condition
(environmental factor only)

Pa the probability of coincidence of the affected and scanned areas
(satellite orbit and puff dispersion factors)

Pt the probability of coincidence of the puff dispersion and sensor scanning times
(environment and satellite orbit factors)

Pd the probability of detection (sensor, puff and satellite factors)

The first three terms are readily determined and allow favourable orbital configurations to be selected. The probability of detection will be a complex function of sensor-satellite characteristics, puff characteristics and environmental factors and can only be estimated on the basis of further assumptions. The overall probability of successful surveillance can then be calculated for the various satellite orbits considered and the following paragraphs give details of such calculations.

Calculation of Probabilities

16. The following assumptions are made as the basis for calculating the probabilities for surveillance:

Source: an instantaneous point source of 10 kg of volatile nerve agent (such as might be produced from one round of a multibarrelled rocket launcher)

Puff: the agent concentration within the puff assumes a normal Gaussian distribution which is maintained during dispersion downwind. The magnitude of this dispersion was calculated on the basis of a mathematical model and the ellipses defining the areas corresponding to various levels of detectable agent (according to sensor sensitivities) were derived on the basis of this model

Environment: a flat test location; neutral temperature gradient; wind steady in direction at 2 mps. Cloud cover is the average incidence of overcast sky during the period 1900 to 1939 (with separate winter and summer values)

Sensor: a multiple-spot line-scan (800 x 800) infrared spectrophotometer with a scan time of 26 s, a resolution of 0.25 mrad and a sensitivity of 0.1 mg m^{-2} (this sensitivity is derived as a product of puff concentration and puff height terms)

Satellites: Details of some possible satellite orbits which have been included in the calculations are given in Table I attached. An important factor which has not been considered is the system cost which will increase with satellite size, complexity and altitude.

Calculation of Pc

17. This is the probability of a clear sky and is obtained as 1 - Po (the probability of overcast sky), the latter being obtained from meteorological records for areas of interest for the months of January and July, taken to represent winter and summer conditions.

Calculation of Pa and Pt

18. These are the probabilities that the ground track area covers the area of puff formation and/or dispersion and the probability that the puff is in the scanned area at the time of tracking. Both terms will differ according to the type of satellite.

a. Polar orbit A sensor in a near-recursion sun-synchronous orbit of this type having a shift for the second day's track of one swathe width (170 km) would achieve complete earth coverage in 18 - 20 days. By a graphical method relating distance travelled by the puff centroid, wind speed and sensor sensitivity, it can be deduced that: Pa x Pt = 0.02 for 0.1 mg $\bar{m}^2$ sensor sensitivity.

b. Inclined orbits The elliptical sun-synchronous inclined orbit with a period of 12 hr may be used to scan the northern hemisphere for two 8 hr periods during each 24 hr at apogee. In view of the persistence of the puff at detectable levels for a sufficient time, Pa x Pt = 1. Scanning at perigee would give a lower Pt value.

The relatively low circular inclined orbit will result in less favourable Pa x Pt terms than the elliptical orbit.

c. Circular equatorial orbits A satellite in a geostationary orbit having a sensor aligned and focussed on a 7,200 km square centred on the puff release point can carry out constant surveillance. Thus Pa x Pt = 1 and Pd will be the critical factor in this case. A satellite in a 10,000 km orbit scanning a band of 2,000 km centred on an appropriate latitude would repeatedly interrogate a given area once every 6 hr.

As with inclined orbits Pa x Pt = 1 except at high wind speeds (during which field tests would be unlikely).

Calculation of Pd

19. Either the sensor will detect a puff or it will not, ie Pd = 1 or 0. A positive sensor system response will depend not only on puff characteristics and environmental conditions, but also particularly on satellite characteristics, especially altitude since this determines the resolved spot area. If the product of the ratio puff area/resolved spot area and a function of the puff height and agent concentration is equal to or greater than the detector sensitivity, then Pd = 1. The area ratios are given in Table 2 attached and show that only with equatorial orbits at low sensor sensitivity (1.0 and 0.1 mg $\bar{m}^2$) will Pd = 0. This arises from the higher altitude of the equatorial satellites, but sensors of higher sensitivity in such satellites will be effective when the puff area has increased over a period of time.

20. In the case of elliptical inclined orbit it is anticipated that sensor performance would be likely to be degraded by directional and focussing problems and that Pd would be low as a result.

21. For a sensor in a non-geostationary orbit, it is considered that the operational characteristics are likely to be a sensitivity limit of 0.1 mg $\bar{m}^2$ and a resolution of 0.25 mradians. This performance is attainable with present technology making allowance for environmental degradation factors but calculations have for completeness been carried out with sensitivities one order of magnitude on each side of this value. As noted earlier (paragraph 12), the use of integration techniques is possible for a sensor in geostationary orbit. By the rapid accumulation of spectra (as in the use of a "computer of average transients") the signal to noise ratio can be improved by a factor which approximates to the square root of the number accumulated. Thus, superimposition of 100 spectra will give an improvement in sensitivity of a factor of 10. For this reason a possible sensitivity limit of 0.001 mg $\bar{m}^2$ has also been included for such a satellite.

The probability of successful surveillance

22. Details of the individual probability terms discussed above and the final values of Ps (with separate values for winter and summer) are given in Table 3 attached.

23. It is evident from the Table that the best orbits are those in an equatorial plane although an inclined circular orbit may also be satisfactory if sensor sensitivity can be improved. A qualification to be applied to equatorial orbits is that sensors may be scanning certain locations at low elevations and the resulting increased atmospheric path length will introduce an unknown factor into the Pd values (see Figure 1).

24. It is seen that in the best conditions the determining factor for successful surveillance is the occurrence of clear sky conditions at the test site. The values given in Table 3 are for a typical Northern Hemisphere continental location. The dominating influence of this particular factor places additional importance on the basic assumption discussed earlier, that tests are random with respect to time. Furthermore, the values for the probability of clear sky (Pc) are derived from data for completely overcast sky and do not take account of partial cloud cover.

Conclusions

25. From this analysis it is concluded that limited detection by satellite sensors of chemical field tests of known agents in known areas is technically feasible. The most promising surveillance system would require an infrared sensor mounted in a satellite in geostationary orbit. The incidence of cloud cover at the test site would be a major factor in determining the probability of successful surveillance.

FIGURE I

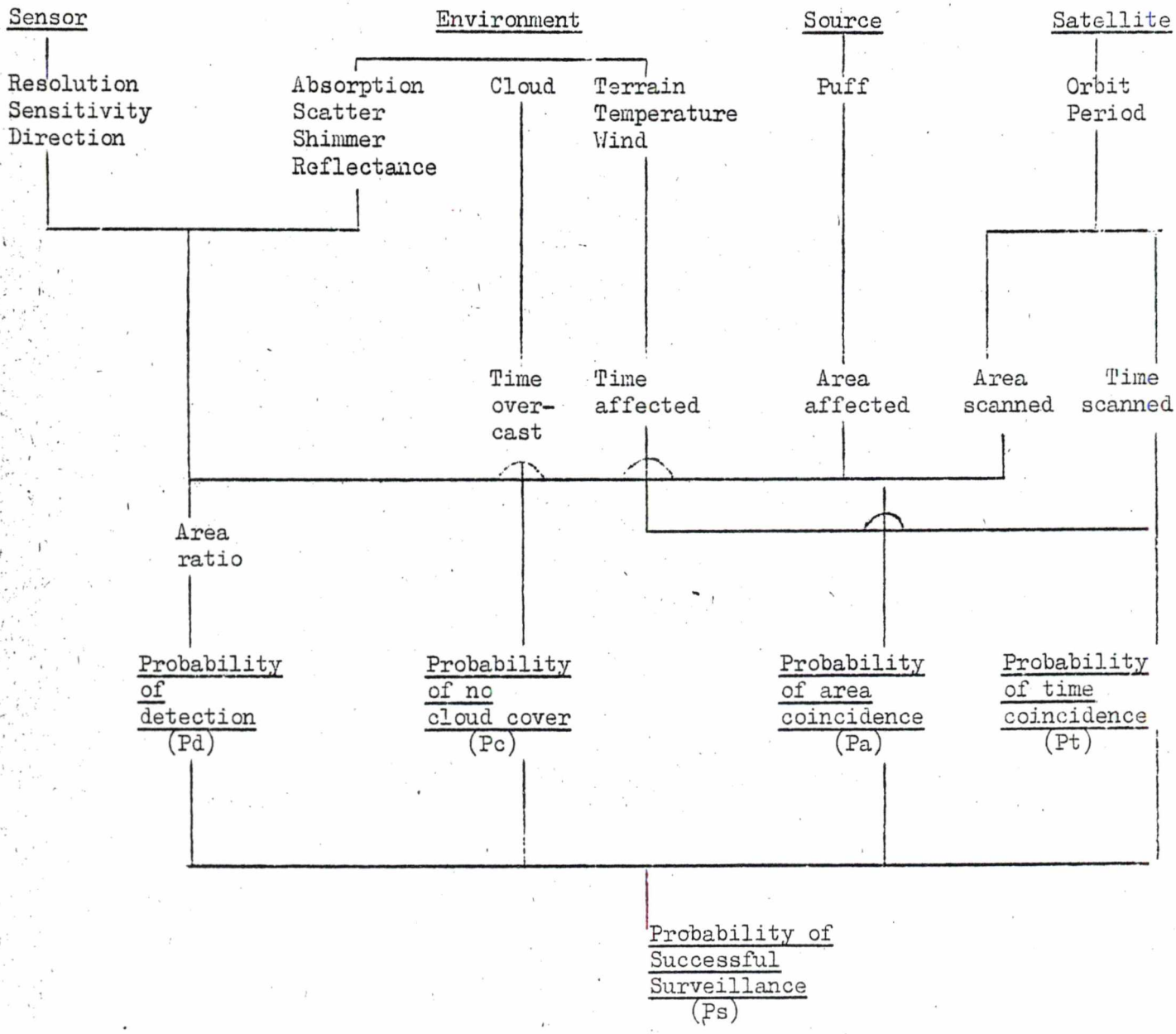

Sensor
Environment
Source
Satellite
Resolution
Sensitivity
Direction
Absorption
Scatter
Shimmer
Reflectance
Cloud
Terrain
Temperature
Wind
Puff
Orbit
Period
Time over-cast
Time affected
Area affected
Area scanned
Time scanned
Area ratio
Probability of detection (Pd)
Probability of no cloud cover (Pc)
Probability of area coincidence (Pa)
Probability of time coincidence (Pt)
Probability of Successful Surveillance (Ps)

TABLE I

SOME POSSIBLE SATELLITE ORBITS (APPROXIMATE VALUES)

Type	Polar	Inclined		Equatorial	
Orbit	Circular	Circular	Elliptic	Circular	Circular
Altitude, Km	880	1000	-	10,000	36,000
Apogee, Km	-	-	40,000	-	-
Perigee, Km	-	-	500	-	-
Inclination, (°)	99	60	63	0	0
Period, h.	1.6	1.7	12	6	24
Recursion No	14	14	2	4	1
Stability, years	>10	>10	>5	>10	>10
Classification	Sun-synchronous	-	Sun-synchronous	-	Geo-stationary
Example	ERS (USA)	-	MOLINYA (USSR)		SYNCOM (NATO)
Sensor, type	IR	IR	IR	IR	IR
Swathe, Km	170	200	Var.	2,000	7,200
Spot diameter, Km	0.22	0.25	Var.	2.5	9.0
Elevation at 50° latitude, (°)	90	90	Var.	18°18'	32°44'

TABLE 2

Ratio of puff area/sensor resolved area

Type	Satellite Altitude km	resolution radius (km)	Puff Area/Sensor resolution for Sensor sensitivity (mgm^{-2})			
			1.0	0.1	0.01	0.001
Polar	880	0.11	92	744	9258	
Inclined	1000 Elliptic	0.125 Variable	71	577 not calculated	7180	
Equatorial	10,000	1.25	0.71	5.8	71.8	
	36,000	4.5	0.055	0.44	5.53	39.5

Source strength 10 kg

Sensor resolution 0.25 mradians

TABLE 3

Summary of Probability Terms

Satellite type and altitude km	Sensor sensitivity m gm^{-2}	Probabilities*					
		Pc(W)	Pc(S)	Pa x Pt	Pd	Ps(W)	Ps(S)
Polar 880	1.0	0.3	0.7	0.01	1	0.01	0.01
	0.1	0.3	0.7	0.02	1	0.01	0.02
	0.01	0.3	0.7	0.07	1	0.03	0.07
Inclined 1000	1.0	0.3	0.7	0.15	1	0.05	0.11
	0.1	0.3	0.7	0.35	1	0.11	0.26
	0.01	0.3	0.7	1	1	0.30	0.75
Inclined Elliptic	1.0	0.3	0.7	not calculated			
	0.1	0.3	0.7	"	"		
	0.01	0.3	0.7	"	"		
Equatorial 10,000	1.0	0.3	0.7	1	0	0	0
	0.1	0.3	0.7	1	1	0.30	0.75
	0.01	0.3	0.7	1	1	0.30	0.75
Equatorial 36,000	1.0	0.3	0.7	1	0	0	0
	0.1	0.3	0.7	1	0	0	0
	0.01	0.3	0.7	1	1	0.30	0.75
	0.001	0.3	0.7	1	1	0.30	0.75

* Pc = probability of clear sky for winter Pc(W) and summer Pc(S)

Pa x Pt = probability of the coincidence of the agent puff and scanned area and coincidence in time

Pd = probability of detection by the sensor

Ps = overall probability of successful surveillance in winter Ps(W) and summer Ps(S)

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/372
28 June 1972
Original: ENGLISH

SWEDEN

Working Paper on two groups of chemical agents of warfare

INTRODUCTION

Within a comprehensive treaty prohibiting the development, production and storing of chemical agents of warfare and prescribing their destruction, those agents which are particularly toxic and therefore capable of inflicting heavy losses would probably require more rigorous methods of control than others. This working paper examines some of the prerequisites for such special treatment. It studies whether chemical agents of warfare as comprised by the Geneva Protocol and the UN Report on Chemical Agents of Warfare (United Nations. Chemical and Bacteriological (Biological) Weapons and the Effects of their Possible Use. Report of the Secretary-General. United Nations, New York, 1969, A/7575/Rev.1) might be divided into two groups with such characteristics that different verification procedures would seem meaningful.

Chemical substances, whether gaseous, liquid or solid, which are suitable to be employed in warfare because of their toxic effects on man, animals or plants, are chemical agents of warfare.

Some compounds are already known as chemical agents of warfare, others as potential chemical agents of warfare. Future compounds which are not yet identified might also become agents of warfare. Known chemical agents of warfare are listed in literature, e.g. the UN and the WHO reports (United Nations. Chemical and Bacteriological (Biological) Weapons and the Effects of their Possible Use. Report of the Secretary-General. United Nations, New York, 1969, A/7575/Rev.1, World Health Organization. Health Aspects of Chemical and Biological Weapons. Report of a WHO Group of Consultants. Genève, 1970.), and some potential ones are also mentioned in scientific publications. Such lists or descriptions are easily expanded when the existence of new agents for chemical warfare becomes known or can be inferred.

The purpose of this paper is to discuss the principal possibilities to delimit two groups of the chemical agents of warfare, i.e. supertoxic agents and other chemical agents of warfare, and to suggest a reasonable procedure for this. A delimitation between them should facilitate the discussions on verification, which are necessary in connexion with negotiations on a comprehensive treaty. Possible methods of verification for the different groups will not, however, be dealt with in this paper.

EARLIER DELIMITATION CONCEPTS

During the discussions in the CCD the following concepts have been used for different delimiting purposes.

Conditional or unconditional prohibition of production
(Swedish Statements 12 March 1970,
CCD/PV.457 and 13 April 1972,
CCD/PV.556).

Supertoxic or toxic agents (Swedish Statement 9 March 1971,
CCD/PV.499),

Single or dual purpose agents (US Working Paper Work
programme regarding negotiations on
prohibition of chemical weapons,
20 March 1972, CCD/360).

These concepts may need further explanations.

A conditional prohibition would be restricted to production for use in war. An unconditional prohibition would mean a total prohibition of production.

Nearly all supertoxic agents are "single purpose" agents, i.e. they have only a belligerent use, and it has been suggested that their production should be unconditionally prohibited. All single purpose agents are not supertoxic. Other chemical agents of warfare may also have a civilian use, i.e. they are "dual purpose agents".

It is apparent that these sets of concepts are closely interrelated, which should be borne in mind in the following discussion, which deals with the supertoxic agents.

SUPERTOXIC AGENTS

Exactly which agents should be considered as supertoxic has not yet been definitely decided, although some have been mentioned, e.g. the nerve agents, mustards, and the toxins. Existing, potential and future chemical agents of warfare will in all probability have the following properties in common:

High toxicity
Rapid onset of effect - minutes to hours
Physico-chemical properties allowing storage and dissemination
(or in the case of binary weapons only dissemination)
Reasonably economic use

From the user's point of view the acute toxicity of a chemical agent of warfare is of the greatest importance, and strong effects of low doses considered as an advantage. The most toxic compounds known, which also fit the other criteria mentioned for a chemical agent of warfare, constitute the greatest threat. Very few of these compounds have any peaceful use, and none has a necessary use outside scientific laboratories. However, it has to be admitted that future warfare agents with a very high toxicity and an indispensible peaceful use are possible, although not likely. There are also technical uncertainties in the determination of acute toxicities, such as lethal or effective doses.

The effects of chemicals on living organisms are indeed complicated. In considering which compounds should be regarded as supertoxic the lethal dose is important, as is the effective dose. The effective dose has to be effective from a military point of view, and the effects have to have a certain predictable duration, say from 24 hours and longer following exposure.

The concept of supertoxic agents should cover all chemical agents of warfare which are particularly dangerous. Such compounds in very small quantities cause death or severe, long lasting disability.

A tentative delimitation of supertoxic agents is illustrated in the table. The delimitation is based upon known facts and data about some known compounds.

Table. A tentative delimitation of supertoxic chemical agents of warfare evaluated f chemical weapons (United Nations. Chemical and Bacteriological (Biological) Weapon New York, 1969, A/7575/Rev. 1, World Health Organization. Health Aspects of Chemic

Evaluation properties	Supertoxic agents		
	Botulinal toxin A	Staphylococcal enterotoxin	Nerve agents[4]
Lethal dose[1] (LCt_{50} mg.min/m^3)	0.02	-	10-400[5]
Effective dose[1] (ECt_{50} mg.min/m^3)	-	0.03[3]	2-20[5]
Time to onset of effect	hours	hours	minutes
Duration of effect	weeks	$\leq$ 24 hours	days - weeks
Dual purpose[2]	no	no	no

1/ The values are estimated for man (see United Nations and WHO reports) when not otherwise stated.

2/ According to US Working Paper CCD/360, 20 March 1972.

3/ Inhaled dose in mg, which caused emesis in rhesus monkey (see WHO report).

4/ Larger groups of agents may be characterized more strictly, e.g. cfr. Dutch Working Paper CCD/320, 2 March 1971 and US Working Paper CCD/365, 20 June 1972.

5/ Sarin, VX, see United Nations and WHO reports; Tabun estimated doses see Franke, S. Lehrbuch der Militärchemie. Vol 1. Deutscher Militärverlag, Berlin 1967.

from data obtained mainly from the United Nations and WHO reports on biological and
s and the Effects of their Possible Use. Report of the Secretary General. United Nations,
a and Biological Weapons. Report of a WHO Group of Consultants, Geneva, 1970).

Other toxic agents				
Mustard gas	Phosgene	Hydrogen cyanide	CS	
1 500	3 200	5 000 8/	50 000	
100	1 600	2 000 8/	< 10	
hours	hours	minutes	< minutes	
weeks - months	weeks - months	days	minutes	
(no) 6/	yes 7/	yes 7/	yes 9/	

Tentative line of delimitation

6/ Might be used as an intermediate in laboratory scale synthesis; at present of no known industrial value.

7/ Raw material.

8/ Varies with the concentration in air during exposition due to the rapid destruction of the agent in the body.

9/ Police use.

TECHNICAL BASIS AND PROCEDURE FOR DELIMITATION

Since the supertoxic agents will have to be treated differently within a comprehensive ban of production, etc., of chemical agents, it will be necessary to agree on a method for deciding which new chemical compounds should be characterized as supertoxic chemical warfare agents. From a technical point of view this should not be difficult. A group of experts using the kind of theoretical and practical approach suggested in this working paper should be able to take on this task.

Many such groups of experts exist for different purposes. Examples can be seen in international scientific and technological organizations, which perform their tasks continually or intermittently. The International Union of Pure and Applied Chemistry (IUPAC) is one such organization, which e.g. handles nomenclature problems.

Accordingly a list of the supertoxic agents might be produced on request by an appropriate United Nations authority. This might be patterned on the work of the United Nations Committee that is evaluating radiation hazards of radioactive chemical isotopes, United Nations Scientific Committee on the Effects of Atomic Radiation on Man and its Environment, UNSCEAR, which in its turn gathers standardized data from two international scientific bodies, the International Commission on Radiation Protection, ICRP, and the International Commission on Radiation Units and Measurements, ICRU, as well as from UNESCO, WHO, FAO, and IAEA.

Reference has already been made to possible technical changes in the future, which might necessitate revisions in a treaty. The need for an updating mechanism covered by a treaty thus seems established. The same groups of experts and United Nations authorities just discussed might perform also this task.

CONCLUSION

There is need for a delimitation of particularly dangerous chemical agents of warfare, i.e. supertoxic agents, as a basis for different means of control within a comprehensive treaty prohibiting production etc. of chemical agents of warfare.

In modern applied science the understanding of patterns of data has increased. The effects of chemicals on living organisms are indeed complicated and are best described by such patterns. Delimitation of supertoxic agents from other chemical agents of warefare has to be founded upon the effects of chemicals on living organisms and thus on the recognition of patterns of data from several scientific disciplines and technical specialties.

Data on chemical agents of warfare are available in literature, e.g. the United Nations and WHO reports on chemical and biological weapons. These data have, as an experiment, been used in this paper to demonstrate the possibility to delimitate supertoxic agents from all agents described in the reports. As a result it was possible to delimit the most dangerous chemical agents of warfare as supertoxic agents, which rarely have a peaceful use and never a necessary one outside scientific laboratories. Many toxic compounds, most of them with peaceful uses such as hydrogen cyanide, could not be considered as belonging to the group of supertoxic agents.

A technical basis for the delimitation, if the concept of supertoxicity becomes operational, has been discussed. This can also serve for a periodic re-evaluation, which becomes necessary because of conceivable future inventions in the field of potential chemical agents of warfare.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/373
29 June 1972
Original: ENGLISH

ITALY

Working Paper on identification and classification of chemical warfare agents and on some aspects of the problem of verification

I. Chemical agents that could be banned

During past meetings of the CCD there was a clearly discernible need for identification of "chemical warfare agents" with a view to negotiations on a treaty to ban the development, production and stockpiling of chemical weapons, and to provide for their destruction.

In our opinion a decisive step towards the identification of chemical weapons could be taken by defining the characteristics which, from a military viewpoint, are necessary to classify a chemical product as a chemical war agent.

It must be borne in mind, when trying to assign an operational effectiveness coefficient to a chemical agent, that this coefficient is the result of a combination of many factors, of which toxicity is merely one and not necessarily the most important. These various factors, which are closely interlinked, cover aspects ranging from the possibility of propagation in the target area, to production, storage, etc. It is only through a careful and correct appraisal of all these factors that it will be possible to classify a chemical substance as a chemical warfare agent.

With a view to negotiating a treaty banning C weapons, the chemical substances which present the following characteristics may be considered as chemical warfare agents:

(a) Substances whose harmful effects are brought about through contact, ingestion or inhalation, excluding those whose effects are caused only through injection.

(b) Substances which, because of their chemical and physical properties, can be diffused in the atmosphere by normal military means (aircraft, helicopters, artiller, missiles, etc.) with a concentration high enough in the emission area to produce the effects predetermined.

(c) Substances which by acting through the means referred to under point (b) are highly toxic or are capable of rendering the area uninhabitable for a certain time.

(d) Substances having the above-mentioned characteristics and capable somehow of remaining in the environment long enough to develop their harmful action.

(e) Substances having the above-mentioned characteristics and which can be produced and stored in such amounts as to constitute a veritable military stockpile.

On the base of these requirements it seems possible to start drawing up a first list of substances which can certainly be considered as chemical warfare agents, with a view to determining the scope of a treaty banning chemical weapons, as follows:

- PHOSGENE or CARBONYL CHLORIDE

  $COCl_2$

  Choking agent. Intermediate product. Used on a large scale in the chemical industry for the preparation of dyestuff, pharmaceutical products, plastics, etc.

- ESTERS OF FLUOROCARBOXYLIC ACIDS

  $F-(CH_2)_nCOOR$ n = odd
  R = alkyl or halogenalkyl

  General toxic action.

- CHLOROPICRIN or NITROCHLOROFORM

  O_2N-CCl_3

  Choking agent. Disinfestor for stored goods and for grounds.

- CYANOGEN BROMIDE

  BrCN

  Tear and general toxic agent.

- CYANOGEN CHLORIDE

  ClCN

  Tear and toxic agent. Used in cyanate preparation and halogenation for the synthesis of dyestuff.

- THIOPHOSGENE or THIOCARBONYL CHLORIDE

  $CSCl_2$

  Choking agent.

- MUSTARD GAS =
  2,2' - DICHLORODIETHYL SULFIDE

  $S(CH_2CH_2Cl)_2$

  Blister agent.

- ETHYL CHLOROSULFONATE

  $Cl\text{-}SO_2\text{-}OC_2H_5$

  Blister and tear agent.

- NITROGEN MUSTARDS and TERTIARY 2,2' DINALO DIALKYL AMINES

  $R\text{-}N\text{-}R'_2$ R = Alkyl, halogenalkyl

  R' = halogenalkyl

  Blister agent.

- ARSINE

  AsH_3

  General toxic agent.

- METHYL DICHLORO ARSINE

  $AsCl_2CH_3$

  Irritant and blister agent. Used for veterinary products.

- ETHYL DICHLORO ARSINE

  $AsCl_2C_2H_5$

  Irritant and blister agent. Used for veterinary products.

- LEWSITE or DICHLORO (2CHLOROVINYL) ARSINE

  $AsCl_2\text{-}CH=CHCl$

  Blister agent.

- PHENYL DICHLORO ARSINE

  $AsCl_2C_6H_5$

  Irritant and blister agent.

- DIPHENYL CHLORO ARSINE

  $AsCl\ (C_6H_5)_2$

  Irritant and blister agent.

- DIPHENYL CIANO ARSINE

  $AsCN(C_6H_5)_2$

  Irritant and blister agent.

- ADAMSITE or DIPHENYL AMINO CHLORO ARSINE

  $AsCl(C_6H_4)_2\ NH$

  Irritant agent.

- IRON PENTACARBONYL

  $Fe(CO)_5$

  General toxic agent.

- CHLOROFORMOSINE

  $ClCH{=}NOH$

  Tear and blister agent.

- PHOSGENE OXIN or DICHLOROFORMOSINE

  $Cl_2C{=}NOH$

  Irritant.

- CHLORO ISONITROSO ACETONE

  $CH_3COCCl{=}NOH$

  Irritant.

- ORGANO PHOSPHURUS COMPOUNDS

  Tabun, GA (ethyl N,N-dimethylphosphoramidocyanidate)
  Sarin, GB (isopropyl methylphosphonofluoridate)
  Soman, GD (1,2,2-trimethylpropyl methylphosphonofluoridate)
  V agents (alkyl esters of S dialkylaminoethylmethyl phosphonathiolic acids).

  The structural formula proposed by the Netherlands approach (see CCD/320, 2 March 1971, page 2, last paragraph) could also be used.

N.B. - In the case of dual-purpose agents their peaceful uses are underlined.

Of course, this is not an exhaustive list. It is proposed as a starting point for a more thorough study of those agents which must be considered as chemical warfare agents for all intents and purposes. However, this list seems to us sufficient to warrant some preliminary remarks on the levels of control which would be required for an effective prohibition of chemical weapons.

II. Classification of chemical agents

As an examination of the list shows us, the chemical warfare agents which could be banned by treaty may be divided as follows:

- according to their use:
  1. single-purpose agents;
  2. dual-purpose agents;
- according to their degree of toxicity:
  1. predominantly lethal agents whose effect is achieved in minimum concentrations. (It is interesting to note that only single-purpose agents fall within this group of warfare agents).
  2. agents whose harmful or lethal effects are achieved through rather high concentration in the environment.

Special attention must be given to the organophosphorus compounds: some are already found in military stockpiles, others can be diverted to warlike uses, and finally others are used in agriculture as insecticides. If, as appears likely, the use of such substances for peaceful purposes is to be banned, all organophosphorus compounds may be considered as chemical war agents.

III. Some considerations on the problem of verification.

1. Single purpose agents.

Turning to the problem of verification, we see that the single-purpose agents - and the most dangerous ones - are in most cases based on the use of raw materials which can be considered "critical": these materials, though abundant, are critical in as much as their sources are limited in number and are located in well-defined areas. In one of our previous working papers (CCD/335 of 8 July 1971) we tried to highlight the possibilities and limits of a non-intrusive system of controls of such materials throughout the entire process of production, trade and use.

This type of control, which is based in large part on the analysis and interpretation of statistical data, will be all the easier to carry out as the proportions of raw materials required for military use are greater than the average amounts used for civilian purposes in a given state, if that state were to decide to build up a militarily useful chemical stockpile.

Accordingly, this type of control would be applicable to a wide range of states, at least for verification of suspected violations, and appropriate procedures should, of course, be laid down for following action. On the other hand, this type of control would be impossible in the case of countries which are major producers and consumers of such raw materials. In their case, it would be useful and fitting to invite contributions in the form of studies and ideas from countries represented on this Committee in order to determine which factors - if any - when combined, might pave the way to a method of control (hopefully, a non-intrusive one), even for this limited number of cases.

2. Dual purpose agents.

Concerning those chemicals which can be used either for civilian or military purposes, the problem of verification seems easier. These chemical agents have, in fact, a low lethal index.

If a State wishes to build up a militarily useful arsenal from such substances, it would have to divert large amounts of them for that purpose with significant impact on the average amount produced for large-scale civilian uses.

Under these circumstances, the establishment of a method of monitoring these substances based on the compilation (already done in part for other purposes) and interpretation of statistical data appears to be a simpler, and certainly not an insoluble problem.

The industrial and economic data would have to be sufficiently ample and an analytical to reveal meaningful deviations either in the average or in the forecast indexes.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/374
5 July 1972
Original: ENGLISH

JAPAN

Working Paper on the question of a criterion to be used to characterize super-toxic chemical agents

1. Determination of a toxic criterion

The LD_{50} of all chemical substances, if plotted accordingly to the degree to toxicity, will give an almost unbroken line (tentatively to be called the LD_{50} spectrum, see Chart I). If the number of such substances is finite, that line will be of a definite length. If botulinum toxin A (LD_{50} in mice 0.00. - 0.00003 µg/kg), which is said to be the most toxic substance known, is placed at the left end of that line, all other substances will be to the right of botilinum toxin A. While it is not clear what will come at the other end of the line, we may ignore substances at the right end as they could never be utilized as chemical weapons.

At the meeting of this Committee held on August 8, 1970, we tried to limit the scope of prohibition to chemical substances coming to the left of a certain marked point (target point) on this LD_{50} spectrum and suggested the toxicity level of LD_{50}, 0.5 milligrams per kilogram of body weight by hypodermic injection (CCD/301). The figure was chosen with a view to listing as many as possible of those compounds which could be used for chemical weapon purposes, at least those recognized as such, and omitting as many as possible of those chemical substances which are used and produced only for peaceful purposes.

The reason why we suggested LD_{50}, 0.5 mg/kg by hypodermic injection was that we chose to concentrate on Soman (LD_{50}, 0.35 mg/kg, s.c.) which is one of the lowest in toxicity among the existing nerve agents, and that, by selecting as the target point a toxicity level close to the LD_{50} of Soman on the spectrum, all the known nerve agents available for use as chemical weapons would come to the left of that target point, while only a few chemical substances used for peaceful purposes will come in this category.

It is a well-known fact that the LD_{50} of chemical substances varies with changes in the experimental conditions, e.g. animal species and administration route, etc. and it is desirable therefore that the LD_{50} spectrum should be arranged with the measurements from tests carried out under identical conditions.

This paper deals in some detail and in a concrete manner with the results of investigations we have conducted making use of the available literature. The LD_{50} of about one hundred and thirty organophosphorus compounds, the group to which the above-mentioned nerve agents belong, are known. The LD_{50} of organophosphorus agents for use as insecticides and in medicine are shown in Tables I and II respectively, while the LD_{50} of organophosphorus agents for use as chemical weapons and other organophosphorus agents of roughly similar toxicity are shown in Tables III and IV.

Many of the data were obtained in tests with mice and rats, while the administration route was mostly intraperitoneal or oral. As to organophosphorus agents for use as chemical weapons, there are many data available on intraperitoneal injections. In the case of insecticides, many statistics are obtained from oral administration. However, we may estimate the LD_{50} for intraperitoneal administration from statistics for oral administration, as about a fifth of orally administered LD_{50} is considered to be the LD_{50} for intraperitoneal administration. Consequently, it becomes possible to construct the LD_{50} spectrum for the more reliable intraperitoneal injection in a mouse, by making use of the available statistics. We believe it will be possible to select a target point on an LD_{50} spectrum, taking into account the same factors as when we selected a target point on the LD_{50} spectrum for hypodermic injection mentioned above. In other words, it would be appropriate to select the LD_{50}, 0.62 mg/kg, i.p. of Soman as the target point.

If we choose this as the target point, among the organophosphorus agents for civil uses coming to the left of this point on the spectrum shown in Chart I, there will be one insecticide (tetram: 0.5 mg/kg, mice, i.p.) and two medicines (paraxon: 0.6 mg/kg, mice, s.c., echothiophate: 0.14 mg/kg, mice, i.p.). Table IV gives thirteen organophosphorus compounds which are considered to be of approximately the same toxicity level as chemical warfare compounds. Nine of those chemical compounds will come to the left of the target point.

Judged from the LD_{50} of these twelve organophosphorus compounds, there is a strong possibility of their being used as chemical warfare agents, while the abovementioned three chemical compounds, which are obviously used for peaceful purposes, could quite

possibly be replaced by other less toxic chemical compounds. Therefore, even if those twelve or so of many organophosphorus compounds are to be prohibited, it would not greatly affect peaceful industry.

Thus, two toxicity levels are suggested; one for hypodermic injection mentioned in our working paper (CCD/301) and the other for intraperitoneal injection. It is also suggested to choose, by way of an example, one promising criterion of Soman, as the lowest in toxicity. However, it would be necessary to make adequate adjustments according to circumstances, as when, for example, a means of increasing the toxicity of lower toxic compounds by combining several chemical compounds or by using adjuvants is developed or when a hitherto unknown chemical warfare compound is discovered.

2. Standardization of experimental conditions for tests to determine LD_{50}.

The above-mentioned toxicity levels have been chosen as a result of our study made exclusively on the basis of the data which are available now. Of course, all LD_{50} to be used in selecting the target point must be accurate and have a high objective validity. Therefore, the following items should be given due consideration in setting the experimental conditions for tests for the determination of toxicity.

(1) animals
  (i) species (e.g. dog, monkey, rat and/or mouse) and strain (pure strain)
  (ii) sex, age, weight

(2) chemical substances
  (i) concentration, vehicle
  (ii) route of administration (intravenous, intraperitoneal, subcutaneous, intramuscular oral, inhalant, and/or cutaneous) and the region where subcutaneous, intramuscular and cuticular injection is to be effected

(3) others
  (i) temperature, humidity
  (ii) fasting time
  (iii) duration of observation, etc.

3. Delimitation of organophosphorus compounds

We believe that the classification of chemical compounds by toxicity criterion as we have suggested is one effective means by which to designate those nerve agents which are available for use as chemical weapons. However, using only a toxicity criterion based on the LD_{50} spectrum, some of the chemical substances for civil uses (alkaloid, plant heart poison, etc.) come under the category (II) of Chart II.

Accordingly, we could limit the scope of chemical agents in amore clearcut way by selecting super-toxic chemical agents, which can be subject to verification and which

would be those most likely to be used in warfare from among the chemical compounds classified as super-toxic compounds using our toxicity criterion. In the light of such a consideration, it might be appropriate that we concentrate ourselves on super-toxic organophosphorus compounds (the square indicated by P on Chart II).

This is because organophosphorus compounds have the following characteristics:

(1) the super-toxic organophosphorus compounds are those of the highest toxicity and there is a strong possibility that more toxic chemical weapons will be developed in the future from among such organophosphorus compounds.

(2) it is possible to measure the amount of such organophosphorus compounds at the stage of production because they are produced from yellow-phosphorus.

(3) all organophosphorus compounds indicate special anti-cholinesterase activities.

(4) there are differences in chemical structural formula between such organophosphorus compounds for peaceful and those for weapon purposes.

It should be noted that, by making use of the characteristics mentioned in para. (3) and (4), we could detect the relevant super-toxic organophosphorus compounds by means of gascromatography or by measuring cholinesterase activity.

4. Possible chemical structural formula for organophosphorus compounds for weapon purposes.

As to the method for defining such super-toxic organophosphorus compounds, the Netherlands representative suggested a method using chemical structural formula (CCD/320).

The common characteristics of organophosphorus nerve agents for weapon purposes, such as sarin, soman, and the V-agents are that there are methyl and phosphorus (CH_3-P) bonds in their molecules. On the other hand, though the mechanism of their action is the same, organophosphorus insecticides, which are of much lower toxicity, do not have any CH_3-P bonds in their molecules. Nor do other organophosphorus compounds for peaceful purposes have such bonds. Therefore, if we could establish techniques for the micro-analysis of CH_3-P bonds, it should contribute greatly to the detection of organophosphorus nerve agents.

However, some super-toxic organophosphorus compounds have bonds of lower alkyl radical and phosphorus. The representative of the Netherlands presented in above-mentioned working paper a general structural formula (see Chart III) as a criterion by which to define super-toxic agents. As we consider that the approach suggested by the Netherlands to be very appropriate, we have carried out our work on the listing of all generally known organophosphorus compounds and putting them in order on the basis of their structural formula.

As a result of this work, we have come to the conclusion that the general structural formula for organophosphorus nerve agents given in Chart IV is the most suitable. (See the annex for details.)

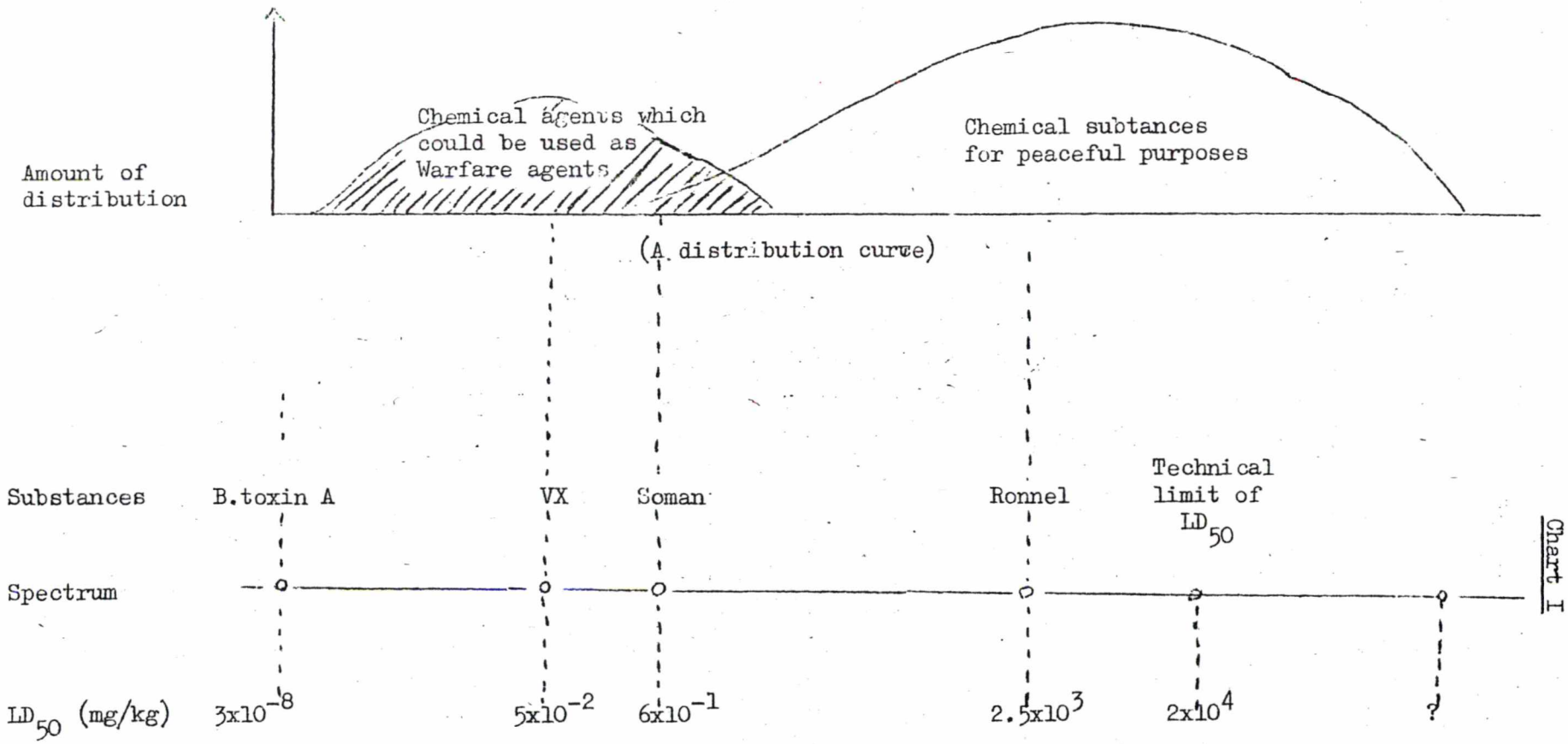

Amount of distribution
Chemical agents which could be used as Warfare agents
Chemical subtances for peaceful purposes
(A distribution curve)
Substances
B.toxin A
VX
Soman
Ronnel
Technical limit of LD_{50}
Spectrum
LD_{50} (mg/kg)
$3x10^{-8}$
$5x10^{-2}$
$6x10^{-1}$
$2.5x10^{3}$
$2x10^{4}$
?

Chart I

Chart II

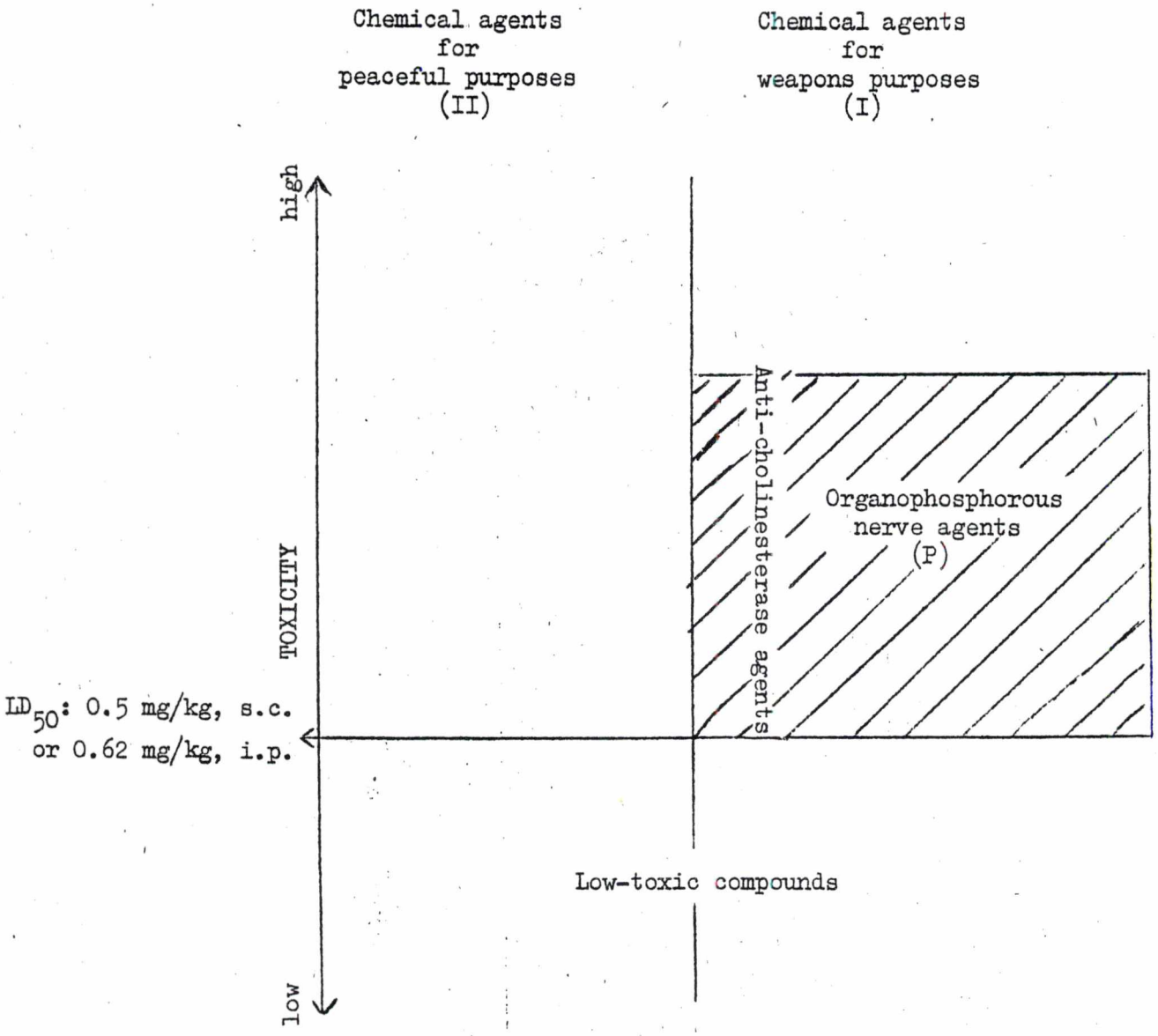
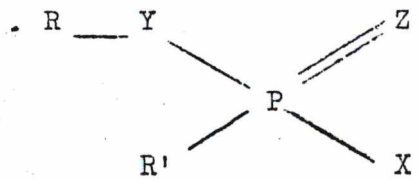

Chemical agents for peaceful purposes (II)
Chemical agents for weapons purposes (I)
high
TOXICITY
low
LD50: 0.5 mg/kg, s.c.
or 0.62 mg/kg, i.p.
Anti-cholinesterase agents
Organophosphorous nerve agents (P)
Low-toxic compounds

Chart III

A general formula proposed by Netherlands (CCD/320)



in which

Y : O or S

Z : O or S

X : F, CN, N_3, SR'', $S(CH_2)_n\overset{+}{S}R''$, $S(CH_2)_nN(R'')_2$, $S(CH_2)_n\overset{+}{N}(R'')_3$

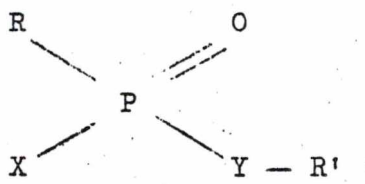
R : (Substituted) alkyl, cycloalkyl or hydrogen

R': Alkyl, dialkylamino

R": Alkyl

Chart IV

A general structural formula of our study



in which

R : Alkyl, dialkylamino, alkoxy

R' : (Substituted) alkyl, cycloalkyl, hydrogen

Y : O, S

X : F, CN, $S(CH_2)_nSR''$, $S(CH_2)_nNR''_2$,

$S(CH_2)_n\overset{+}{S}R''_2$, $S(CH_2)_n\overset{+}{N}R''_3$, $S(CH_2)_nNHR''$,

$S(CH_2)_nSO_2R''$

R" : Alkyl

TABLE I

Name	LD_{50} (mg/kg)		
Accthion	1280	mice	i.p.
Amiphos, DAEP	432	mice	p.o.
Azethion	1000	rats	p.o.
Chlorothion	337	mice	p.o.
	1500	rats	p.o.
	750	rats	i.p.
Cyanox, CYAP	995	mice	p.o.
Delnav	110	rats	p.o.
DDVP	29	mice	i.p.
	50-70	rats	p.o.
Diazinon	65	mice	i.p.
	108	rats	p.o.
Dibrom	120	mice	p.o.
Dicapton	400	mice	p.o.
Dimefox, Hanane	1.2	mice	i.p.
	4.5	rats	p.o.
Dimethoate	140	mice	p.o.
Diptrex	500	mice	i.p.
	450	rats	p.o.
Disyston, Dithiosystox	5-6	mice	i.p.
	14.4	mice	p.o.
	5	rats	p.o.
DSP	65.4	mice	p.o.
EDDP, Hinosan	218	mice	p.o.
EPN	48	mice	i.p.
	33	mice	p.o.
	14	rats	p.o.
ESBP	750	mice	p.o.
Ethion, Nialate	179	rats	p.o.

Name	LD_{50} (mg/kg)		
Gusathion, Guthion	3-5	mice	i.p.
	16	rats	p.o.
IBK, Kitazin-P	660	mice	p.o.
IPSP	86	mice	p.o.
Isomethylsystox	60	rats	p.o.
Isosystox, Isodemeton	5.6-5.9	mice	i.p.
	1.5	rats	p.o.
Lebaycid, Baycid	88	mice	p.o.
	250	rats	p.o.
Malathion	720	mice	p.o.
	750	rats	i.p.
Mecarbam	92	mice	p.o.
MEP, Sumithion	870	mice	p.o.
	242	rats	p.o.
Mesyston	27.2	mice	p.o.
	50	rats	p.o.
Metasystox, Methyldemeton	2.9-3.3	mice	s.c.
	17	mice	p.o.
	40	rats	p.o.
Methylparathion	19-22	mice	p.o.
	30	mice	s.c.
	25	rats	p.o.
	2.8	rats	i.p.
Mipafox, Isopestox	90	rats	i.p.
	4.5	rats	p.o.
Nemacide	270	rats	p.o.
NPD	1100	rats	i.p.
OMPA, Schradan	17	mice	i.p.
	8	rats	i.p.
	8-10	rats	p.o.
Paraoxon-ME	1.4	mice	s.c.
Parathion	10-12	mice	s.c.
	5.5	mice	i.p.

Name	LD_{50} (mg/kg)		
PAP	34	mice	p.o.
	3.5	rat.	i.p.
Phosdrin	8.9	mice	p.o.
PMP	34	mice	p.o.
Potasan	25	mice	s.c.
	15	rats	i.p.
Pyrazoxon	4	mice	p.o.
Pyrazothion	12	mice	p.o.
	36	rats	p.o.
Ronnel, Nankor	2500	rats	p.o.
Resitox, Asuntol	100	rats	p.o.
Rubitox,	131.3	mice	p.o.
Sulfotepp	8	mice	s.c.
Systox, Demeton	3	rats	i.p.
	30	rats	p.o.
Tetram, Amiton	0.5	mice	i.p.
	3-7	rats	p.o.
Thimet	2.1	mice	i.p.
	0.7-2.1	rats	p.o.
Thiometon, Ekatin	64	mice	p.o.
TIPP	16	mice	i.p.
Vamidothion	45.6	mice	p.o.
VC-13, ECP	270	rats	p.o.

p.o. = oral, s.c. = subcutaneous, i.p. = intraperitoneal

TABLE II

Name	LD_{50} (mg/kg)		
DFP	4	mice	i.p.
Echothiophate	0.14	mice	i.p.
Paraoxon	0.6-0.8	mice	s.c.
	7.8	rats	p.o.
TEPP	0.7	mice	i.p.
	0.85	mice	i.p.
	1.9	mice	p.o.
	0.65	rats	i.p.

p.o. = oral, s.c. = subcutaneous, i.p. = intraperitoneal

TABLE III

Name	LD_{50} (mg/kg)			Reference
Sarin	0.214	mice	s.c.	B.M. Askew (1957)
	0.42	mice	i.p.	B. Holmstedt (1951,1959)
	0.580	mice	i.p.	T.A. Loomis (1963)
	0.585	mice	i.p.	T.A. Loomis (1956)
	9.2	mice	p.c.	T.A. Loomis (1963)
	0.045	rats	i.v.	K.P. DuBois (1963)
	0.056	rats	i.v.	J.H. Fleisher (1960)
	0.113	rats	s.c.	J.H. Fleisher (1970)
	0.116	rats	s.c.	B.M. Askew (1957)
	0.55	rats	p.o.	DuBois (1963)
	0.016	rabbits	i.v.	K.P. DuBois (1963)
	0.046	guinea-pig	s.c.	B.M. Askew (1957)
	0.038	monkeys	s.c.	B.M. Askew (1957)
Soman	0.0752	mice	i.v.	D.H. McKay (1971)
	0.2	mice	i.p.	
	0.62	mice	i.p.	T.A. Loomis (1963)
	7.8	mice	p.c.	T.A. Loomis (1963)
Tabun	0.15	mice	i.v.	K.P. DuBois (1963)
	0.6	mice	i.p.	B. Holmstedt (1951)

Name	LD_{50} (mg/kg)			Reference
Tabun	0.06	rats	i.v.	K.P. DuBois (1963)
	0.12	rats	i.v.	J.H. Fleisher (1960)
	3.7	rats	p.o.	K.P. DuBois (1963)
	0.06	rabbits	i.v.	K.P. DuBois (1963)
	16.3	rabbits	p.o.	K.P. DuBois (1963)
	0.08	dogs	i.v.	K.P. DuBois (1963)
	8	dogs	p.o.	K.P. DuBois (1963)
VX	0.05	mice	i.p.	S.M. Aquilonius et al (1964)

TABLE IV

Name	LD_{50} (mg/kg)		
Diethyl S-ethylsulfonylmethylthiophosphate	0.5	rats	p.o.
Diethyl S-ethylthiomethyl thiophosphate	0.25	rats	p.o.
Diethyl S-(2-dimethylaminoethyl) thiophosphate	0.41	mice	i.p.
Diethyl S-(2-triethylammonium methyl) thiophosphate iodide	0.17	mice	i.p.
Dimethylamido-isopropoxy-phosphoryl cyanide	0.5	mice	i.p.
Ethoxy-methyl-phosphoryl thiocholine iodide	0.03	mice	i.p.
Methylfluorophosphorylcarbocholine	0.80	mice	i.p.
	0.100	rabbits	i.v.
Methylfluorophosphoryl- -methylcholine	0.07	mice	i.p.
	0.008	rabbits	i.v.
Methylfluorophosphorylcholine	0.10	mice	i.p.
	0.010	rabbits	i.v.
Methylfluorophosphorylhomocholine	0.05	mice	i.p.
	0.06	rabbits	i.v.
Methylisopropoxy-(2-dimethylaminoethyl) thiophosphine oxide	0.27	mice	i.p.
Methylisopropoxyphosphorylthiocholine	0.12	mice	i.p.
Tetraethylmonothionopyrophosphate	0.7	mice	i.p.

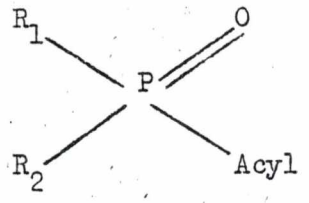
JAPAN

Working Paper on the question of a criterion to be used to characterize super-toxic chemical agents

ANNEX: The explanation of the general formula for the designation of super-toxic organophosphorus compounds

In this annex a detailed explanation of the possible general formula proposed for the super-toxic organophosphorus compounds is presented for consideration in connexion with CCD discussion to find possible general formula to designate nerve agents within the field of the organophosphorus compounds. The following remarks relate to the chemical structure and toxicity of the super-toxic organophosphorus compounds.

A general formula (I) has been proposed by G. Schrader[1] for those organophosphorus compounds which have high toxic properties:



(I)

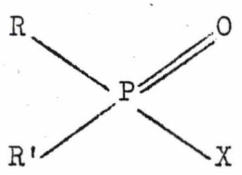
in which

R_1, R_2 = alkoxy, alkyl, or amine

Acyl = inorganic or organic radical groups (for example, -F, -Cl, -SCN, -S, phenol, enol, etc.)

Among the compounds with this formula, there are many super-toxic nerve agents, many of which are the so-called chemical warfare nerve agents.

M. F. Sartori, et al. also proposed, in the Chemical Review[2] a general formula (II) for some of those super-toxic organophosphorus compounds known as G-agents, and the toxicity of the agents covered by the formula was compared with that of diisopropyl fluorophosphate (DFP).



(II)

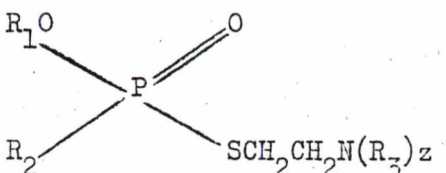
in which

R = C_2H_5O, CH_3

R' = $(CH_3)_2N$, C_6H_5NH, $(CH_3)_2CHO$

On the other hand, the high mammalian toxicity of such nerve agents as sarin, tabun, soman, etc. has been investigated by many researchers using various measuring methods. Table-1 and -2 list the toxicity of those agents which have been reported in the published literature. As shown in Table-2, however, differing values of LD_{50}, as median lethal dosage, are reported for the same animals using the same experimental method. This is one of the problems which should be carefully discussed by toxicology experts when a toxicity standard is being established. If a toxicity criterion is adopted, it will be necessary to provide for a uniform laboratory method for determining the toxicity of a compound. For example, the following factors should be dealt with; the kind of animal to be used, their number and weight, the method of application of the chemicals, measuring conditions, vehicle, equipment and instruments, and other conditions.

Since World War II, new compounds which are extremely toxic to warm-blooded animals have been developed by many investigators, such as Dr. Schrader and Dr. Ghosh, etc. Nowadays, under such code-names as VX, VE, GT-23, S-27, Edemo, or F-gas, these new nerve agents are known as chemical warfare nerve agents. Table-4 lists sixteen compounds that have been described in the published literature and which correspond to the general formula (III) for the V-agents published by the British CW establishment namely:



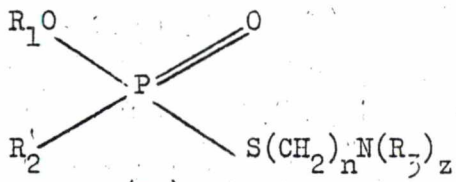
(III)

in which

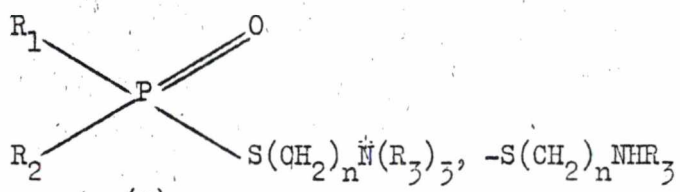
R_1, R_2, R_3 = alkyl or aryl

Of these V-agents, the phosphates known as VE which have CH_3 - radical in their P - alkyl bond are exceptionally toxic. When compared with the G-agents, such as sarin, tabun and soman, the toxicity of the V-agents is found to be from several times to several hundred times greater than that of the G-agents, as shown in Table-3.

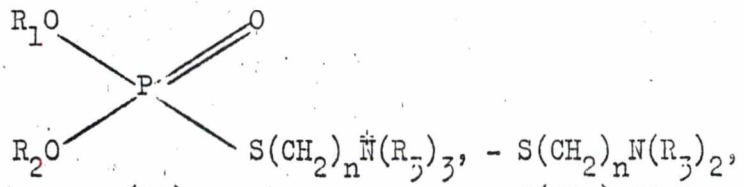
In addition, several super-toxic organophosphorus compounds with chemical structure analogous to that of the V-agents, and whose toxic effects are reported in the literature, are listed in Table-5, from which the chemical structure and the toxicity of these compounds are seen to be almost the same as those of the V-agents. From this table, the following three sub-general formulae (IV), (V) and (VI) are summarized



(IV)



(V)

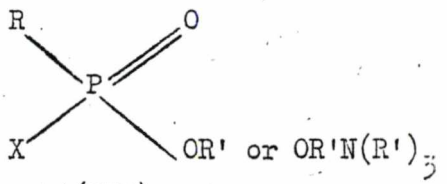


(VI)

in which

R_1, R_2, R_3 = Alkyl

Similarly, the following two sub-general formula (VII) and (VIII) are summarized from Table-6, in which the chemical structure and the toxicity of the compounds are almost the same as those of the G-agents.

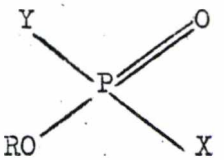


(VII)

in which

X = F

R, R' = alkyl



(VIII)

in which

X = CN

Y = $N(CH_3)_2$

On the other hand, since it was proved that organophosphorus compounds exert their toxic effects by inhibition of the enzyme acetylcholinesterase, a considerable amount of information about the relationship between chemical structure and ability to inhibit acetylcholinesterase has become available. The reactivity of organophosphorus compounds with the enzyme is considerably influenced by the following factors;

(1) the strength of the electron affinity of phosphorus atom

(2) bonding-force of ester group to phosphorus atom

(3) steric effects of substituted groups, etc.

Furthermore, the ability of these phosphorus compounds to inhibit the enzyme is also in proportion to their affinity to cholinesterase.

The agents with a great capability for inhibiting cholinesterase in warm blooded animals are in general of two main types, namely, organophosphorus compounds and carbamate compounds. Here, three or four hundred of the more toxic organophosphorus compounds are listed from among those compounds which have relatively high toxic effects, and which are mentioned in the literature, and subsequently, various sub-general formulae are summarized in Table-7 as groups 1 -- 12.

The super-toxic group mentioned previously is, of course, covered by these sub-general formulae, but not all the compounds which have these general formulae are super-toxic compounds, and it is obvious that one group will contain compounds of differing toxicity; in other words, these sub-general formulae cover probably almost all the super-toxic organophosphorus compounds which have been reported in the published literature. However, considered from the point of view of reactivity of phosphorus compounds mentioned above, it is very possible that new, more toxic nerve agents will be produced in the near future by the inclusion of different elements in the P - X bond or as radicals R_1 or R_2, etc. For example, it is said that the chemical structure of phosphonate type, R(O)RP(O) - or (RO)RP(S) - may show extremely strong toxic effects when compared with the structure of phosphorate type $(RO)_2P{=}O(S)$-, and that organophosphorus compounds with leaving groups analogous to that of acetylcholine in their P - X bonds, as shown below, may show greater inhibition of cholinesterase: for example, analogous leaving groups,

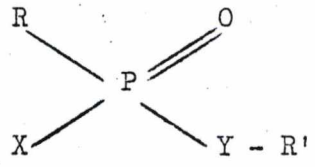
$$X = -SCH_2CH_2\overset{+}{N}(C_2H_5)_3,\quad -SCH_2CH_2\overset{+}{S}\begin{matrix}C_2H_5\\CH_3\end{matrix}$$

$$-SCH_2CH_2\overset{+}{N}(CH_3)_3,\quad -OCH_2CH_2\overset{+}{N}(CH_3)_3,\ \text{etc.}$$

As mentioned above, we have here dealt with the principal super-toxic organophosphorus compounds or related compounds from the standpoints of their chemical structure and toxicity. It goes without saying that the problem of deciding on a toxicity level is very important, when a possible general formula for the designation of the nerve agents is discussed.

If the toxicity level of 0.5 mg/kg, s.c. were to be adopted as the line of demarcation, as our delegation proposed at the CCD last year, all of the organophosphorus compounds which have hitherto been reported in the literature as chemical warfare nerve agents may be covered by the sub-general formulae mentioned above. However, in addition to these compounds, such compounds as those in Table-9, which lie close to the line of demarcation, toxicity level 0.5 mg/kg, should be carefully studied.

We may conclude from the above that as a possible general formula for the designation of potential nerve agents, the following general formula (IX) may be the most suitable formula, in which radical group R, R', Y or X should be carefully selected; that is, in order that it shall cover



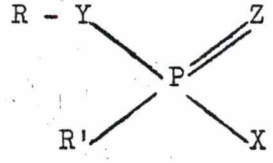
(IX)

in which

R, R', Y, X = see table-9

all super-toxic nerve agents with toxic effects equal to or exceeding toxicity level 0.5 mg/kg s.c., as shown clearly in Table-1 - Table-6, the radicals which are shown in Table-9 should be included.

Last year, the delegation of the Netherlands suggested at the CCD the possible general formula (X), the radicals for which are shown in Table-10.



(X)

in which

R, R', Y, Z, X = see Table-10

This suggestion of the Netherlands seems to be very reasonable. Basically, we give our support to this approach of the Netherlands.

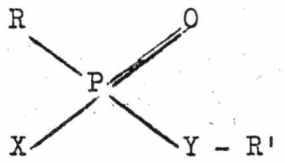
However, in addition to the difference in the two general formulae, we would suggest different radicals as can be seen from Table-9.

In order to include all of the super-toxic nerve agents and related compounds with toxic effects equal to or exceeding the suggested level, such as the compounds shown in Tables 4-6, it may be more reasonable, we think, to suggest the radicals shown in Table-9. In addition, for the possible general formula, for the reason that

the super-toxic agents which have been reported to date in the published literature are only the compounds with the phosphine oxide bond, $P^{1}_{1} = O$, in their chemical structure, it may be appropriate to suggest the general formula (IX) described above.

Of course, it is impossible to designate nerve agents using a general formula only. Thus, as the delegation of the Netherlands suggested last year, it goes without saying that it will be necessary for this general formula (IX) to be used in conjunction with a carefully selected toxicity level, for example, 0.5 mg/kg s.c.

Consequently, for the general formula we suggest:



in which

R = alkyl, dialkylamino, or alkoxy

R' = (substituted) alkyl, cycloalkyl or hydrogen

Y = O or S

X = F, CN, $S(CH_2)_nSR''$, $S(CH_2)_n\overset{+}{S}R''_2$, $S(CH_2)_nNR''_2$, $S(CH_2)_n\overset{+}{N}R''_3$, $S(CH_2)_nNHR''$, $S(CH_2)_nSO_2R''$

R'' = alkyl

References

1) G. Schrader, Angew. Chem. 62, 471 (1950).

2) M.F. Sartori, Chemical Review, 225 (1951).

3) BC - stridsmedel, F O A, Stockholm (1964).

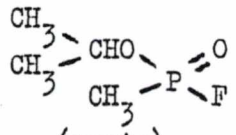
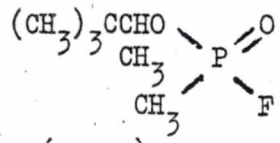
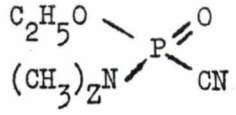
4) Siegfried Franke: Lehrbuch der militärchemie, Band 1, Deutchemilitär Verlag (1967).

5) "The problem of chemical and biological warfare", Vol. 1, SIPRI, Almiqvist & Wiksell, Stockholm (1971).

6) Handbuch der Experimentelle pharmakologie, Vol. 15, cholinesterase and anticholinesterase, Springer Verlag (1963).

7) "Development and production of new agricultural chemicals" edited by Y. Yamamoto and T. Toguchi, Konan-do (1965).

Table 1. Toxicity of G-nerve agents[4)]

Chemical structure (Name)	LD_{50} (mg/kg)	Animals used	Administration route
 (sarin)	0.42	mice	i.p.
	9.2	mice	p.c.
	0.045	rats	i.v.
	0.113	rats	s.c.
	0.55	rats	p.o.
	0.016	rabbits	i.v.
 (soman)	0.2	mice	i.p.
	0.62	mice	i.p.
	7.8	mice	p.c.
 (tabun)	0.15	mice	i.v.
	0.6	mice	i.p.
	0.06	rats	i.v.
	3.7	rats	p.o.
	0.06	rabbits	i.v.
	16.3	rabbits	p.o.
	0.08	dogs	i.v.
	8	dogs	p.o.
(VX)	0.05	mice	i.p.

i.p. = intraperitoneal, p.c. = percutaneous, i.v. = intravenous,
s.c. = subcutaneous, p.o. = oral.

Table 2. The toxicity (LD_{50}) of Sarin (GB)

Animals used	Administration route	LD_{50} (mg/kg)	Reporter
mice	i.p.	0.585 ± 0.023	T.A. Loowis
	i.p.	0.42 - 0.59	Hodge, Holmstedt
	s.c.	0.06 - 0.15	Lohs et al.
	s.c.	0.173	E. Bay
	s.c.	0.22	B.M. Askew
	inhalation	150 - 360 ($mg\text{-}min/m^3$)	DuBois et al.
rats	s.c.	0.17	D. Grob
	s.c.	0.14	D.R. Davis
	s.c.	0.63	E. Bay
	s.c.	0.109	S. Calaway
	s.c.	0.097	H. Culumbin
	s.c.	0.127	B.M. Askew
	i.v.	0.08	H. Culumbin
	p.o.	0.6	D. Grob
	inhalation	220 - 300 ($mg\text{-}min/m^3$)	DuBois
monkey	s.c.	0.025	S. Calaway
	s.c.	0.025	B.M. Askew
	i.v.	0.0205	P. Cresthull
	i.v.	0.021	S. Oberst
	inhalation	64 - 150 ($mg\text{-}min/m^3$)	DuBois
	inhalation	0.0235	W.S. Koor et al.

Table 3. The toxicity of typical nerve agents[3)]

Name	Lethal dosage on bare skin (mg)
Tabun	200 - 400
Sarin	100 - 200
Soman	50 - 100
VE	2 - 10

Table-4. V-agents that have been described in the published literature 5)

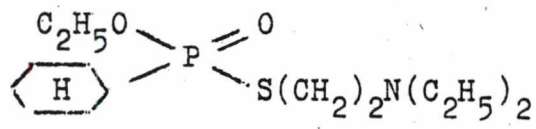
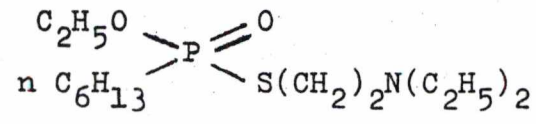
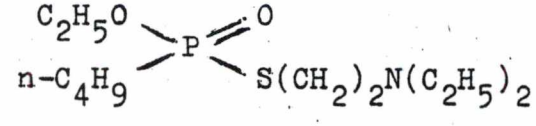
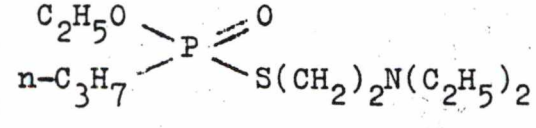
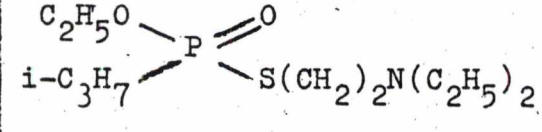
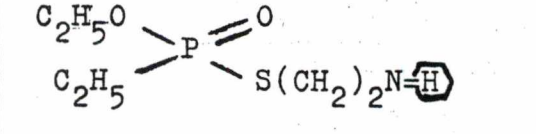
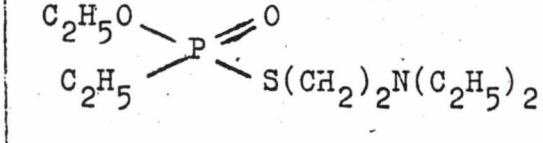
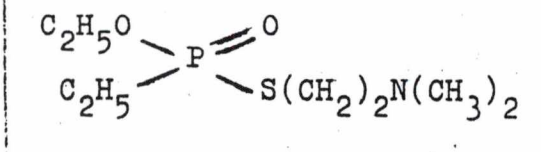
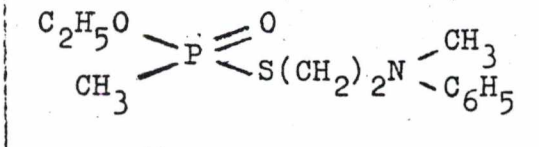
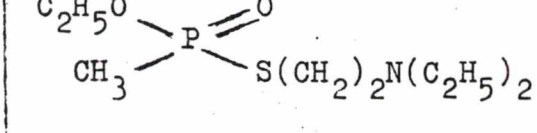
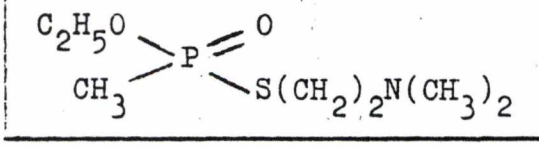
Formula	Name
	Ethyl S-2-diethylaminoethyl cyclohexyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl n-hexyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl n-butyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl n-propyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl i-propyl phosphonothiolate
	Ethyl S-2-piperidylaminoethyl ethyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl ethyl phosphonothiolate
	Ethyl S-2-dimethylaminoethyl ethyl phosphonothiolate
	Ethyl S-2-methylphenylamino-ethyl methyl phosphonothio-late (GT 23)
	Ethyl S-2-diethylaminoethyl methyl phosphonothiolate (F-gas)
	Ethyl S-2-dimethyl aminoethyl methyl phosphonothiolate (VX)

Table-4. Continued.

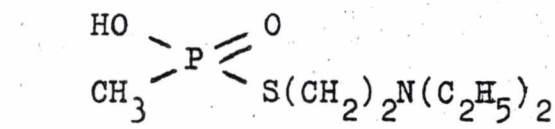
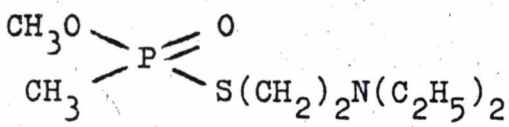
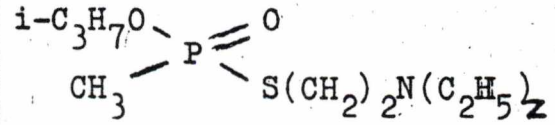
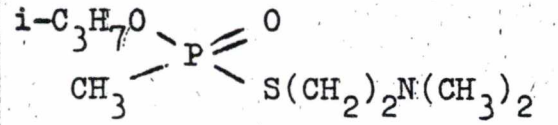
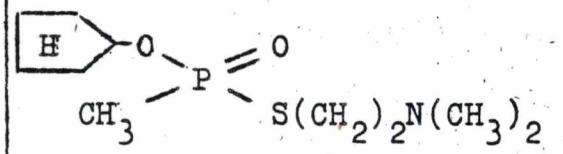
Formula	Name
	(S 27)
	Methyl S-2-diethylaminoethyl methyl phosphonothiolate
	Isopropyl S-2-diethylaminoethyl methyl phosphonothiolate (37 SN)
	Isopropyl S-2-dimethylaminoethyl methyl phosphonothiolate
	Cyclopentyl S-2-dimethylaminoethyl methyl phosphonothiolate

Table-5. Compounds analogous to the V-nerve agents [4,6]

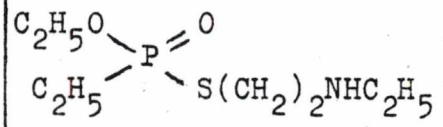
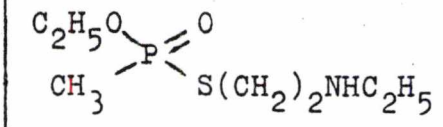
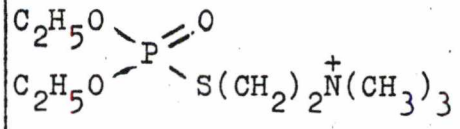
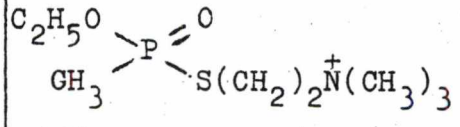
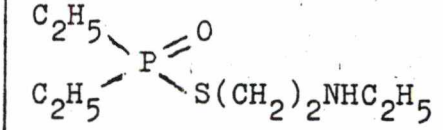
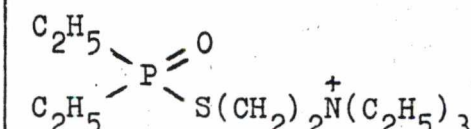
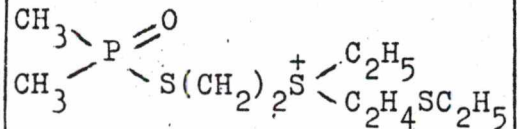
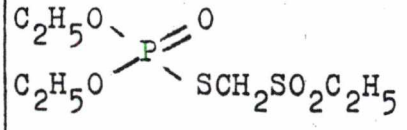
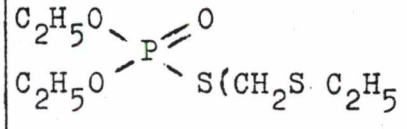
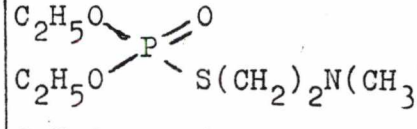
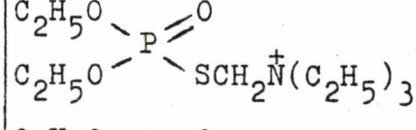
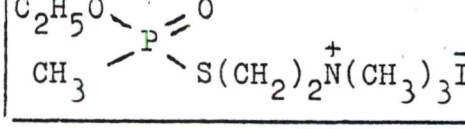
Formula	Name	Animals used	Administration route	LD_{50} (mg/kg)
	Ethoxy S-2-ethyl-aminoethyl ethyl phosphine oxide	rats	p.o.	0.25
	Ethoxy S-2-ethyl-aminoethyl methyl phosphine oxide	rats	p.o.	0.25
	Diethoxy phosphoryl thiocholin	mice	i.p. s.c.	0.14 0.26
	Ethoxy methyl phosphoryl thiocholin	mice	i.p.	0.03
	Diethyl S-2-ethyl-aminoethyl thiophosphate (Amiton)	rats mice	p.o. i.p.	3.5 0.5
	Diethyl S-2-triethylammonium ethyl thiophosphate iodide	mice	i.p.	0.17
	Dimethyl S-(2-(S'-ethyl-S'-ethyl-thioethylsulfonium) ethyl) thiophosphate	rats	i.v.	0.004 0.005
	Diethoxy S-ethyl-sulfonyl methyl thiophosphate	rats	p.o.	0.5
	Diethoxy S-ethyl-thiomethyl thiophosphate	rats	p.o.	0.25
	Diethoxy S-(2-dimethylaminoethyl) thiophosphate	mice	i.p.	0.41
	Diethoxy S-(2-triethylammonium methyl) thiophosphate iodide (DST)	mice	i.p.	0.17
	Ethoxy methylphosphoryl thiocholin iodide	mice	i.p.	0.03

Table-6. Compounds analogous to the G-nerve agents[4,6].

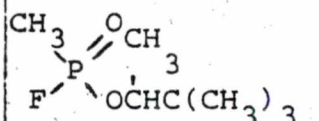
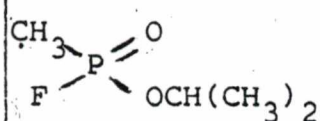
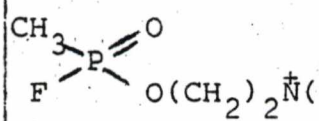
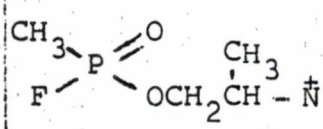
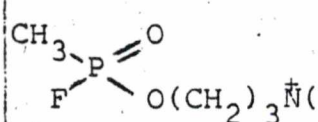
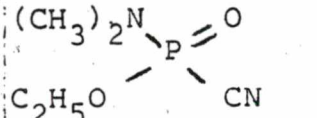
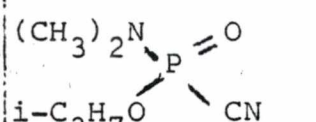
Formula	Name	Animals used	Administration route	LD_{50} (mg/kg)
	3,3-dimethylbutoxy(2)-methyl phosphoryl fluoride (Soman)	mice	s.c.	0.04 0.1
	propoxy-(2)-methyl phosphoryl fluoride (Sarin)	mice	i.p. s.c	0.2 0.05 0.2
	methyl fluoro phosphoryl cholin	mice	i.p.	0.1
	methyl fluoro phosphoryl 2-methyl cholin	mice	i.p.	0.03
	methyl fluoro phosphoryl nomo cholin	mice	i.p.	0.05
	dimethylamino ethoxy phosphoryl cyanide (Tabun)	mice	i.p.	0.6
	dimethylamino iso-propoxy phosphoryl cyanide	mice	i.p.	0.5
	methyl fluorophosphoryl carbo cholin	mice	i.p.	0.8

Table-7. Possible sub-general formula for relatively high toxic organophosphorus compounds.

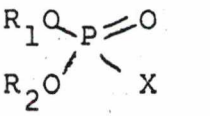
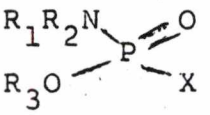
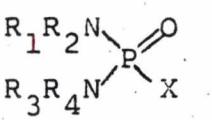
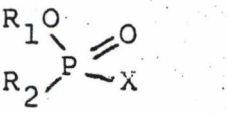
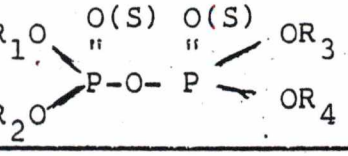
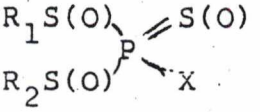
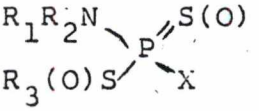
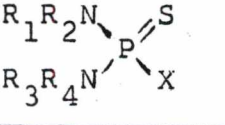
Group	Sub-general formula	Radical groups
1		X = F, Cl, OR_3 R_1, R_2, R_3 = alkyl, aryl
2		X = F, CN, Cl, OCN, SCN, OR_4 R_1, R_2, R_3, R_4 = alkyl, aryl
3		X = F, Cl, OR_5 R_1, R_2, R_3, R_4, R_5 = alkyl, aryl
4		X = F, OR_3 R_1, R_2, R_3 = alkyl, aryl
5		R_1, R_2, R_3, R_4 = alkyl, aryl RO exchangeable for $(CH_3)_2N$-
6		X = F, Cl, SR_3, OR_3 R_1, R_2, R_3 = alkyl, aryl
7		X = F, Cl, OR_4 R_1, R_2, R_3, R_4 = alkyl, aryl
8		X = F, Cl, aryloxy R_1, R_2, R_3, R_4 = alkyl, aryl

Table-7. - continued

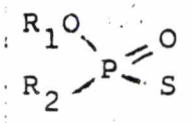
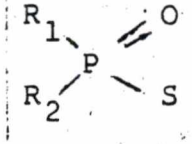
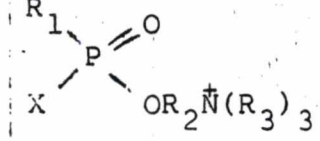
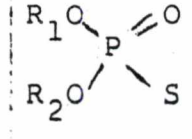
Group	Sub-general formula	Radical groups
9		R_1,R_2,R_3 = alkyl, aryl Y = $-(CH_2)_nNHR_3$, $-(CH_2)_nN(R_3)_2$ $-(CH_2)_n\overset{+}{N}(R_3)_3$
10		R_1,R_2,R_3 = alkyl, aryl Y = $(CH_2)_nNHR_3$, $(CH_2)_n\overset{+}{N}(R_3)_3$, $(CH_2)_n\overset{+}{S}(R_3)_2$
11		R_1,R_2,R_3 = alkyl, aryl X = F
12		R_1,R_2,R_3 = alkyl, aryl Y = $(CH_2)_n\overset{+}{N}(R_3)_3$, $(CH_2)_nN(R_3)_2$, $(CH_2)_nSO_2R_3$, $(CH_2)_nSR_3$

Table-8. The organophosphorus compounds which should be studied

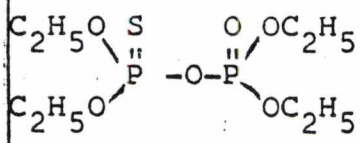
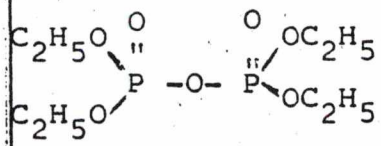
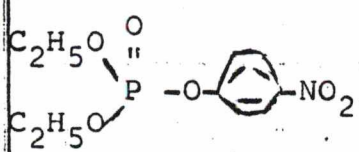
Formula	Name	Animal used	Administration routes	LD_{50} (mg/kg)
	tetra-ethyl monothiono pyrophosphate	mice	i.p.	0.7
	T E PP	mice	i.p.	0.7
	Echothiophate	mice	i.p.	0.14
	Paraoxon	mice	i.p.	0.6 0.8

Table 9. The radicals suggested for inclusion in general formula (IX)

R	Y	R'	X
alkyl	O	(substituted) alkyl	F
dialkylamino	S	cycloalkyl	CN
Alkoxy		hydrogen	$S(CH_2)_nSR''$
			$S(CH_2)_nNHR''$
			$S(CH_2)_nNR''_2$
			$S(CH_2)_n\overset{+}{S}R''_2$
			$S(CH_2)_n\overset{+}{N}R''_3$
			$S(CH_2)_nSO_2R''$
			R'' = alkyl

Table 10. The radical groups in general formula proposed by the Netherlands

R'	Y	R	Z	X
alkyl	O	(substituted) alkyl	O	F
dialkylamino	S		S	CN
		cycloalkyl		N_3
		hydrogen		SR''
				$S(CH_2)_nSR''$
				$S(CH_2)_nNR''_2$
				$S(CH_2)_n\overset{+}{S}R''_2$
				$S(CH_2)_n\overset{+}{N}R''_3$
				R'' = alkyl

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/375
5 July 1972
Original: ENGLISH

YUGOSLAVIA

Working Paper on some aspects of the definition, classification and prohibition of chemical agents

Endeavours to achieve complete prohibition of chemical weapons have given particular importance to the question of development, production and stockpiling of chemical agents. For that purpose a more detailed and precise explanation of the question of definition, classification and prohibition of chemical agents is required.

1. Definition

It seems necessary to call attention to possible harmful uses of chemical compounds which are not classified as chemical warfare agents. For instance, a total herbicide used in standard concentrations has toxic effects on plants but it is not dangerous for men. However, if used in concentrations ten times higher, it may also have, beside its basic effect, direct and indirect toxic effects on people and animals. As another example, one could mention TOCP, which is normally used in chemical industry, but if applied intentionally against man can have harmful consequences on the nervous system and may even be lethal after a latent period of several months. Applied together with certain organophosphorous insecticides of low toxicity, the combination may reach an index of toxicity similar to that of highly toxic chemical agents.

In order to define what precisely is prohibited, any agreement should contain a definition of what are the chemical agents intended for purposes of war. This definition should be given in a sufficiently precise and clear manner.

Definitions of chemical agents are found in the Report of the Secretary-General of the United Nations, Chemical and Bacteriological (Biological) Weapons and the Effects of their Possible Use (A/7575/Rev.1, para. 17), in the report of the WHO entitled "Health Aspects of Chemical and Biological Weapons", and also in Protocol III[1/] to the Bruxelles Treaty of 23 October 1954 relating to the renunciation of those weapons by the Federal Republic of Germany.

1/ United Nations Treaty Series, Vol. 211, pp. 364 et seq.

In an attempt to find a suitable definition of chemical agents that would cover all the already known chemical agents and prevent the eventual use of any chemical compound which, under certain conditions, could be used as chemical agents, we think that the following definition could be useful:

"All chemical compounds intentionally used in quantities which directly or indirectly, immediately or after some time, can produce physiological disturbances or cessation of physiological functions in men and animals, should be considered as chemical agents".

2. Classification

In classifying chemical agents two main criteria can be used:

1. Tactical
2. Physiological (according to their basic mechanism of action).

The tactical classification which is in fact a military one, refers primarily to the aim which is to be achieved when specific agents are used. Depending on the effect to be achieved and on the degree of protection of the adversary as well as on other elements, this classification includes:

- Lethal agents
- Incapacitating agents
- Harassing agents

The physiological classification is based on the so-called dominant effects of chemical agents in war conditions: lung irritants, blood gases, vesicants, nerve gases, lacrymators, sternutators, etc.

Under these classifications almost all substances which are classified as chemical agents could be further sub-divided into different groups, depending on their use and target, and on their concentration.

It seems, however, that these classifications do not represent a good starting point for the gradual solution of the technical aspects of a comprehensive prohibition. The physiological classification could be more acceptable as a basis for discussion, even though it does not refer to the degree of toxicity of different groups of chemical agents and within such groups.

It seems very likely that the value of median lethal dose (LD 50), precisely defined, should be the most acceptable parameter for the delimitation of chemical agents.

What is at present known about chemical agents points out to the toxicity index (LD-50) as the most acceptable basis for further discussion, owing in particular to the following facts:

(a) possibility of standardization,

(b) possibility of determining the protective index on the basis of such standardization.

The present knowledge of technical and medical protection should not be neglected either. For instance, a poison which has toxicity X and for which there is no effective medical protection represents danger Y. A poison whose toxicity amounts to, let's say, 10 X, for which there is 100 X effective medical protection, although more toxic, is less dangerous.

On the basis of all that has been said, it is quite feasible for a group of experts to prepare, in a reasonably short period of time:

(a) a comprehensive definition of all classified and potential chemical agents;

(b) an elaborated study of laboratory testing procedure and criteria of chemical agents toxicity.

The report of Secretary-General (A/7575/Rev.1) and the report of the WHO, mentioned above, represent a sound basis for the further elaboration of this problem.

3. Prohibition

Consideration of the prohibition of chemical weapons should not be limited to the prohibition of highly toxic chemical agents and related problems since other groups of chemical agents as well represent real danger also closely related to the degree of technical and medical protection of the country which may be attacked.

Chemical weapons, ready for use, are concentrated in the hands of very few countries. One cannot exclude the possibility that in an eventual conflict, a greater number of countries might come into possession of chemical weapons either by producing them or acquiring them from others. However, a high degree protection against chemical weapons exists only in modern and well equipped armies. Moreover, the means for an effective protection of the civilian population exist only in a very small number of countries, which means that by far the greater part of the world population remains unprotected. Consequently, the prohibition of only one group of chemical agents (the highly toxic) does not essentially eliminate the danger of chemical warfare for the unprotected population in the world. The use of "less" toxic substances might have catastrophic consequences for it.

Therefore an agreement on the prohibition of chemical weapons should cover the prohibition of chemical agents "in toto" and not only of highly toxic chemical agents.

In view of the existence of different groups of chemical agents, (low or high-toxic agents, dual purpose agents, etc.), an agreement on complete prohibition might contain specific provisions in connexion with the development, production, stockpiling and destruction, as well as the control, of certain groups of chemical agents, since the use of chemical weapons is prohibited by Geneva Protocol of 1925 and is contrary to generally accepted norms of international law.

The degree of danger represented by certain groups of poisons is not uniform, since it depends on a series of variables, namely, who is using it and against whom it is used, ways and means of such use, and the level of technical and medical protection. Moreover, the very same substance with its determined degree of toxicity has entirely different effects on the target if applied by different means of delivery.

Consequently, all chemical agents, and not only the most potent ones, represent nowadays a latent danger for the greatest part of mankind and the elimination of only one group of highly toxic chemical agents does not essentially exclude the danger of chemical warfare. For instance, the use of phosgene or mustard gas against less developed countries today would have the same effect as before.

Therefore, it should be stressed once again that any agreement concerning the prohibition of chemical agents must be a comprehensive one, i.e. cover all kinds of chemical weapons and all phases of their development, production, stockpiling and destruction.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/377/Corr.1
20 July 1972

ENGLISH and
SPANISH ONLY

YUGOSLAVIA

Working Paper on the elements of a system for the control of the complete prohibition of chemical weapons

CORRIGENDUM

On page 3, under item A. International control organ, insert the number (1) before the beginning of the first paragraph.

On page 4, second paragraph, third line should read: "Council might for that purpose consult the council of experts before deciding about the"

GE.72-15820

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/381
27 July 1972
Original: ENGLISH

LETTER DATED 21 JULY 1972 FROM THE PERMANENT REPRESENTATIVE OF FINLAND TO THE SPECIAL REPRESENTATIVE OF THE SECRETARY-GENERAL TO THE CONFERENCE OF THE COMMITTEE ON DISARMAMENT TRANSMITTING A WORKING PAPER BY THE GOVERNMENT OF FINLAND

ON DEFINITIONS OF CHEMICAL WARFARE AGENTS AND ON TECHNICAL POSSIBILITIES FOR VERIFICATION AND CONTROL OF C-WEAPONS WITH PARTICULAR REGARD TO A FINNISH PROJECT ON CREATION ON A NATIONAL BASIS OF A CW-CONTROL CAPACITY FOR POSSIBLE FUTURE INTERNATIONAL USE

Sir,

Upon instructions from my Government, I have the honour to enclose a Working Paper by the Government of Finland to the Conference of the Committee on Disarmament with the request that you would take appropriate steps to have it distributed in the Conference of the Committee on Disarmament.

Accept, Sir, the assurances of my highest consideration.

Encl.

(Signed) Klaus A. Sahlgren
Ambassador
Permanent Representative
of Finland

GE.72-15987

WORKING PAPER BY THE GOVERNMENT OF FINLAND TO THE CCD

On definitions of chemical warfare agents and on technical possibilities for verification and control of C-weapons with particular regard to a Finnish project on creation on a national basis of a CW-control capacity for possible future international use

1. There is a need for substantive preparatory work in the field of promoting scientific knowledge and co-operation in the study of technical problems connected with the verification and control of chemical weapons within the framework of a CW-treaty now under consideration in the CCD. To be effective, it should be truly international and employ leading scholars working in their personal capacity. It is the opinion of the Finnish Government that all nations, whether members of the CCD or not, have a vital interest in promoting concrete progress in disarmament. By its project designed to create a national CW-control capacity for possible future international use, the Finnish Government is endeavouring to make a practical contribution towards this end.

2. In pursuance of the General Assembly resolution 2827A(XXVI), on December 16, 1971, which in paragraph 3(b) requested the CCD "to take into account in its further work ... other proposals, suggestions, working papers and expert views put forward in the Conference and in the First Committee", the Government of Finland has the honour to submit to the CCD the following working paper on definitions of chemical warfare agents and on technical possibilities for verification and control of C-weapons with particular regard to a Finnish project on creation on a national basis of a CW-control capacity for possible future international use.

This paper is also intended to elaborate the ideas put forward by the representative of Finland in a speech in the First Committee of the General Assembly on November 17, 1971. He stated inter alia: "In the opinion of the Finnish Government, the chances of success in the negotiations on chemical weapons should be improved by paying special attention ... to following issues: (1) one should, in international co-operation, study and develop methods which would make available to all interested governments expert information on verification and control of the chemical agents and chemical weapons ... (2) technical capacity should be developed and the facilities

should be acquired on a national basis for verification of chemical agents and for control of their prohibition, having in mind the eventuality that this kind of practical capacity would be needed for international use."

3. As far as definitions of CW-agents are concerned a purpose criterion would provide the simplest and most comprehensive definition of chemical warfare agents for a comprehensive treaty. Such a general definition would have the advantage of covering all possible future agents and also binary systems of weapons.

In addition, a classification of known agents by categories may also be necessary, because the most dangerous agents require the most stringent control and verification measures. Such a classification would also facilitate a progress step by step. It is rather a common view that among the possible supertoxic CW-agents the nerve agents form the group of compounds of greatest concern. As suggested by the Dutch delegation in 1971 (CCD/320) they can be defined with a general chemical formula connected with a toxicity level criterium (LD_{50}) of 0.5 mg or less per kilo of body weight determined subcutaneously in a specified test animal. Modifications to this formula have been proposed later by Japan on July 4, 1972 and by the United States (CCD/365). In the latter document a very general formula is proposed, which would cover practically all derivatives of orthophosphoric acid. Between the Dutch and Japanese formulas, there seems to be only minor differences and it seems not too difficult to come to an agreement on a definition of organophosporus nerve agents on the basis of these proposals. The Italian (CCD/373) and the Swedish (CCD/372) working papers provide further valuable contribution on these problems.

It has been pointed out in the working paper of the United States delegation (CCD/365) that carbamates present a second type of nerve agents. While certainly highly toxic, their chemical and physical properties seem less suitable for use in warfare and it is not known that any state would have developed a weapons system based on them. They could also be covered by a general formula but this would also cover some carbamates in civilian use.

It has been suggested that the production of organophosphate nerve agents (and possibly carbamates, too) should be subject to unconditional prohibition (save for minimal amounts of carbamates for medical purposes) and that the compliance with the prohibition should be stringently verified. Regarding organophosphates, verification could be based on national recording and international statistical analysis of the principal raw materials, yellow phosphorus, phosphorus trichloride, and phosphorus oxichloride, as suggested in several working papers in CCD.

However, economic monitoring alone would not provide a complete answer to the verification problem in all cases. Some additional generally acceptable international verification mechanism is evidently needed, and the national systems would provide the basis for an eventual international mechanism. The Finnish Government has taken cognizance with great interest about the views put forward by the expert from the USSR at the informal CCD-meeting on July 5, 1972, on the possible ways of co-ordinating a verification by national teams of inspection at an international level.

A second category of compounds which have no peaceful use, but which are stockpiled as chemical warfare agents, are the mustards. Their production also should be subject to unconditional prohibition. Economic monitoring would be even less feasible to this category of compounds than for nerve agents because they are produced from raw materials which are widely used in civilian industry. National control with reporting statistics to an international agency might be sufficient regarding these agents. Some mustards have small-scale medical and peaceful research uses and a clause making possible these uses might be necessary in this case, too.

A third group of chemical warfare agents, the so-called dual purpose agents, contains all those toxic compounds which can also have peaceful uses and which are less toxic than indicated by the above toxicity value (LD_{50}) equal to or more than 0.5 mg/kg body weight. This group would contain e.g. such common raw materials of chemical industry as phosgene, hydrogene cyanide, cyanogene chloride, etc. Although the technologically advanced nations probably would not even consider them as chemical warfare agents today, they might still be usable as such under some circumstances. National control, possibly combined with reporting of statistics on use to an international agency, could be sufficient to this category of compounds.

According to this analysis, efforts to develop verification and control methods could be concentrated in the first instance on the group nerve agents, at least initially. The Finnish efforts visualizing the creation of a national CW-control capacity for possible future international use will focus primarily on this aspect.

4. It is not the intention of the Finnish Government to exaggerate unduly the technical aspects of an eventual treaty on C-weapons. All efforts to find a basis for a comprehensive political solution, like e.g. the Draft Convention presented by seven socialist members of the CCD on March 28, 1972 (CCD/361), are indispensable and welcome. It is obvious that in the final analysis, the achievement of a CW-treaty will depend on political will rather than on solving problems of technical character. Besides the obvious need for adequate verification, the purpose of efforts to solve the most obvious technical problems connected with a CW-treaty would be to promote an atmosphere of mutual trust and thus to provide conditions for the emergence of a political consensus. The goal is, in other words, to obtain a positive feed-back from technology to politics. An analogous case is the problem of the comprehensive test ban, where the role of detection seismology is also to contribute to mutual trust necessary for the conclusion of an agreement.

5. The functions of a national control capacity would be threefold: (1) to assure that the prohibition against the manufacturing of CW-agents is observed. (2) verification of the destruction of existing stocks of CW-agents. (3) to investigate a possible complaint about the use of C-weapons in the field. Although the first function is the more important in the context of an eventual CW-treaty, the third one should not be forgotten, either. The use of C-weapons, at least those of the traditional World-War I-type, might still occur, despite the prohibitions of the Geneva Protocol of 1925, in certain cases of limited warfare. However, it is mainly the problem of verification of the production of CW-agents which plays a significant role in the negotiations at this moment. The methods, equipment and the crews capable of performing inspection duties in order to assure the non-production can in most cases be converted for verification of an alleged use and vice-versa.

6. As has been stated in CCD, e.g. by Minister Myrdal of Sweden on March 14, 1972, the work on a CW-treaty could be concentrated in the beginning on those agents which correspond to the double criterium of (1) being produced solely for military purposes and (2) are highly toxic: The so-called "supertoxic agents". Mrs. Myrdal emphasized the importance of studying, "which methods are or may be made available for the technical control of the production etc. of supertoxic chemical agents (CCD/PV.549). (3) Ambassador Rosenberg Polak of the Netherlands stated on March 23, 1972 that one possible course of action would lead us to concentrate initially on a prohibition of nerve agents as a model for progress in other fields (CCD/PV 552 p. 16-17).

7. Although the ultimate goal is, of course, a comprehensive ...ty banning all C-weapons, this approach is supported by the Finnish Government for practical reasons and without prejudice to its views on the scope of the prohibitions of a future CW-treaty. In his speech on November 17, 1971, the representative of Finland announced that the Finnish Government, for its part, has begun to study how to establish, on a national basis, and within the resources available in Finland, for possible international use a verification and control capacity on chemical weapons. The study has proceeded as planned. A survey of resources has been made, and the Government of Finland is considering the necessary budgetary allocations for an initial research- and training programme for this purpose.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/383
1 August 1972

Original: ENGLISH

THE NETHERLANDS

Working Paper on the possibility of delimitating nerve gases within the field of organophosphorus compounds

(Background paper presented to the informal meeting of the CCD at Geneva, July 5, 1972 by Dr. A.J.J. Ooms. This paper will be published in Volume VI of "The Problem of Chemical and Biological Warfare" by SIPRI, scheduled for October 1972 and was also presented at the SIPRI-symposium on "Possible Techniques for Inspection of Production of Organophosphorus Compounds".)

GE.72-21216

Introduction

Both from the Report of the Secretary-General of the United Nations (1) and from the Report of the World Health Organization (2) it is clear that the nerve agents constitute by far the greatest threat in chemical warfare.

Nerve agents belong to the group of organophosphorus compounds which also contains very useful compounds such as pesticides, polymers, flame retardents and plasticizers. This immediately brings up the problem of the possibility of distinguishing between organophosphorus compounds which have, and compounds which do not have, legitimate uses for civilian purposes. In other words: is it possible to delimitate nerve agents within the field of organophosphorus compounds.

In order to be considered as a potential chemical warfare agent a chemical compound should meet certain requirements (3). Some of these can be listed as follows: a considerable toxicity for mammals, chemical stability in the presence of air and water, stability at explosion and a certain rate of penetration through skin and materials. This list can easily be extended. In this paper we have limited ourselves to the most important property of a potential warfare agent, namely that of toxicity, taking the view that this property, more than any of the others mentioned, might be used in the delineation mentioned above.

In order to be classified as a potential pesticide an organophosphorus compound has also to meet certain requirements. Here, too, the most important will be a considerable toxicity for the pest species it is intended for, e.g. insects or spiders. Ideally a good pesticide should possess a very low toxicity for mammals in general and for man in particular: in other words it should possess selective toxicity.

Unfortunately, in the field of organophosphorus compounds the molecular basis of the toxicity is the same in both mammals and insects. Toxic action is mainly based on the inhibition of the enzyme acetylcholinesterase in positions where acetylcholine acts as a neuro-transmitter (4,5). However, there are a number of cases where organophosphorus compounds have a high toxicity for insects and a low toxicity for mammals (e.g. the insecticide Malathion). In these cases the selectivity can be contributed to secondary effects such as differences in the rate of detoxification or to differences in the rate of penetration through membranes.

We are thus faced with the problem of whether we can draw a borderline between organophosphorus compounds that have an exclusive (potential) use as nerve agents and related compounds that can be used as pesticides. Such a borderline could be

based on a certain toxicity level. Whereas it is theoretically possible to use a nerve agent such as Sarin as an insecticide, this is highly improbable due to the very great hazards this procedure would cause to humans.

Thus, the delegation from Japan at the CCD (6) has proposed a toxicity level of 0.5 mg/kg subcutaneously as a borderline between compounds having exclusive use as chemical warfare agents and other compounds. In the same way, the Swedish delegation at the CCD (7) proposed a level of 1.0 mg/kg orally. These proposals seem to be very reasonable indeed provided that sufficiently standardized methods for the determination of the toxicity could be worked out internationally by toxicological experts.

We do, however, feel that if this criterium can be backed up by a kind of general chemical formula we will have at least a lead in a possible verification process.

Toxicity of organophosphorus compounds related to chemical structure

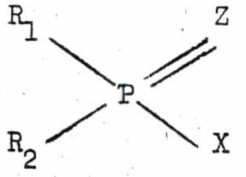
In a way the position with organophosphorus compounds is a favourable one in that we know a good deal about the mechanism of the toxicity on the molecular level: the fore-mentioned inhibition of the enzyme acetylcholinesterase. There seems to be a reasonable relationship between toxicity and the anti-acetylcholinesterase potency (8). As toxicity depends not only on the intrinsic pharmacological effect but also on factors like permeability through membranes, rate of excretion and rate of metabolism, a better-than-reasonable relationship cannot be expected. As the dependence of cholinesterase inhibition on chemical structure is more clear-cut than the dependence of toxicity, we have in the following limited ourselves to a survey of the first-mentioned relationship bearing in mind that some organophosphorus compounds are not cholinesterase inhibitors per sé but are metabolised into potent inhibitors in the organism.

All the nerve agents mentioned in the literature (9) are powerful inhibitors of acetylcholinesterase, in the majority of cases much more powerful than compounds used as insecticides. The problem is thus limited to that of predicting chemical structures giving rise to potent anti-acetylcholinesterases.

The relation between chemical structure and the inhibition of acetylcholinesterase

A very great amount of literature is available on this problem. It is not our intention to review these publications. We will instead give some summarizing results with the emphasis on measurements carried out in our laboratory, not that these are better than those obtained elsewhere but for comparative reasons.

The general formula of an organophosphorus compound which is able to inhibit acetylcholinesterase may be represented by



In this formula R_1 and R_2 are alkyl, alkoxy or amino groups, Z is oxygen or sulphur and X is a group that is split off in the reaction with the enzyme and is therefore called the "leaving group". In the process of inhibition the active site of the enzyme is phosphorylated in an irreversible way: recovery of enzyme activity does not occur or only at a very slow rate. The process of inhibition can be described by the following equation (10).

$$E + I \underset{k_2}{\overset{k_1}{\rightleftharpoons}} \left[EI\right]_R \xrightarrow{k_p} \left[EI\right]_I$$

in which E is the enzyme, I the inhibitor, $\left[EI\right]_R$ an enzyme-inhibitor complex and $\left[EI\right]_I$ the irreversibly phosphorylated enzyme. The reversible step of the reaction depends on the affinity of the inhibitor for the active site of the enzyme and is determined by the dissociation constant $K_d = k_2/k_1$. The phosphorylation constant k_p is a measure for the rate of phosphorylation.

The most relevant data to obtain are obviously K_d and k_p. Unfortunately, however, only few data are available and fewer still for powerful anticholinesterases. Main (11, 12) in a number of publications gives some data and we also obtained both constants for the reaction of stereoisomers of a V-type compound. However, for the problem with which we are concerned, we may also use the bimolecular rate constant of the reaction.

$$E + I \xrightarrow{k_i} \left[EI\right]_I$$

for which the relation $k_i = k_p/K_d$ in the case of a powerful inhibitor can be shown (12). k_i is reasonably easy to determine (for methods see inter alia ref. 13).

In the following, we will use this rate constant as a measure for anti-acetylcholinesterase effects. In general, the rate of enzyme inhibition depends on a number of factors that can be grouped in two categories: (a) the strength of the P-X bond and (b) the interactions of the different parts of the organophosphorus compound with sites of the enzyme. The factors are of course interdependent.

For reasons of simplicity we will discuss the influence of the structure of group X and of groups R_1 and R_2 successively

The influence of the structure of the "leaving group" X

Some data on the rate of reaction of isopropyl methylphosphonates are shown in the table (taken from 14, 15). Only the rate constant of the faster reacting stereoisomer has been shown.

As indicated above two factors can be distinguished.

(a) the strength of the P-X bond.

(b) the interaction of group X with the enzyme.

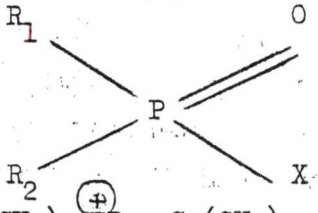
Ad. (a) In general, the greater the strength of the P-X bond the less reactive a compound will be in regard to reactions involving the breaking of this bond. This is a general effect which can be observed in both the hydrolysis and the rate of reaction with esterases. The strength of the P-X bond is related to the pK of the conjugated acid HX; the lower the pK_a of HX the more reactive the organophosphorus compound will be. Thus we find that fluoridates are very reactive towards acetylcholinesterase whereas m-dimethylaminophenyl compounds are very unreactive (14). The few experiments we carried out with azidates ($X=N_3$, pK_a $HN_3=4.7$) point in the same direction. A number of p-nitrophenyl compounds also show a reasonable rate of enzyme inactivation (pK_a p-nitrophenol = 7.0).

Ad. (b) The interaction of group X with certain sites of the enzyme is of course much more specific and will vary from enzyme to enzyme. Limiting ourselves to acetylcholinesterase it is well known that this enzyme contains an anionic site which interacts with the cationic ammonium head of the substrate acetylcholine. If one introduces such a cationic head in the leaving group, a very high rate of inhibition of acetylcholinesterase is obtained (16) with a far more specific effect than with the compounds mentioned under (a). This rate is not

in agreement with the above-mentioned dependence on the pK_a of the conjugated acid (see table) and is therefore attributed to a favourable interaction of this leaving group with the enzyme, probably the so-called anionic site. The importance of the charge can be seen by comparing the rates of compounds 4, 5 and 6 on the one hand and compounds 7 and 9 on the other hand. Studies on the pH dependence have shown (14) that in the case of compound 8 only the protonated (charged) form reacts with acetylcholinesterase. That there is still a dependence on the strength of the P-X bond stems from the fact that the corresponding P-O-C-compounds do not show any anti-acetylcholinesterase affect whatsoever. Concerning the size of the groups on the nitrogen or the sulphur atom, we observed no great changes in the rate constants if the alkyl groups do not exceed a certain size. Concerning the number of carbon atoms between the thiol sulphur and the cationic head there seems to be an optimum between 1 and 4.

The cyano-group as leaving group takes a special position. In phosphates and phosphonates the cyano group gives rise to extremely unstable compounds, but together with amido groups linked to the phosphorus atom, compounds with a fairly high anticholinesterase effect (Tabun) are obtained.

Summarizing the results discussed we may conclude that in the formula

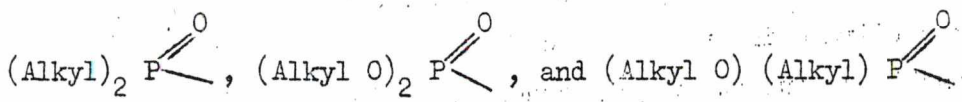


compounds with X = F, N_3, CN, $S-(CH_2)_n-\overset{(+)}{S}R_2$, $S-(CH_2)_n-NR_2$ and $S-(CH_2)_n-\overset{(+)}{N}R_3$ in general are very powerful anticholinesterases. The corresponding toxicity is in most cases also very high. These compounds have therefore to be regarded as potential chemical warfare agents with merely limited non-military use.

The influence of the structure of the groups R_1 and R_2

If the influence of the structure of the leaving group X on the acetylcholinesterase inhibition rate is rather clear-cut, that of the structure of the groups R_1 and R_2, which remain bound to the central phosphorus atom in the process of the inhibition, (we will not discuss here the subsequent process of ageing whereby one of these groups can be split off) is much more complex. The general outcome of our investigation, together with other results available, will be presented here.

First of all, we will distinguish between the following three groups



called phosphinates, phosphates and phosphonates respectively.

The phosphinates are in general rather poor inhibitors of acetylcholinesterase (some of them however do inhibit other enzymes rather well) and fairly unstable.

The phosphates (among them e.g. DFP) give rise to rather good inhibitors with rate constants in the order of 10^5 M^{-1} min. $^{-1}$.

For chemical warfare agents their potency seems to be too low, however.

The phosphonates comprise the group containing the most dangerous nerve agents, so a somewhat more detailed consideration seems to be in place.

Concerning the alkyl group directly bound to the phosphorus atom in the phosphonates, it seems that maximum rates are obtained with methyl groups and fairly high rates with ethyl groups. With larger alkyl groups the reaction rates drop off very rapidly (14).

The structural requirements for the alkoxy group seems to be less stringent. There seems to be a maximum in the C_4-C_6 range. Very high rates are obtained with alkoxy groups containing a dialkylamino or a trialkylammonio group (so called Tammelin compounds) (16) and with cycloalkyl groups. Rate constants of cycloalkyl methylphosphonofluoridates are all in the 10^8 range (M^{-1}min.$^{-1}$) from cyclopropyl up to cyclooctyl. Also unsaturated alkoxy groups give mostly very effective cholinesterase inhibitors.

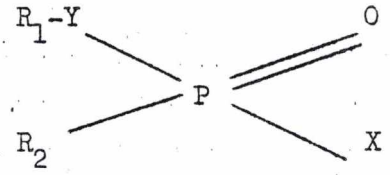
In general the substitution of thiols for the alcohols, giving phosphonothiolates, give somewhat less but still some very potent inhibitors (17).

The dialkylamido group has a somewhat peculiar position. In combination with an alkoxy group and the cyano group as the leaving group, it gives rise to compounds reacting rather rapidly with acetylcholinesterase and showing a correspondingly high toxicity (e.g. Tabun) (18). In some other combinations, rather unreactive compounds are obtained. The situation is certainly less clear than in the cases discussed above.

Finally, we have to consider the OH group. In the literature (19) it is stated that O-desalkylation normally reduces anticholinesterase activity more than 100,000-fold but with certain tertiary amine-containing organophosphates the activity is only reduced

100-fold. As the last mentioned tertiary containing amine compounds are the most active anticholinesterases known, the corresponding OH-containing compounds are still very active, a fact that was confirmed in our own studies.

Summarizing the results discussed, we may conclude that in the formula



compounds with Y = O or S; R_1 is alkyl, cycloalkyl, substituted alkyl or hydrogen and R_2 is alkyl or dialkylamino can give rise to compounds with high anticholinesterase rates and corresponding high toxicity although not in every combination.

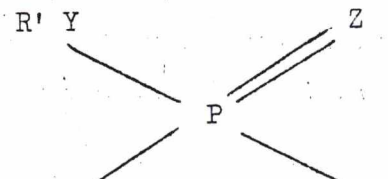
The compounds mentioned (with the X groups discussed earlier) have thus to be regarded as potential chemical warfare agents.

The influence of the P=Z group

Up till now we have discussed compounds containing a P=O group. It is, however, known that a number of compounds containing the P=S group are also toxic. Some of the compounds, virtually the P=S analogue of the nerve gas soman, is as potent an inhibitor as the corresponding P=O compound (20). In other cases, the P=S compounds show a much lower inhibition rate that the corresponding P=O compounds but are still rather toxic because of a biooxydation to the corresponding P=O compounds (e.g. 21). For this reason, we believe that certain organophosphorus compounds, containing the P=S group, may have an application as chemical warfare agents.

Summary

In the preceding paragraphs we have tried to establish some general rules according to which an organophosphorus compound behaves as a potent inhibitor of acetylcholinesterase. As with most structure activity relationships these rules should be regarded rather as tendencies and no firm predictions are possible (although some quantitative predictions turned out surprisingly good (14)). It is therefore impossible to delimitate the potential nerve agents using a general formula only. This formula has to be used in conjunction with a toxicity criterium which should be established by toxicological experts. For the general formula we propose:



in which

Y = O or S

Z = O or S

X = F, CN, N_3, $S-(CH_2)_2-\overset{\oplus}{S}R_2'''$, $S-(CH_2)_n-NR_2'''$ or $S-(CH_2)_n-\overset{\oplus}{N}R_3'''$

R' = (substituted) alkyl, cycloalkyl or hydrogen

R'' = Alkyl, dialtvylamino

R''' = Alkyl

In combination with a carefully selected toxicity criterium, we consider the delimitated group of compounds to include very few compounds which are used as pesticides whereas the majority of compounds may be used as chemical warfare agents. This group could therefore be liable to an unconditional prohibition of production and stockpiling.

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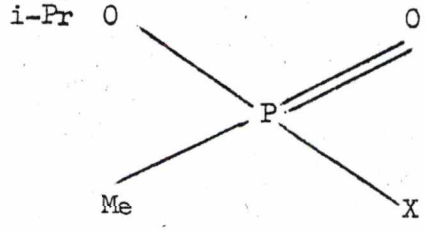
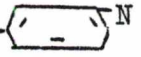
Table

Bimolecular rate constants (M^{-1} $min.^{-1}$) of the inhibition of acetylcholinesterase by a number of compounds with the general formula.



HX	pK_a of HX	k_i(25°, pH = 7.7)
(1) HO-  NMe_2	11.8	1.0×10^3
(2) HO- $-NO_2$	7.0	7.0×10^5
(3) H F	3.5	1.4×10^7
(4) $HS-CH_2-CH_3$	10.4	5.4×10^1
(5) $HS-CH_2-CH_2-CH\ Me_2$	10.6	7.1×10^2
(6) $HS-CH_2-CH_2-S\ Me$	9.6	1.5×10^4
(7) $HS-CH_2-CH_2-\overset{(+)}{S}\ Me_2$	8.2	3.7×10^7
(8) $HS-CH_2-CH_2-N\ Me_2$	8.0	1.0×10^7
(9) $HS-CH_2-CH_2-\overset{(+)}{N}\ Me_3$	8.2	5.3×10^7

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/384
8 August 1972
Original: ENGLISH

SWEDEN

Working Paper on domestic legislation in Sweden regarding chemical substances

During the discussions in the Conference of the Committee on Disarmament on a chemical weapons prohibition particular attention has hitherto been focused on the super-toxic agents, which have no peaceful use. As the goal should be a comprehensive treaty on the prohibition of the development, production and stockpiling of all chemical weapons and on their destruction, time has now come to consider more in detail also the less toxic, so called dual-purpose agents.

As has been pointed out, considerable control efforts are already being devoted by experts and organs in other fields than disarmament to the vast quantities of chemical agents which are used in civilian life. The Conference of the Committee on Disarmament should therefore be able to take advantage of the national and international control which is being built up for environmental and health purposes, in the form of submission of statistics, licensing etc.

It is in order to illustrate this view that a paper on domestic legislation in Sweden regarding chemical substances is presented. The aim of this legislation is to prevent injury to human health and damage to the environment from the increased use in daily life of chemical substances.

The regulations now in force in Sweden in this field are numerous. A review prepared by the Swedish delegation last year for internal working purposes listed no less than 44 different laws and regulations of widely different character.

These laws and regulations largely belong to two different groups. One group refers to products as such and their direct control, e.g. their composition, manufacture, distribution, use, etc. This category includes the Poisons Act, which is the basic piece of legislation as far as products injurious to health are concerned. Coupled with this there is special legislation concerning products such as medicines, narcotics, flammable goods, explosives, radioactive substances, foods, animal feeding-stuffs, pesticides, polychlorinated biphenyls (PCB) and fuel oils containing sulphur, used for heating purposes.

The other group of regulations refers to actions such as the emission or release of hazardous substances, pollutants, etc. Most noteworthy in connexion with pollution control is the Environment Protection Act. The Public Health Act and other legislative provisions, to a greater or lesser extent, control the discharge and spread of substances potentially detrimental to the environment.

It has been found, however, that the present legislation does not provide adequate protection. The Government therefore requested the National Environmental Committee to study the situation and to make appropriate suggestions. The Committee has recently recommended a more comprehensive legislation in the form of a new Act on Products Hazardous to Man and the Environment which it proposes should come into force on 1 July 1973. The already existing National Environment Protection Board should be the responsible authority and - based on authorization given in the Act - issue regulations etc. regarding chemical products. It should also be the supervisory authority under the terms of the Act.

It is recommended that the new legislation be flexible. The risks connected with a certain substance or other product may depend on many different factors. Any one harmful effect may be caused by a range of different products and different control measures may be required depending on the product involved. In addition, the degree of intervention in each case would have to be based on a risk-benefit evaluation, i.e. decisions should be made after a consideration of the socio-economic need for the product balanced against the risks connected with it. Furthermore, new developments in science demand continuous reconsiderations of regulations in force and of decisions already made. For these reasons the Environmental Committee has found precise and detailed regulations out of the question. Accordingly, the Committee has suggested that the new Act on Products Hazardous to Man and the Environment should have the form of a central statute containing (a) fundamental principles concerning the pre-requisites for importation, manufacture, marketing, destruction or other handling of such products, and (b) authority to the administration to issue special regulations for implementation of the Act.

As to the more detailed contents of the Act, the following proposals of the Committee may be of some interest.

The Act shall be applicable to products hazardous to human health and to the environment, defined as substances and preparations that because of their properties and handling are known or suspected to cause poisoning or other injury to man or harmful effects in the environment.

Those engaged in the handling of products referred to in the Act shall take all the necessary steps to prevent or minimize harmful effects from the goods. Those who manufacture or import a product should normally be primarily responsible for any preventive measures required.

The obligation to investigate the effects of a product on human health and the environment shall include all known relevant hazards as far as current methods of examination permit. These investigations obviously cannot be required to exceed the prevailing level of scientific knowledge.

The Government or an authority nominated by the Government shall be authorized to require that hazardous products as well as particular groups of substances and preparations among which such products are to be found, may be imported or handled only after permission has been given by an authority nominated by the Government. The Environmental Committee has considered the question of extending the system of compulsory licensing which now applies to pesticides so as to cover all or at least a great part of chemical products. This system involves a decision by the authorities in each case before a product is put on the market. Considering the great number of individual products concerned and the inadequate availability of toxicological and other expertise, the Environmental Committee has not found it possible to recommend the universal adoption of a system of compulsory licensing. However, the Committee assumes that the number of product groups subject to this kind of licensing will be gradually extended under the provisions of the Act.

The Government or an authority nominated by the Government shall be authorized to prohibit the importation or handling of particular hazardous chemical products.

The Government or an authority nominated by the Government shall receive an authorization to issue special regulations and to stipulate special conditions regarding the importation, manufacture, marketing, destruction and conversion and any other handling of hazardous products as well as particular groups of substances and preparations among which such products are to be found.

In addition to instructions to protect the health of the consumer, the Committee mentions, as an example of a new kind of regulation necessary for some products, instructions for destruction or for bringing remains of the product to an authorized destruction plant.

To be able to maintain a satisfactory control of hazardous products the supervisory authority needs access to information about which products are on the market or otherwise used and their ascertainable composition, toxicological-ecological characteristics, their sales-turnover. An authority nominated by the Government is authorized to issue regulations about an obligation to report the above facts.

A supervisory authority shall have the right to decide on prohibitions that are clearly necessary in order to ascertain that the regulations made are being complied with.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/387
24 August 1972
Original: ENGLISH

CANADA

Working Paper on toxicity of chemical substances, methods of estimation and applications to a chemical control agreement

(Background paper prepared for presentation by Mr. Roy MacPherson at the Informal Meeting of the CCD, 5 July 1972)

INTRODUCTION

Considerable difficulty has been encountered by the Conference of the Committee on Disarmament in the formulation of an agreement banning the development, production and stockpiling of chemical agents for use in warfare. A question which has been raised a number of times by various delegates to the C.C.D. (Japan CCD/301, 344; Netherlands CCD/320; et.al.) has been that of developing a means of defining those chemicals which should fall within the terms of reference of such an agreement. The United States in their paper of March 20, 1972 (USA CCD/360) outlined a number of criteria by which a chemical arms agreement might delineate, for the purposes of control, those chemical substances which have potential usefulness in warfare. Since an agenda item of this meeting is "Criteria for Characterizing 'Super Toxic' Agents", we have chosen to discuss toxicity as a means of classifying chemical substances to be controlled.

Generally, the term toxicity refers to the capability of a chemical substance to produce a noxious effect upon living processes. The physiological effects can range from those that are just observable, to the extreme end of the spectrum, acute lethality. Classes of chemical substances are available for use in warfare, which encompass this spectrum of noxious effects, as is illustrated in Figure I. We shall consider in this paper procedures for estimating the potency of potential chemicals of warfare which have lethality as their primary toxic effect, and in particular those which might be referred to as "super toxic", for example the nerve agents. Our comments in regard to the role of a toxicity criterion for defining CW agents will not be applicable to the control of the less toxic chemical warfare substances, for example the irritants, incapacitants, or some of the older agents such as the mustard gases. We are assuming herein, as the United States paper suggests, that such chemicals would be defined by other criteria of the control agreement.

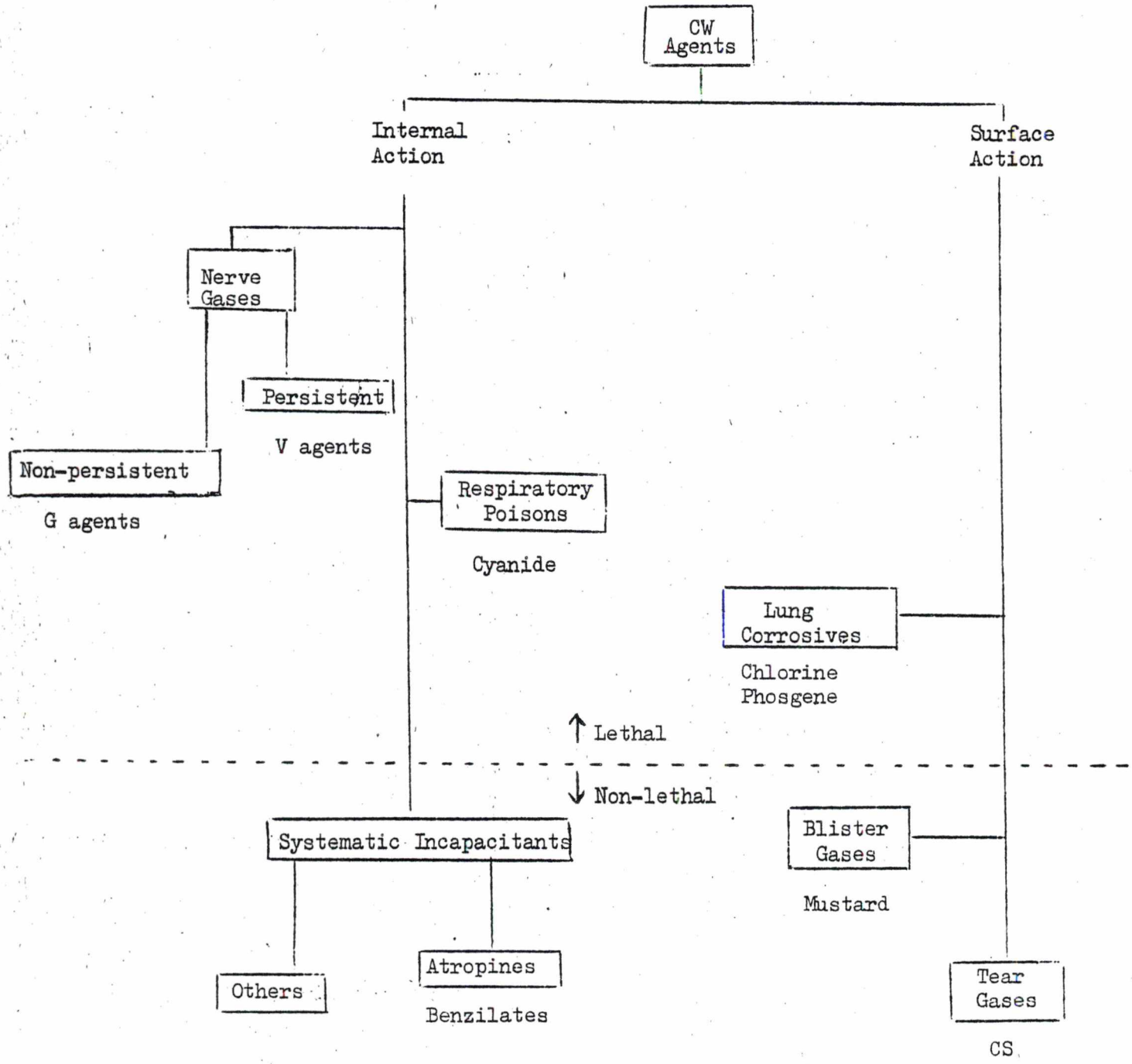


FIGURE I: Classes of CW Agents Defined by Primary Mode of Action

In order to have a toxicity criterion, and in this context we imply lethality, as a part of a chemical control agreement, it will be necessary to develop standardized laboratory testing procedures and means for interpreting the ensuing results should a complaint arise concerning the production or use of a specific chemical substance. We will outline briefly procedures for estimating the lethal toxicity of such compounds, considering for example, resource requirements, choice of test animals, methods of testings, experimental design considerations, etc., and conclude our remarks by giving our opinion on the relationship of lethality testing to a chemical control agreement.

FACILITY AND RESOURCE REQUIREMENTS

To assess the lethal potency of a chemical substance properly, the following supporting factors should be considered in order to make a biological test system functional;

(1) A minimum quantity of the chemical will be required for complete testing; 5 g if it is a solid or liquid, and the ability to synthesize it if it is a gas.

(2) Physico-chemical information is required on each sample tested to verify its authenticity, solubility, composition, etc., for use by the toxicologists directing the biological tests.

(3) Testing laboratories must be equipped with adequate facilities as well as trained operators to handle safely compounds of a "super toxic" nature.

(4) Conditions of storage for the test compounds must be such that the chemical stability of the samples is maintained.

(5) Test laboratories must have the facility to destory or detoxify the samples after testing thereby ensuring no unnecessary holding of toxic chemicals.

To carry out the task of defining the lethality of candidate chemical substances adequately, the following specific investigational requirements must be met:

(1) Quantitative testing must be carried out on more than one animal species, the minimum requirement being two rodent and one non-rodent species.

(2) The species of animals used must be of uniform genetic stock which are guaranteed to be in continuous long term supply. Rodent species used should be albino to facilitate the observation of eye and skin effects. Swine if used should be white-skinned.

(3) Optimum standards of animal care must be practised with uniform environmental conditions for animal treatment and post-treatment holding being employed.

LETHALITY TESTING - RECOMMENDED GENERAL PROCEDURES

It is not possible to define in detail rigid procedures which should be followed in the estimation of the lethal potency of a chemical substance with relevance to its

possible usage in warfare. Much depends upon the nature of the substance and the circumstances under which it is being tested. We would, however, recommend the following general approach to lethality testing:

Stage 1

If the substance to be tested is a gas, then, for simplicty the analyst should carry out inhalation studies, the elements of which we will discuss at a later stage of this presentation. If it is a solid or liquid, it should first be administered to mice by intraperitoneal injection using a gross observational method for recording dose-effect similar to that described by Campbell and Richter.[1] Initial testing should be carried out at a dose of 50 mg/kg. It and all subsequent dilutions (in a 0.9 per cent saline solution) should be administered at a volume of 0.005 ml/g to male mice weighing from 28 to 32 g. If the substance is non-water soluble it can be suspended in 0.9 per cent saline solution containing 0.5 per cent methylcellulose. The animals in each dose group should be closely observed for 30 minutes and all physiological symptoms recorded; subsequent observation for mortality should be carried out at 24, 48 and 72 hours. If animals die between 24 and 72 hours, it will be necessary to extend mortality observation to 14 days.

In addition to the above testing, other groups of male mice should be similarly injected intravenously with the chemical in a saline solution, or if it is insoluble, subcutaneously in suspension at an injection volume as above. The rate of the i.v. injection should be constant at 0.01 ml/sec. The dose administered should again be 50 mg/kg, and a similar observation time as employed following the i.p. injection is recommended.

If deaths appear in groups of ten animals treated at a dose of 50 mg/kg by either method of administration, subsequent dilutions should be made and injected into other groups for determination of LD_{50}'s by appropriate statistical techniques.[2,3]

Under the assumption that further testing is still required, male rats weighing 200-250 g should be injected with a saline solution or suspension of the test compound. Groups of not less than five rats are to be tested with the compound being injected by both the intraperitoneal and the intramuscular routes. The volumes for administration are 0.002 ml/g for i.p. and 0.001 ml/g for i.m. Observation for dose mortality effect should be carried out for 72 hours and again if death occurs between 24 and 72 hours the groups of animals should be observed for a total of 14 days for final recording and compilation of data. LD_{50}'s for the compound, administered by the two different routes, would be required.

Stage 2

Compounds with LD_{50}'s significantly less than 50 mg/kg in either of the rodent species by any route of administration thus far used should now be tested in a non-rodent species. The animal of choice for this testing is the dog.

If the compound is soluble in water it can again be administered in a 0.9 per cent saline solution via the intravenous route (injection volume 0.2 ml/kg, rate 0.2 ml/sec). If it is non-water soluble it should be administered subcutaneously in an aqueous suspension containing 0.5 per cent methylcellulose at a volume of 0.1 ml/kg. Each animal would then be closely observed for eight hours after injection for symptoms and subsequently at 24, 48 and 72 hours. Surviving animals should be held for a total of 14 days for observation of the occurrence of delayed symptoms and death.

On the basis of the toxicity data obtained from the three species possibly tested, the chemical substance should now be categorized according to its lethal potency utilizing the minimum LD_{50} thus far recorded. One possible categorization is that given in Table I.

TABLE I

CW LETHALITY CATEGORIZATION

Class	LD_{50} Dose Range
Toxic	50 - 1 mg/kg
Highly toxic	1.0 - 0.025 mg/kg
Extremely toxic	<0.025 mg/kg

Those chemicals classified as toxic may be viewed as being within the upper limit of what would be logistically feasible as lethal weaponry. Further toxicity studies are not recommended on such chemicals since it is unlikely that they would come within the terms of definition of a toxicity criterion; however, this does not imply that the information available cannot be interpreted with regard to other criteria of the chemical control agreement. Those found to be highly or super toxic would warrant further consideration and this implies that the investigators must orient their approach to evaluating the chemical substance with regard to its potential usefulness in warfare. This requires a detailed interpretation of the potency data obtained thus far, and also an understanding of the physico-chemical properties of the substance.

Stage 3

Chemicals which are found to have an intrinsic toxicity categorizing them as potential lethal CW agents (e.g., LD_{50} <1 mg/kg), should be subjected to further testing as follows. Similar toxicity studies as previously carried out in the two rodent species should be extended to include separate assays for both male and female animals. If significant differences in lethality appear which are attributable to sex, it will be necessary to carry out both male and female assays in the other species utilized.

Autopsies should be carried out on the rats and dogs tested to look for any gross pathological changes. This should be done on animals killed by the agent and also on those which had survived the sub-lethal dose treatments for a period of 14 days.

Compounds which are highly or extremely toxic should also be tested with relevance to their most practical route of entry in man, the most practical route of entry being based upon the physico-chemical properties of the substance, e.g., as illustrated in Table II.

TABLE II

PRACTICAL ROUTES OF ENTRY IN MAN VS THE AGENTS PHYSICO-CHEMICAL PROPERTIES

Physico-chemical property	Route of Entry
gas (at normal temperature and pressure)	inhalation
liquid - high vapour pressure	inhalation - vapour
liquid - low vapour pressure	inhalation - aerosol
	percutaneous - intraocular
	- normal skin
solid - high vapour pressure	inhalation - vapour
solid - low vapour pressure	inhalation - aerosol
	percutaneous - introcular
	- normal skin

The assessment of the lethal hazard of the chemical substance being tested by the above mentioned routes of entry should be carried out according to standardized techniques, and we recommend the following points be considered:

(a) Inhalation Route:

Inhalation lethality should be calculated from two relatively short exposure periods of two minutes and ten minutes, and the dose response reported as an LCt_{50}. The choice of species for inhalation studies is either the dog or swine. The vapour or aerosol exposure facility would require the support of an analytical chemistry facility to monitor actual agent concentrations in the chamber during the exposure. If the substance is a solid, it will be necessary that aerosol particles be generated in an optimum particle size range to permit penetration into the lung alveoli.

Immediately after exposure the animals must be observed closely for symptoms for a period of eight hours and the surviving animals periodically observed for 14 days. Special note should be taken of the delayed increase in post-treatment pulmonary insufficiency and pulmonary secondary infection. All animals, both in cases resulting in mortalities, as well as those surviving for 14 days, should be autopsied with particular attention being given to the incidence of lung necrosis and edema.

(b) Percutaneous Route:

Specialized integuments such as the corneal surface or conjunctival sac of the eye should be challenged with the lethal substance. Water soluble liquids or solids should be dissolved in a saline solution and instilled as a 5 ul drop into the conjunctival sac or as a 1 ul drop on the corneal surface of the eye of a rabbit. Non-water soluble substances may be dissolved in propylene glycol or suspended in 0.9 per cent saline containing 0.5 per cent methylcellulose. The animals should be closely observed for time to onset of symptoms and death, and surviving animals should be retained for 14 days at the end of which they should be examined for ocular pathological effects.

Chemical liquid substances, classified as highly or extremely toxic by previous animal tests, may be further tested for their percutaneous lethal potential on intact normal skin. In this case clipped rabbits and clipped swine can be contaminated on the skin of their back with 200 micron free-falling drops of the pure liquid chemical. The animals would be restrained for a period of two hours after treatment and then released for an additional 14 day observation period. Close observation of the contaminated area would be carried out for the formation of chemically induced lesions.

Thus far, we have outlined briefly test procedures for determining the lethal potency of a chemical substance with particular attention to its application as a lethal CW agent. These procedures are summarized graphically in Figure II. The major problem that would arise after such testing is the interpretation of the data in relationship to a chemical arms control agreement.

RELATIONSHIP OF LETHALITY TESTING TO CHEMICAL ARMS CONTROL

The objective of the lethality testing is to assess quantitatively the relative potency of a substance in terms of its LD_{50} or LCt_{50}, and relate these to a chemical arms control agreement. These derived lethality indices can contribute to a chemical arms control agreement in a number of ways. They not only provide a means of categorizing toxic chemical substances but also they can be used to define this categorization. If the situation arises that a specific chemical is being produced or used in apparent contravention of the terms of a chemical control agreement, its lethal potency can be established according to the procedures outlined, and then its derived index compared to a "cut-off" level defined by a toxicity criterion of the agreement. This information will contribute to the interpretation of the situation being investigated.

The Japanese representatives to the CCD have suggested (Japan, CCD/301) that a chemical substance with a lethal dose less than 0.5 mg/kg be considered for control. We would agree with this "cut-off" point for intrinsic toxicity. Such a level will not however control the less lethal potential chemicals of warfare and in this paper, as stated before, we assume that such chemicals would be defined by other criteria of the agreement.

The problem will arise that some chemicals because of their high intrinsic toxicity could be considered for control when in fact they need not necessarily be practical CW agents. It is for this reason that we have attempted to emphasize the fact that the toxicity data must be interpreted with relevance to the chemical's potential for meeting the necessary characteristics of a chemical warfare agent.

Toxicity alone does not make a chemical substance a good lethal agent of warfare. Other factors must be considered, for instance, availability of raw materials to produce it, simplicity of production, cost involved, storage stability, stability during and after dissemination, ease and efficiency of dissemination. Failure to meet a number of these factors could prevent a highly toxic substance becoming a CW agent.

It will be necessary to define toxicity test procedures in more detail than discussed herein. This can best be done by a panel of toxicologists and for the sake of brevity we have tried to limit the amount of detail presented. The United States in their paper have suggested that a consultative body of experts be set up to co-ordinate and interpret such work. Scientific investigations could provide estimates of LD_{50}'s and LCt_{50}'s according to procedures such as have been outlined, but it would be the responsibility of the consultant experts to interpret the results in relationship to the control agreement.

CONCLUSIONS

(1) Procedures for estimating the lethal toxicity of a chemical substance have been outlined with emphasis being placed upon assessing the potential of such substances for chemical warfare.

(2) If a toxicity (lethality) criterion is to be included in a chemical arms control agreement we would recommend the following points:

(a) Control of chemical substances (considered as lethal CW agents) which have an $LD_{50} > 1$ mg/kg cannot be based upon toxicity alone.

(b) Those with an LD_{50} greater than 0.5 but less than 1.0 mg/kg should be considered as potential lethal chemicals of warfare but it would be necessary to assess their practicability as CW agents. This would depend, to a large degree, upon the substance's physico-chemical properties. Means other than a toxicity criterion would be necessary to define controls for such chemicals.

(c) Chemical substances which have an $LD_{50} < 0.5$ mg/kg should be controlled and a feasible approach to this control within a chemical arms agreement would be a toxicity criterion.

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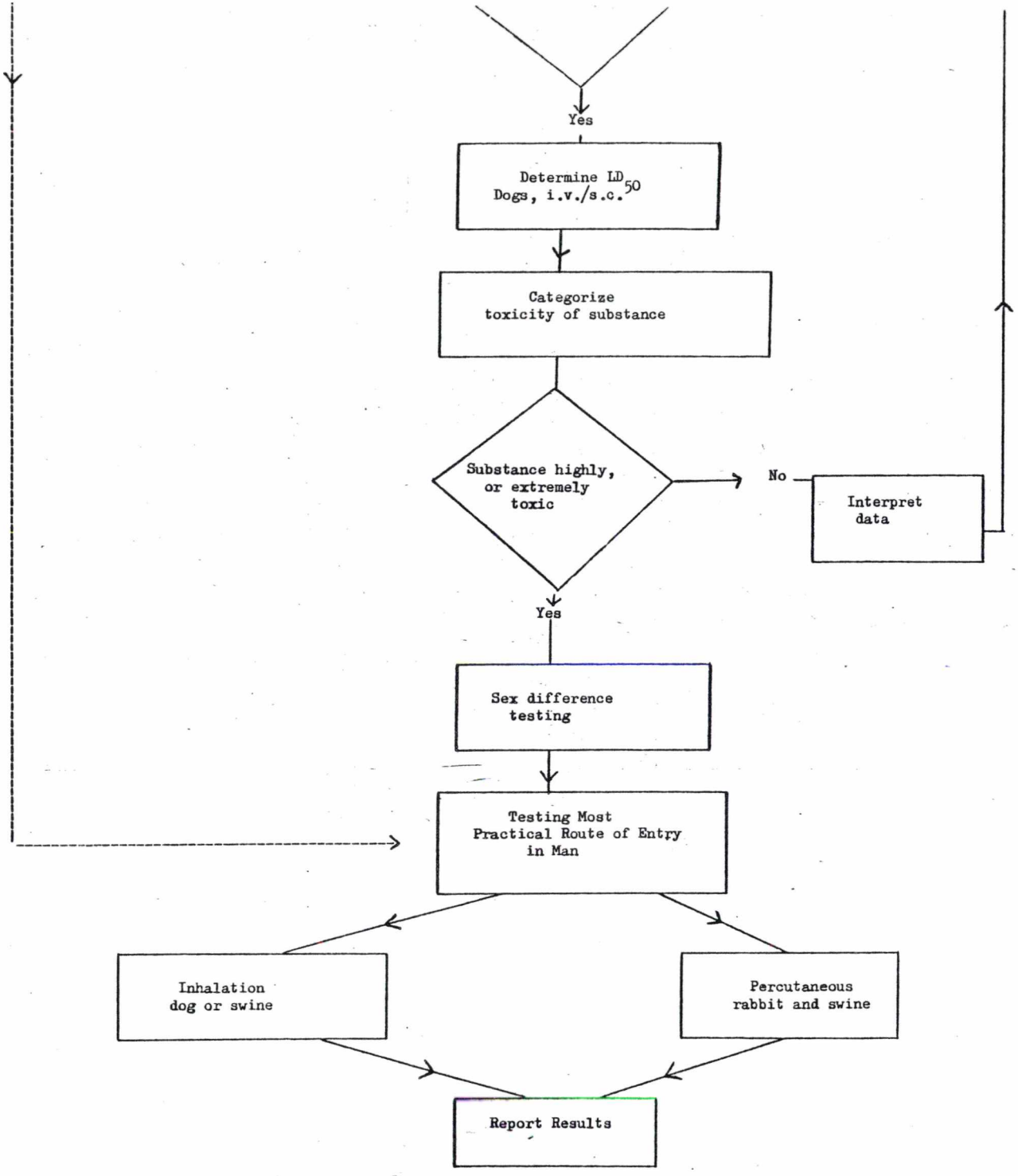
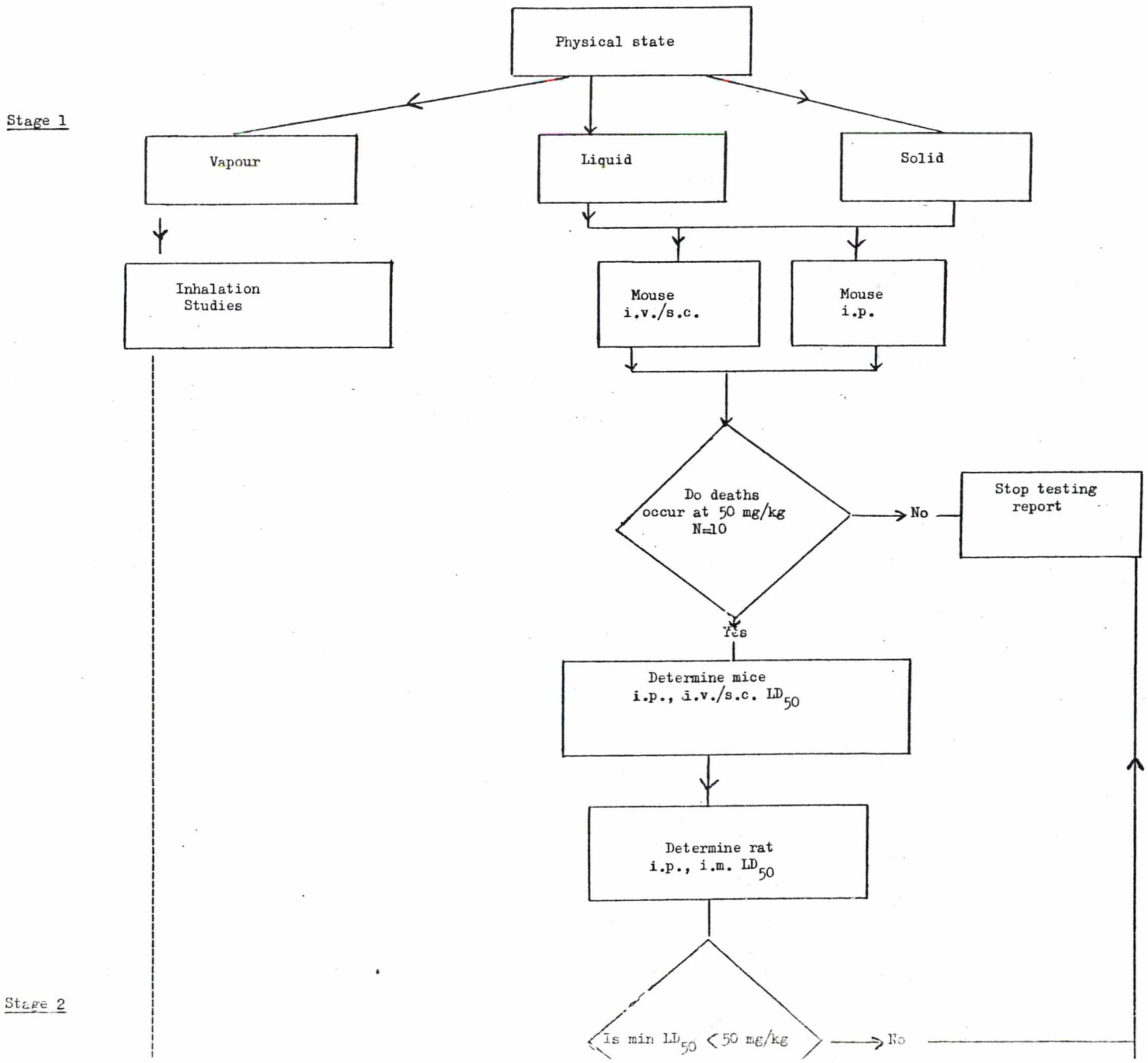
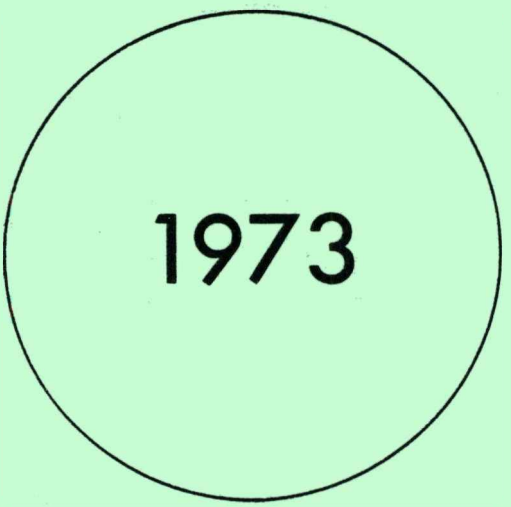


Stage 3

FIGURE II: CHEMICAL AGENT LETHALITY TESTING - GENERAL PROCEDURES


Stage 1
Physical state
Vapour
Liquid
Solid
Inhalation Studies
Mouse i.v./s.c.
Mouse i.p.
Do deaths occur at 50 mg/kg N=10
No
Stop testing report
Yes
Determine mice i.p., i.v./s.c. LD_{50}
Determine rat i.p., i.m. LD_{50}
Stage 2
Is min LD_{50} < 50 mg/kg
No


1973

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/395
6 March 1973
Original: ENGLISH

SWEDEN

Working paper on the concept of amplified verification in relation to the prohibition of chemical weapons

The principal role of verification in disarmament treaties

The use of control methods is stipulated in a treaty in order to verify that the parties comply with their undertakings under that treaty. General models for different types of control can be worked out. However, the conditions in the field to be covered by a treaty determine the actual verification measures to be stipulated. This can be exemplified briefly: with regard to the comprehensive test ban, only one control measure (detection of underground explosions) is discussed; with regard to nuclear material, control of the production of only one substance (down to kilogram quantities) by means of several methods is discussed. In contrast, a possible treaty prohibiting the development, production and stockpiling*/ of chemical agents of warfare will have to employ several control methods, covering not only several activities but also (tons of) many different chemical substances. This fact implies not only that usual decision theories are not easily applicable, but also that the question of false alarms must be given special attention. A discussion of these two aspects is attempted in the following. Practical and political implications are considered.

The role of verification in a ban on DPS of chemical agents of warfare

A chemical DPS ban covering several chemical agents will require several different control methods. This has become quite clear from the discussions in the CCD.

It has been argued, although no consensus has been reached so far, that the primary purpose of the many possible control methods in a future chemical ban should be to trigger some kind of procedure to establish whether a violation of the treaty has occurred or not. Furthermore, no agreement has been reached whether this procedure should involve on-site inspection or be restricted to some less intrusive

*/ The expression "development, production and stockpiling" is in the following abbreviated "DPS".

procedure. This part of the verification process will not be discussed in this paper. It is, however, assumed that the control methods discussed in the following are to be managed by an international control organization, using e.g. nationally gathered information for the purpose of control, as may be agreed upon in a treaty.

The necessity of using many control methods and the uncertainty as to the form for establishing a treaty violation makes it insufficient to consider the kind of discriminatory decision levels generated by a single verification measure which would apply in the case of the comprehensive test ban. Instead, it will be necessary to consider the effects of several verification measures in combination; in other words, to evaluate the amplified verification described later in this paper.

Amplification of verification efficiency

Much discussion has been devoted to how effective a non-intrusive method for the verification of the compliance with a disarmament treaty should be in order to deter its parties from violating the treaty, when subsequent on-site inspection is allowed or not, as the case may be. There seems to be consensus that the verification methods need in no case be 100 per cent effective.

Less attention seems to have been focused on the consequences of using several independent methods of verification, each with limited prospects of success, in revealing a violation. This is commented upon in the following, with special reference to the attempts to agree upon a ban on the DPS of chemical agents of warfare.

It is intuitively felt that the use of several independent methods of verification should increase the possibility of detecting treaty violations. Such an increase can easily be shown formally by applying a simple mathematical reasoning about probabilities. (See J. Lundin, Considerations on a chemical arms control treaty and the concept of amplified verification, FOA Reports 7:1 (1973) 1 - 5.)

To illustrate the effect of the amplification of the verification, one may consider the hypothetical situation concerning a ban on the DPS of chemical warfare agents given below. The revealing probabilities given in the example may be too high to be realistic, but then more methods can be introduced under the headings given. In a real case the given "revealing probabilities" should be evaluated by relevant experts, as discussed later.

Elements contained in an assumed prohibition of chemical arms and hypothetical verification results of their application

Forbidden activity	Possible verification method	Hypothetical values of revealing probabilities
Development		
Research on supertoxic substances, antidotes	Scanning literature by computer	0.03
Field tests	Remote sensing from satellites	0.1 */
Production	Statistical survey of export-import data for basic chemicals, e.g.	
	Phosphorus	0.03
	Phosphorus trichloride	0.03
Stockpiling	Finding instructions for handling of chemical munition	0.03
Training	Finding manuals on offensive use of chemical munition	0.01

*/ Cf. CCD/371, 1972.

False alarms

Evidently, the political drawbacks of a false alarm due to the performance of a control method are serious. That a nation, because of imperfect technical means, can be falsely accused of violating a treaty may to some parties be more objectionable than being left with a verification method that cannot detect every violation committed by other parties. It is thus important that the verification results be presented in a way that cannot be interpreted as an accusation. To achieve this is one of the aims of the verification model discussed in this paper.

It is assumed that the function of the accumulating circumstantial evidence from the several verification methods shall be to trigger such further investigatory procedures as may be agreed upon in a treaty. One could then foresee that requests for complementary information to back up quite normal findings about toxicological work, pesticide production, etc., obtained by the verification methods, would be considered as a normal routine procedure. Such a procedure would probably also make it easier to secure co-operation with industries.

The way of circumventing the problem of false alarms would lie in the insight and acceptance of the fact that each verification method is in itself a weak instrument which only in exceptional cases can give a straight answer, and which normally provides incomplete answers. Thus, there should be no reason to look upon a single result as an alarm, but rather as part of the continuous information procedure.

Need to give alarm alleging that a party has violated a treaty will arise only when several or all verification methods concur to indicate the possibility of a treaty violation, when requests made by routine for complementary information are rejected without reason, or when the information given turns out to be inconsistent with other information obtained.

The remaining genuine uncertainty

It might be questioned whether the application of the "amplified verification" system has a reassuring rather than a deterring effect on a party to the treaty. This may be described in the following way:

When two potentially adverse parties adhere to a treaty prohibiting production of chemical warfare agents, this implies that both parties officially wish to uphold the treaty. Being signatories of the treaty, neither wishes to be exposed as violating the treaty ban. At the same time, neither can accept that the other party could secretly violate the treaty. Thus the primary need is to have a verification system sufficiently reliable to expose to some degree an adverse violator. If one of the parties feels reassured about these possibilities, he can abstain from a capability of waging chemical war himself for any of three reasons: (1) he does not wish to have such a capability; (2) he would not need it, since an adversary can be expected to be disclosed at an acceptable level of probability (provided, as is done here, that this gives himself time to take countermeasures); (3) he would himself suffer the same risk as the adversary of being exposed by the verification system. From this reasoning it can be inferred that the reassuring effect would come first and thus in itself be sufficient.

The situation would essentially be the same if one or both of the parties already possessed a war-waging capability with chemical agents before becoming parties to the treaty. A treaty prescribing destruction of stockpiles would require verification methods for this, as well as for other activities covered by the treaty. Thus, by definition, the verification effect would be amplified again by introducing another control activity.

Thus, if it is possible to construct a reasonably reassuring control system, the problem would revert to the genuine uncertainty of whether some other power - perhaps

a potential adversary - intends in the future to acquire a chemical war capability. It can be assumed that any party entering into a treaty would expect other parties to observe the treaty obligations. The genuine uncertainty referred to above would therefore only relate to a more distant future. To assess this remains a political task, where one would have to take into account the option offered by the withdrawal clause in the treaty.

Practical and political implications

It may be interesting not only to determine how successful a verification method may be in disclosing a forbidden activity which is in effect not likely to occur. As suggested above one could e.g. also introduce a concept implying that a verification method investigates some normally occurring activity which is likely to undergo some change if and when a violation of the treaty is being prepared or is already taking place. The control method could be designed to analyse certain relevant data. The efficiency might be expressed through the confidence which experts would have in the verification method as to its ability to perform its task.

Politically, this means that it would be difficult for a country to start an activity in the field of chemical warfare which could go on totally unnoticed: warning signs would be obtained, even if they might be explained away.

Should several warnings appear simultaneously, they should certainly, taken together, be sufficient to warrant an investigation, if such a procedure is provided for in the treaty, or to entitle any party to withdraw from the treaty. Since the result of the verification methods would be official and be known by all parties, it would be easy for all other parties to judge the fairness of a withdrawal.

This procedure should therefore be easier to apply in the event that a suspected violator was unwilling to explain the coincidence of several "warning signs" or vetoed an investigation.

A withdrawal clause similar to the one just discussed hypothetically is found in the first DPS ban on biological and chemical agents of warfare, the convention on biological and toxin weapons.

Conclusions

The over-all efficiency of the verification system of a treaty prohibiting DPS of chemical agents is increased by the use of several verification methods. The verification methods may not be exclusively aimed at detecting violations, but could

primarily be designed to detect, with known efficiency, changes in normal activities in the chemical field. Such changes might constitute warning signs. The occurrence of many warning signs on behalf of a party to the treaty, in connexion with unwillingness to explain them or to let an investigation take place, might enable other parties to withdraw from the treaty. This construction of the verification system makes it reassuring rather than deterring. In view of the fact that the use of chemical warfare agents is already forbidden by the Geneva Protocol of 1925, such a reassurance should be sufficient.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/400*
26 April 1973
Original: ENGLISH

ARGENTINA, BRAZIL, BURMA, EGYPT, ETHIOPIA, MEXICO, MOROCCO, NIGERIA, SWEDEN AND YUGOSLAVIA

Working paper on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction

Having, on previous occasions, expressed in working papers (CCD/310, CCD/352) their preliminary views on banning bacteriological (biological) and chemical methods of warfare, the delegations of Argentina, Brazil, Burma, Egypt, Ethiopia, Mexico, Morocco, Nigeria, Sweden, and Yugoslavia, members of the Conference of the Committee on Disarmament now wish, as a concrete contribution to progress in negotiation, to present some further views on the following four important aspects of a Treaty banning chemical weapons: (I) General Provisions; (II) Scope of the Prohibition; (III) Verification and System of Control; (IV) Complaints procedure.

(I) GENERAL PROVISIONS

Any agreement banning Chemical weapons should include:

1. A clear understanding whereby future agreed provisions for the prohibition of the development, production and stockpiling of chemical weapons are not to be interpreted as in any way limiting or detracting from the obligations assumed by the Parties under the Geneva Protocol of 1925.
2. Provisions to ensure that the agreement should be implemented in a manner designed to avoid hampering the research, development, production, possession, transfer and application of chemical agents for peaceful purposes or hindering the economic or technological development of States Parties.
3. An undertaking not to assist, encourage or induce any State, group of States or international organizations in prohibited activities.
4. Undertakings to facilitate, and a right to participate in, the fullest possible exchange of chemical agents, equipment material and scientific and technological information for the use of such chemical agents for peaceful purposes.

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* Re-issued for technical reasons.

5. A recognition of the principle that a substantial portion of the savings derived from measures in the field of disarmament should be devoted to promoting economic and social development, particularly in the developing countries.

6. Security guarantees which in the interest of many countries should go beyond those envisaged in already existing disarmament and non-armament agreements.

(II) SCOPE OF THE PROHIBITION

7. Discussions in the Committee show a basic agreement on the objective of the negotiations relating to Chemical Weapons, namely that they should aim, in accordance with relevant United Nations resolutions, at reaching a comprehensive ban, covering the development, production and stockpiling of all Chemical Weapons, their equipment and means of delivery, as well as the destruction of existing stocks.

8. The degree of danger represented by the use of chemical agents for purposes of war depends besides their toxicity, to a high degree, on the protection available, as well as on the means of delivery. Since adequate protection against any kind of chemical weapons is not available to the greater part of the world population, even less toxic agents can create as great a danger as highly toxic ones and therefore should be prohibited.

9. It is essential that the prohibition of chemical weapons should be coupled with adequate verification. The question of verification has both technical and political aspects which should be reconciled and therefore it is connected with the scope of the prohibition. Solutions to the problems of scope and verification should not be discriminatory and should maintain an acceptable balance of obligations and responsibilities for all States. A partial solution with respect to the scope of the activities to be prohibited, which would only ban the development and production of chemical weapons, will be particularly discriminatory and will not be acceptable to many countries, specially to those which have abstained from procuring such weapons.

10. In the Treaty's text, a comprehensive ban could deal with the problem of scope by a general purpose criterion while more detailed provisions could be elaborated in the annexes to the Treaty. These agreed provisions may be revised and updated by the international control organ referred to in part III, paragraph 14.

(III) VERIFICATION AND SYSTEM OF CONTROL

11. The purpose of the verification system in a treaty prohibiting chemical weapons should be to give every Party a reasonable assurance of compliance of the prohibition. Such assurance could be provided through a combination of national and international measures, which would complement and supplement

each other, thereby providing an acceptable system which would ensure effective implementation of the prohibition. At least the following basic elements should be included: (A) the self-control of states, (B) national means of verification, and (C) international measures of verification.

(A)

12. The self-control of states parties to the treaty might encompass (a) declarations, at the time of entering into force of the prohibition, as regards national activities related to production and development of chemical weapons and agents, particularly concerning the destruction of existing stockpiles; (b) measures aimed at implementing the prohibition, including the enactment of laws and regulations; (c) the organization of a national system of control and control body with authorization to co-operate with the international control organ and (d) informing the international control organ of these measures of self-control.

(B)

13. Every state could use its own means to verify the observance of the prohibition, in accordance with international law and United Nations charter. The States Parties might undertake to consult one another and to co-operate in solving any problems which might arise in relation to the objective of, or in application of provisions of the Treaty. Consultation and co-operation might also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its Charter.

(C)

14. International measures of verification should be performed by a qualified and independent international control organ to be designated by the States Parties, and the results should be made available to all parties on an automatic and fact-finding basis.

They might comprise collection, analysis and circulation of relevant data and assistance to states parties in the development of self-control as well as national means of verification. On the other hand, the international control organ should receive full assistance of States Parties in the development of international verification measures, including relevant technology at the disposal of States Parties. The verification system should encompass all activities related to development, production and stockpiling of chemical warfare agents. As a non-recurrent measure, international inspection could also be

specially provided for in order to verify destruction of stocks, in a manner to be agreed upon between the International Control Organ and the State Party concerned.

15. The international verification system should, within the provisions of the Treaty, be reviewed and as appropriate improved, taking into account new scientific and technological achievements. The verification system should be conceived and implemented in such a way as to avoid the disclosure of scientific, industrial and commercial secrets.

(IV) COMPLAINTS PROCEDURE

16. Any State Party might, as a last resort, lodge a complaint with the Security Council concerning an alleged breach of the provisions of the Treaty by another State Party.

17. The complaining State Party should submit all possible evidence, including a report or reports, which might be prepared by the international control organ mentioned in part III paragraph 14 above, to the Security Council.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/403
28 June 1973

ENGLISH
Original: RUSSIAN

BULGARIA, CZECHOSLOVAKIA, HUNGARY, MONGOLIA, POLAND, ROMANIA, UNION OF SOVIET SOCIALIST REPUBLICS

Working paper on ways of implementing control over compliance with the convention on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction

Introduction

A system of guarantees to ensure that all parties to the agreement are complying with the obligations they have assumed should be based on national forms of control combined with certain international procedures. This is the basis from which the present working paper proceeds. Of course, it is for each State party to the convention to determine the form and methods of implementing national control. The following considerations may be regarded as outlining possible ways of fulfilling the obligations of States parties, as provided for in article IV of the draft convention submitted by the socialist States on 28 March 1972 (CCD/361).

National control committees

A State Party to the Convention establishes a national control committee as an element in the national system of control over the prohibition of the development, production and stockpiling of chemical weapons within the territory of the state concerned, under its jurisdiction or control. The national control committee should, by way of random verifications, supervise the destruction of stockpiles of chemical weapons and the closure or conversion to peaceful production of the chemical enterprises which had, before the conclusion of the convention, been engaged in production of means of warfare. It would also supervise compliance with the prohibition of the production of the means of delivery of chemical weapons. The composition of the national control committee could be determined by the State party to the convention. The committee could consist of representatives of governmental and public organizations, depending on the specific conditions existing in the country concerned. The committee staff could include specialists in chemistry and economics. Effectiveness of control is ensured by the modern methods available to specialists in chemistry. These include the use of detection apparatus, analysis of waste gases, analysis of waste water and soil at enterprises, the installation of sealed sensing devices, and visits to enterprises by the appropriate specialists

representing the national committee. It is also desirable that the national control committees should, as necessary, be able to examine reports on research work carried out by various research institutions in the chemical industry and related fields. Internal legislation should provide for the national control committees to submit reports to national governments on their activities, and should also allow for the possibility of publishing such reports for general information.

Exchanges of information

The national system of control could also be accompanied by exchanges of information among States, on a voluntary basis, in the form of discussions on new data obtained as a result of scientific research on the development of new products for peaceful purposes.

Statistical analysis

Analysis of statistical data, contained in open publications, on the production and consumption of raw materials and semi-finished products could form one of the elements of control over the prohibition of chemical weapons. A comparison of the amount of chemicals (raw materials and semi-finished products) manufactured over a year or some other long enough period, with the volume of the consumption of chemicals for peaceful purposes, might to a certain degree provide evidence of the way in which a State is complying with the obligations it has assumed under the agreement. A sizable excess of production over consumption would give grounds for assuming that the surplus was being diverted for military production. In such a comparison, due account should of course be taken of the amounts of chemicals imported, which should be added to the total production figure, and also of the amounts exported, which may notionally be included under consumption. Some proportion of output may be placed in storage if there is temporarily no market for it, or for other reasons. On the other hand, consumption may include chemicals which had been produced before the beginning of the period under study. Bearing these circumstances in mind, any discrepancy between the volume of production and the volume of consumption should be carefully studied. When no data are available on the consumption of a particular chemical, it would be useful to analyse data on the production of substances in whose manufacture this chemical is used as an initial or semi-finished product. If one knows the

approximate amount of the chemical needed for the production process, one can thus calculate the total amount of the chemical consumed. At the same time, it is of course essential to remember that the rate of use of one and the same chemical may differ widely from enterprise to enterprise, depending on the level of industrial technology, the degree of mechanization, etc.

Limitations on patenting

It would be expedient, as a measure to increase control over scientific research, to prohibit the patenting of chemical substances, weapons, equipment and means of delivery which are banned by the convention, i.e. to stop issuing patents and to cancel existing patents in this field. This measure, which is in keeping with the provisions of article IV of the draft convention submitted by the socialist States, would considerably lessen the incentive for further research in the field of chemical means of warfare.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/410
31 July 1973
Original: ENGLISH

NETHERLANDS

Working paper on an international organ for the support of a CW convention and other disarmament agreements

I

1. In recent discussions concerning the possible form and contents of a CW convention, the creation of a standing organ for the operational support of such a convention has been suggested by several delegations. The subject was first broached in the United States working paper CCD/360.

2. The present working paper contains an elaboration of Netherlands views expressed on this subject in the past and it is submitted with a view to stimulating further discussions on this important aspect of a ban on chemical weapons.

3. The paper is mainly of an illustrative nature. In part II it briefly describes some organizational aspects of the establishment of a standing organ and deals in part III with the functions to be allocated to an international organ as envisaged by the Netherlands delegation. Part III is based on a number of working hypotheses, which could be modified if found to be unsatisfactory. This part is also mainly illustrative, but it could stand on its own if, rather than discussing the concept of an "embryonic IDO", the CCD would prefer to focus attention on organizational arrangements in the context of a CW convention.

II

4. The Organ could be constructed along the familiar pattern of many international organizations, i.e. a plenary Conference, a Board and a Secretariat.

5. Membership of the Conference would raise no problem if the Organ would function in the context of a CW convention only; members would be the parties to the convention. Taken as the nucleus of an international disarmament organization with future responsibilities also in other fields, the Organ should be open-ended. Rights and duties of individual members, except for the right of speech, would then have to be limited and determined by their adherence to the treaties (or their review conferences) which specificially provide for certain tasks of the Organ.

6. While the Conference, as a rule, would only meet at certain intervals, the Board would have to be so organized as to be able to function continuously. Members of the Board would be elected by the Conference. Its main functions could be envisaged as providing practical guidance to the work of the Organ on the basis of a programme to be established by the Conference.

7. The Secretariat, headed by an Administrator, would consist of a permanent staff and such additional panels of experts as may be required for the performance of ad hoc or highly specialized activities such as special investigations or technical studies.

III

8. It is assumed that a CW convention will have an annex containing a list of agents that would specifically be forbidden. (This assumption is based on the insufficient precision of the purpose criterion by itself. It may be noted that the assumption is consistent with a comprehensive approach towards chemical disarmament as well as with a phased or partial one. The Organ would have to do the up-dating of the annex if necessary. Whenever a party would dispose of information which, in its opinion, would require an amendment to the annex, it should notify the Administrator of the Organ and furnish him with the information in support of the notification. Appropriate procedures would be needed to enable the Board to amend the annex provisionally, pending a definitive decision to be taken by the Conference.

9. It is assumed that, even under an unconditional prohibition of certain agents, parties will be entitled to keep small quantities of these agents for prophylactic, protective or other peaceful purposes. Parties would undertake to supply to the Administrator on a regular basis all information on the kinds and quantities of the agents concerned and on the purpose of their use. The Administrator should make this information available to all other parties.

10. A provision of a CW convention for the destruction of existing stockpiles of chemical means of warfare or their diversion to peaceful purposes, should call for the declaration of these stockpiles and for international observation of their destruction or diversion. The Administrator could be the addressee of the declarations as well as the originator of observational activities, in which experts of the Secretariat could take part together with observers from interested parties. The Administrator should keep all parties informed concerning matters pertaining to the destruction or diversion of military stockpiles.

11. A CW convention will probably contain a non-transfer and a non-assistance clause. The Conference, on its own initiative, or upon recommendation by the Board or by the Administrator, could give guidance for its implementation, e.g. by means of im- and export regulations.

12. An article of a CW convention could call for national legislation to ensure the fulfilment of the basic obligations under the convention. Such measures could be reported to the Organ and coordinated by the Organ.

13. Should a CW convention provide for the exchange of economic data, the Organ would be the indicated clearing house for such an exchange.

14. In general, parties could undertake to furnish to the Administrator such information as the Board might request for the performance of its functions, and in particular an annual report on the working of the convention within their respective territories stating inter alia if any activity prohibited under the convention has occurred.

15. Upon decision by the Board the Administrator could be authorized to request any party to provide complementary or supplementary information regarding any event or circumstance connected with compliance with the convention, setting out his reasons for the request. Parties should undertake to cooperate with the Administrator.

16. This procedure could also be initiated upon a request to the Board by a party.

17. Confidence in the information to be supplied would significantly be enhanced if the Administrator could be given standing authorization to carry out random checks.

18. If reasonable doubts would remain whether a party has fully complied with his obligations under the convention, these doubts could only be removed by a special investigation. Such a special investigation should be decided upon by the Board, which should formulate the procedure for the organization and execution of the investigation. As a rule, such investigations would have to be carried out by experts to be appointed by the Board from a list of experts drawn up every year by the Administrator upon recommendation by parties. Parties should undertake to render all assistance to the investigators as necessary for the performance of their duties. A copy of reports resulting from such an investigation should be transmitted to all parties and to the Secretary-General of the United Nations for transmission to the Security Council.

19. A special investigation might also be carried out at the request of a party suspected of having violated the convention or at the request of a party which is of the opinion that certain activities on its territory could give rise to suspicion.

20. The Board might decide, or any party might request, the convening of a special session of the Conference for the purpose of considering the reports resulting from any special investigation. The Conference might make recommendations to the parties and submit reports to the Secretary-General of the United Nations for transmission to the Security Council.

21. If the Organ would be available, a CW convention could dispense with a provision for a review conference.

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CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/412
14 August 1973
Original: ENGLISH

LETTER DATED 9 AUGUST 1973 FROM THE ACTING PERMANENT REPRESENTATIVE OF FINLAND TO THE SPECIAL REPRESENTATIVE OF THE SECRETARY-GENERAL TO THE CONFERENCE OF THE COMMITTEE ON DISARMAMENT TRANSMITTING A WORKING PAPER BY THE GOVERNMENT OF FINLAND

ON THE PROGRESS OF THE FINNISH PROJECT FOR THE CREATION ON A NATIONAL BASIS OF A CW CONTROL CAPACITY FOR POSSIBLE FUTURE INTERNATIONAL USE

Sir,

Upon instructions from my Government, I have the honour to enclose a Working Paper by the Government of Finland to the Conference on Disarmament with the request that you would take appropriate steps to have it distributed in the Conference of the Committee on Disarmament.

Accept, Sir, the assurances of my highest consideration.

(Signed) Seppo Kauppila
Acting Permanent Representative
of Finland

Encl.

GE.73-50695

WORKING PAPER BY THE GOVERNMENT OF FINLAND TO THE CCD

On the progress of the Finnish project for the creation on a national basis of a CW control capacity for possible future international use

1. In the working paper presented by the Government of Finland to the CCD a year ago (CCD/381) it was stated that

> "There is a need for substantive Preparative work in the field of scientific knowledge and co-operation in the study of technical problems connected with the verification and control of chemical weapons within the framework of a CW-treaty now under consideration in the CCD".

The Finnish project was intended to concentrate on the creation of a national CW-control capacity for possible future international use and would focus in the first instance, on the group of nerve agents. The goals of the Finnish project were further described in a statement by the Representative of Finland in the First Committee of the General Assembly of the United Nations on November 7, 1972, as follows:

> "In a way the Finnish project looks beyond the present toward a situation when a CW-treaty may have become a reality. In order to be useful in alternative situations which a future treaty may entail, it has been conceived as a multipurpose project both substantially and functionally. Substantially the planned control capacity could be useful in three different verification activities: verification of the destruction of stocks, of non-production of chemical weapons and of alleged use. Functionally the capacity could be of service whatever the ultimate solution of the verification problem might be: it would obviously be useful for national verification in Finland or any combination of national inspection with international elements. It could also be of potential use in connexion with an investigation ordered by the Security Council subsequent to a complaint. Finally, it seems to respond to a concern which has been voiced in the CCD by a number of developing countries on account of their difficulties in shouldering the tasks of verifications by their available national means only."

2. The Finnish project has proceeded as planned. Concrete research work was initiated in the spring of 1973 when budgetary funds became available. The project is under the direction of Foreign Ministry and supervised by its Advisory Committee on Disarmament. Its purpose is to train scientific experts and to develop verification and control methods for chemical agents. At its initial stages, the work focuses on chemical problems and enzymatic methods for the detection of the effects of nerve agents. The work is divided between 6 research teams located in the following laboratories of Finnish Universities and the Defence Forces:

Departments of polymer chemistry, organic chemistry and forensic medicine of Helsinki University, Department of organic chemistry of Jyväskylä University, Department of chemistry, Defence Forces' Research Centre and the CBR-school (Chem., Biol., Radiol. protection) of the Army. The work of these research teams is centrally co-ordinated and provides for exchange of information, preparations and personnel as the need may be.

The research teams have at their disposal very modern scientific instrumentation including gas chromatograph-mass spectrometry units with computorized data processing, IR and NMR spectrometers etc.

3. The initial research programmes focus on the following aspects of organophosphorus nerve agents,

their synthesis including precursors of binary systems,

their analysis, primarily by gas chromatography and thin layer chromatography,

their detection by the anticholine esterase method and by specific indicator reactions,

their decomposition reactions, and the persistance in nature of their decomposition products.

Identification of unknown compounds is most effective when a large collection of reference samples is available. In addition to all possible nerve agents of military interest and related organophosphates with peaceful use, like insecticides, identification of their precursors, intermediates and decomposition products is also relevant. This requires a considerable amount of synthetic work, part of which has to be carried out in a special laboratory with appropriate safety arrangements. Because the scope and nature of a possible chemical-weapons convention are as yet undetermined the goals of the project are defined with a certain flexibility. Initially, however, the emphasis is on analytical methodology.

4. It is hoped that one of the results of the project will be an analytical handbook which could be useful in the verification activity of national control systems, of possible international groups of experts or of other international disarmament control and monitoring organs ("IDO", "UN-DISCO"), as proposed e.g. by the representative of Sweden (CCD/PV.610, p. 13) or in the Dutch working paper submitted to the CCD on July 31, 1973 (CCD/410).

5. The socialist countries have devoted a working paper CCD/405 to national verification activities. To carry out such activities requires, of course, specialized scientific expertise, that may not be readily available to all nations. Reliable chemical data in handbook form could therefore be useful for national as well as international control and verification activity. It is hoped that the Finnish Project can provide a contribution, albeit a modest one, in this field.

The Finnish Government will keep the CCD informed about the future progress of this project.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

JAPAN

CCD/413
21 August 1973
Original: ENGLISH

Working paper on the main points of an international agreement on the prohibition of the development, production and stockpiling of chemical weapons and their destruction

In his statement on March 22 (CCD/PV.594) and June 26 (CCD/607), the Japanese representative Ambassador Nisibori suggested that a gradual approach be adopted in a practical as well as realistic manner in order to facilitate an early settlement of the question of banning chemical weapons.

Using this as a basis and with a view to facilitating the settlement of this question in a concrete manner, the Japanese Delegation presents this working paper which includes suggestions on an international agreement embodying a treaty and its supplementary document.

The working paper contains: I. General Items, II. Scope of Prohibition, III. Verification.

I. General Items.

1. The international agreement on banning chemical weapons would incorporate: (a) a treaty which prescribes a comprehensive ban; and (b) a supplementary document defining the scope of the foregoing treaty.

The supplementary document would be regarded as an inseparable part of the treaty. The procedures allowing for amendments to the supplementary document would be simplified ones and would be included in the treaty.

2. While the matters which should be prohibited in the international agreements cover (a) activities (development, production, stockpiling, transfer, etc.), (b) chemical agents, and (c) weapons, equipment and means of delivery, Japan considers it appropriate to start temporarily with a partial ban on (a) activities and (b) chemical agents.

3. In drafting the international agreement, the following formula may be considered:

the treaty would first prescribe in a comprehensive manner the matters (ennumerated in (a), (b) and (c) above) to be prohibited, and then the supplementary document and a provision of the treaty would prescribe the matters to be excluded temporarily from the comprehensive ban.

In prescribing the exclusions, a choice between the two following formulae is suggested:

(1) The supplementary document would prescribe a part of the matters (ennumerated in (a) and (b) above) to be excluded, and a provision of the treaty would prescribe that the foregoing matters be excluded from a comprehensive ban;

(2) the supplementary document would prescribe a part of the matters (ennumerated in (a) and (b) above), and a provision of the treaty would prescribe that matters other than those mentioned in the supplementary document be excluded from a comprehensive ban.

4. In adopting either of the foregoing formulae of the treaty prescribing a comprehensive ban (including (1) and (2) above), Japan considers it appropriate to place a ban in the treaty on:

(a) developing, producing, stockpiling or otherwise acquiring or retaining of; and

(b) transfer and assistance, encouragement, or inducement in manufacturing or acquiring of;

chemical agents and weapons, equipment or means of delivery designed to use such agents.

5. On matters which have been excluded temporarily from a comprehensive ban, the treaty should include a provision by which States parties to the treaty undertake to continue negotiations in good faith in order to agree at the earliest date on concrete measures for realizing a comprehensive ban.

6. The treaty would contain a provision that each State party to the treaty undertakes to conduct national verification probes which by nature are autonomous, and also another provision under which international verification would be conducted, for the purpose of ensuring the fulfilment of the obligation assumed under the treaty. Details pertaining to national and international means of verification would be provided in the supplementary document.

7. Relations between the Geneva Protocol and the international agreement on banning chemical weapons, consultation and co-operation among the States parties, and such procedural matters as entry into force and duration of the treaty would be drafted in conformity with the corresponding provisions of the BW treaty.

II. Scope of Prohibition

1. While general purpose criteria (e.g. types and quantities that have no justification for protective or peaceful purposes) would be adopted in a comprehensive ban on the agents; the agents which for a partial ban should be prohibited

immediately as mentioned in I.2. would be prescribed in the supplementary document under objective criteria (e.g. toxic criteria, general structural formulae, listing, etc.).

2. General purpose criteria (e.g. for hostile purposes or in armed conflict) would be adopted in a comprehensive ban on the weapons, equipment and means of delivery as mentioned in I.2. . Japan considers developing and producing as the activities which should be prohibited immediately.

3. The supplementary document would contain an additional provision prescribing that the time and formula for the destruction or diversion for peaceful purposes of chemical agents, weapons, equipment, means of delivery, etc., as mentioned in foregoing 1. and 2. are to be settled at the time of the agreement on concrete measures for banning their stockpiling.

III. Verification

1. National verification

National verification to be conducted by each State party to the treaty would be primarily autonomous, its purpose being to ensure the fulfilment of the treaty. Study should be made as to the inclusion of an obligatory provision in the treaty which would oblige each State party to co-operate when necessary with the international verification organization mentioned in 2. below including reporting on a regular basis to the organization on matters deemed necessary for the purpose of ensuring the fulfilment of the treaty.

2. International Verification

International verification would be conducted by an international verification organization. Activities of the organization would include constant and objective surveillance and inquiry as deemed necessary.

If an inquiry is conducted by the international verification organization, it would be desirable for the treaty to contain a provision which obliges the organization to report the results of the inspection to an appropriate United Nations Organ, in order to define relations between the organization and the United Nations.

The supplementary document would have an additional provision regarding the composition, activities, etc. of the international verification organization.

3. Request for Explanation

Both the international verification organization and States parties to the treaty would be permitted to request an explanation in the case of suspected breach of obligations deriving from the treaty. It might be effective for the treaty to contain the following provisions on the procedures for this purpose:

(1) The international verification organization or any State party to the treaty which suspects that any other State party is acting in breach of obligations deriving from the treaty may request an explanation from the other party in question.

(2) A State party which has not received a satisfactory explanation from the other State party in question through the foregoing procedure (3.(1)) may request an inquiry by the international verification organization.

4. Inspection

It would be useful for the treaty to contain provisions on the following procedures on inspection to be conducted by the international verification organization:

(1) A State party which has been required to provide an explanation in accordance with the foregoing 3.(1) may at any time invite the international verification organization to conduct on-site inspection;

(2) the international verification organization may notify a State party of its planned inspection in case; (a) the organization finds that the State party has not provided a satisfactory explanation and that it is acting in breach of the obligations deriving from the treaty or (b) a request for inspection is filed by any other State party;

(3) any State party which is notified by the international verification organization of its planned inspection would have to give strong reasons for not complying with the notification.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/414
21 August 1973
Original: ENGLISH

CANADA

The problem of defining chemical substances in a treaty prohibiting the development, production and stockpiling of chemical weapons

The Problem

The purpose of this paper is to address the question of defining as simply and unambiguously as possible the substances that might be banned or controlled as chemical weapons agents if a comprehensive agreement on chemical weapons could be negotiated.

2. As the effects of chemical substances on living organisms are both varied and complex, it has proven difficult to formulate simple definitions to separate those chemicals that are relatively harmless from those that have military utility and which are also in production for civil purposes.

3. A widely expressed view in the CCD has been that a treaty could set out the scope of a comprehensive ban by way of a general description of the chemical agents to be affected by a general purpose criterion, while more detailed technical provisions could be elaborated in an annex to the treaty which could be subject to periodic review and revision by an international body established for that purpose by the treaty. There has also been a view that to the extent possible the scope of a treaty should encompass the chemical agents found in civil use which have been or could be put to military use.

4. This paper examines the basis on which a general purpose criterion in a comprehensive treaty could be supplemented by a more detailed technical scheme of definition of chemical warfare agents based on levels of toxicity of chemicals. It also examines how such a scheme of definition could be used, together with other definitions, to assist in establishing the scope of prohibition under a treaty.

5. It is useful at this point to draw attention to the meaning of some of the terms used in this paper:

toxic means poisonous in the sense of causing physiological injury to a human; this effect includes blistering, blindness, and death;

supertoxic means highly poisonous; that is, only very small quantities are needed to produce physiological harm; in practice, for the modern nerve agents, this means death;

binary agents or precursors are agents employed in weapons in which the components necessary to produce a super-toxic agent are kept separated until mixed during the process of delivery. The main advantage of such a weapon is the ease of handling.

Approaches to defining CW agents

6. From a number of working papers presented to the CCD, it is apparent that three general approaches to defining chemical weapons agents can be employed.

(a) a definition based on purpose or intent;

(b) a strict technical definition of chemicals based on generalized formulae, supplemented where necessary by the specific identification of chemicals; and

(c) a definition based on chemical agent effects, as in the Geneva Protocol.

7. A definition based on purpose or intent. This approach would be exemplified by a general criterion derived from the Biological Weapons Convention, requiring the prohibition of "agents ... of types and in quantities that have no justification for ... peaceful purposes" and "weapons equipment or means of delivery designed to use such agents for hostile purposes or in armed conflict".

8. A general prohibition based on purpose or intended use, given the difficulty of objectively identifying intent, might not take sufficient account of technical considerations to allow a meaningful CW prohibition. The filling of munitions with toxic chemicals and the production or stockpiling of single purpose agents are the only self evident measures. However, it would be possible to use toxic CW in war without employing either single purpose agents or special munitions. Hence the need has been seen to supplement a general purpose criterion with technical definitions.

9. A definition of chemical substances based on generalized formulae. This approach is based on the idea that it may be possible to derive a generalized formula or series of such formulae which would encompass all agents, present and future, that could have military utility. To be valid, however, this approach would require a direct correlation between formula and desired military effectiveness. Unfortunately, it has not proven generally possible to determine the lethality of a chemical from an examination of its molecular structure or its formula, nor to predict lethality from the formula of an untested compound.

10. While this correlation cannot be established generally, there has been some success in relating the formulae of organophosphorus compounds to toxicity [CCD/320 (Netherlands), CCD/365 (USA), CCD/374 (Japan)] and it may be possible to extend this concept to the mustards and arsines. On the other hand, for carbamates and some of the older dual purpose agents, even a limited general formula approach has not proven to be practical and it becomes necessary to list specific compounds.

11. A definition based on chemical agent effects, such as in the Geneva Protocol, which prohibits "the use in war of asphyxiating, poisonous or other gases, and of all analogous liquid materials or devices".

12. Agents having lethal effects or producing serious and permanent injury can be described by toxicity. Discussion of toxicity and the methods of its measurement have been features of a number of presentations to the CCD [e.g., Canada (CCD/387), Japan (CCD/301, 374) and Sweden (CCD/372)]. There has been no discussion of other agent effects.

13. A scheme of definitions based on toxicity has the strength of focussing on the effects which are of military importance: death or permanent injury. By establishing lines of demarcation or thresholds, based on the dosages required to produce such effects, it is possible to define chemicals as agents of war and, supplemented by agreement on whether a chemical agent has civil uses, to establish for different chemicals, the scope of activities which should be prohibited.

14. A general purpose criterion may be essential to a treaty to describe its broad intent and to encompass certain CW agents and weapons; of the technical means of supplementing such a general purpose definition, the third of the approaches to definition holds the most promise.

Toxicity Thresholds

15. The question arises whether by considering a range of toxicity, a toxicity threshold can be established above which compounds can be considered as potential weapons and below which, for all practical purposes, no such potential exists.

16. A number of CCD papers have discussed the concept of a threshold by considering the determination of a line of demarcation (CCD/372) or a target point (CCD/374) to separate the single purpose supertoxic agents from all other chemicals of lower toxicity, including some which have military application. This threshold of effective median dosage is used as the upper or first threshold in this paper and could be used to separate modern single purpose "nerve" agents from those of lower yet significant lethality.

17. To assist in the problem of defining those chemical agents of lower toxicity but potential military usefulness from the rest, it is proposed to introduce the concept of a second threshold to separate militarily useful agents from those chemicals that have no practical potential as CW agents. This lower threshold would serve to define the scale of toxicity so that any militarily useful chemical would be above this boundary, while those below would be classed as non-military.

18. For the purposes of this paper an upper threshold is set by naming tabun, the least toxic of the single purpose supertoxic agents, as a boundary agent. Other supertoxic agents would fall above tabun. Mustard would be just below this threshold. Chlorine, which is not a highly lethal agent, could be used to set the lower threshold or level of the least militarily significant lethal agent.

19. This classification of toxic chemical agents is shown in Table I.

20. While no numerical values of these thresholds for toxic agents are included in the table, the following values are suggested:

Upper threshold	Lct50 = 500 mg.min/m^3
Lower threshold	Lct50 = 20,000 mg.min/m^3

(Lct50 = Dosage vapour concentration multiplied by time of exposure lethal to 50 per cent of exposed personnel. (The toxicity units chosen depend on inhalation. Equivalent values for dosages associated with other methods of exposure, for example, through the skin or the eyes, could be derived. Uncertainties in the dosage value of a particular agent are within the range defined by the threshold valued.))

21. The upper threshold is suggested because of the major difference of toxicity between tabun and mustard, and should be the subject of both international discussion and agreement. This value has no significance in the definition of a chemical as an agent of war. It is relevant, however, to the scope of activities which might be prohibited, for once we drop below this toxicity level, we begin to encounter toxic chemicals in industrial use.

22. The lower value was also chosen somewhat arbitrarily. Chlorine, although used in World War One, is not now considered as an effective agent and has been relegated by some countries to training purposes. It might be regarded as the least toxic agent to have military utility, at least against an unprotected force.

23. From this, it now seems possible to suggest a general definition of toxic chemical substances that might be agents of war subject to control and/or prohibition: a chemical compound or element can be considered as an agent of war if its toxicity has a median lethal dosage less than 20,000 mg.min/^{3} or a practical equivalent of this dosage.

Use of Agent Definitions in establishing Scope of Prohibition

24. Having now suggested a system for identifying chemical substances as being potential agents of war, it remains to consider how these definitions might be applied in determining the scope of prohibition of a comprehensive chemical weapons ban.

25. Thresholds have been suggested which separate those chemical substances which have military potential based on their lethality, from those that do not have such a potential. (Some of the chemical substances thus defined as being potential agents of war also have recognized peaceful uses.)

26. A threshold of toxicity has been suggested which defines the supertoxic compounds for which there are no recognized peaceful uses (other than for small quantities required for defensive research and medical purposes). From this, it is possible to suggest that the development, production and stockpiling of these chemicals could be prohibited if a chemical weapons prohibition could be negotiated.

27. Of those toxic chemical substances identified by the lower threshold as being potential agents of war, but which fall below the upper threshold, some have recognized civil uses, i.e., the "dual-purpose" toxic agents having peaceful industrial uses. It would, therefore, not be possible to ban the development, production and stockpiling of these chemicals solely on the basis of their place on the scale of toxicity. It is suggested that an international committee of experts could identify those chemicals having such civil uses for which development, production and stockpiling could be permitted. However, the filling of military ordnance with toxic dual purpose industrial chemicals could be prohibited. The development, production and stockpiling of other chemicals above the lower threshold and not identified as having recognized civil uses could be prohibited. The toxic chemicals in this latter sub-class could be identified by specific formula in some cases and possibly by family of formulae for others (both the mustards and arsines may be accommodated by the "family approach").1/

28. Binary weapons, are designed to create a supertoxic compound only on discharge; it is likely that in any binary system at least one of the components would have a toxicity falling above the lower threshold. If this component were identified as having a civil purpose, it could be treated in the same way as the other dual-purpose agents; that is, its production and stockpiling for peaceful purposes might be permitted, but the filling of munitions with such binary weapons components could be prohibited.

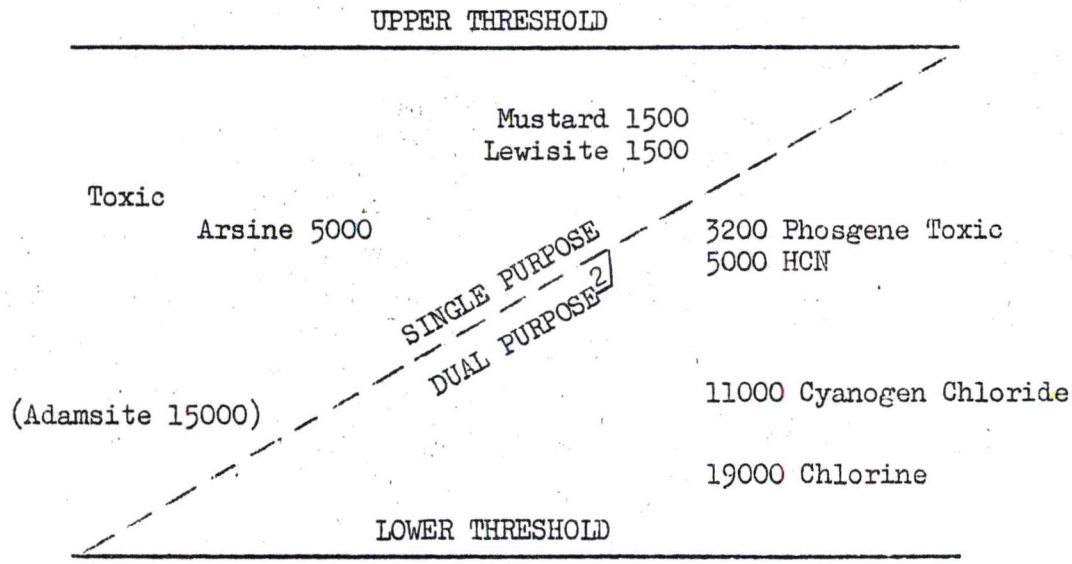
29. For illustrative purposes the application of the types of definition to the scope of prohibition is shown in condensed form in Table II.

1/ The formula approach is considered to be useful in the case of older single purpose toxic agents because (a) the exhaustive surveys that have been undertaken since World War I have not produced compounds significantly better than those already known and (b) there may be no incentive to find new chemicals in this range of lethality when the supertoxics exist on one hand and where there are dual purpose agents available on the other hand. If in any event such chemicals were discovered, they could be added to any list of specifically proscribed compounds.

TABLE I

Classification of some chemical compounds and elements based on toxicity including sub-groupings based on purpose

Lethal Agents	Lct50[1] mg.min/m^3
VX	10-50
Sarin	100
Soman	50-100
Tabun	400



All other chemicals that have no significant military value

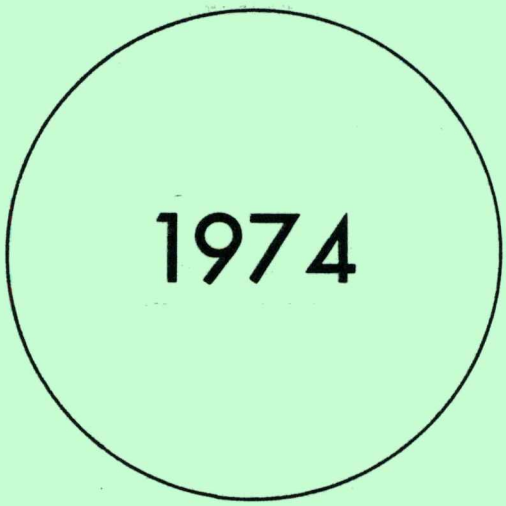
1/ Dosage vapour concentration multiplied by time of exposure lethal to 50 per cent of exposed personnel.

2/ Chemicals having both military and civil uses.

TABLE II

Application of types of definitions to the scope of prohibition: ILLUSTRATIVE ONLY

	Super-Toxic	Single Purpose Toxic	Dual Purpose Toxic	Binaries
Development Production and Stockpiling Agents	Banned by toxicity (upper threshold)	Banned by toxicity (lower threshold) and purpose as determined	Allowed (determined by agreement as being required for civil use and identified by formula)	N/A (at least one component may fall into foregoing categories)
Filling of Military Ordnance	N/A	N/A	Banned on basis of intent or end use	Banned on basis of intent or end use


1974

CCD/420
30 April 1974
Original: ENGLISH

JAPAN

Draft Convention on the Prohibition of the Development, Production and Stockpiling of Chemical Weapons and on their Destruction

The States Parties to this Convention,

Determined to act with a view to achieving effective progress towards general and complete disarmament, including the prohibition and elimination of all types of weapons of mass destruction, and convinced that the prohibition of the development, production and stockpiling of chemical weapons and their elimination, through effective measures, will facilitate the achievement of general and complete disarmament under strict and effective international control,

Recognizing the important significance of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 17 June 1925, and conscious also of the contribution which the said Protocol has already made, and continue to make, to mitigating the horrors of war,

Reaffirming their adherence to the principles and objectives of that Protocol and calling upon all States to comply with them,

Recalling that the General Assembly of the United Nations has repeatedly condemned all actions contrary to the principles and objectives of the Geneva Protocol of 17 June 1925,

Recalling also that each State Party to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction, in Article IX of the Convention, affirmed the recognized objective of effective prohibition of chemical weapons and, to this end, undertook to continue negotiations in good faith with a view to reaching early agreement on effective measures for the prohibition of their development, production and stockpiling and for their destruction, and on appropriate measures concerning equipment and means of delivery specifically designed for the production or use of chemical agents for weapon purposes, and

Convinced that an agreement on the prohibition of chemical weapons, in the wake of the above-mentioned Convention on bacteriological (biological) and toxin weapons, will contribute to the strengthening of confidence between peoples and the general improvement of the international atmosphere, and also contribute to the realization of the purposes and principles of the Charter of the United Nations,

Have agreed as follows:

Article I

Each State Party to this Convention undertakes never in any circumstances to develop, produce, stockpile or otherwise acquire or retain:

(a) Chemical agents of types and in quantities that have no justification for protective or other peaceful purposes;

(b) Weapons, equipment or means of delivery designed to use such agents for hostile purposes or in armed conflict.

Article II

1. Each State Party to this Convention undertakes to destroy, or to divert to peaceful purposes as soon as possible all agents, weapons, equipment and means of delivery specified in Article I, which are in its possession or under its jurisdiction or control.

2. States Parties to this Convention shall notify the International Verification Agency, defined in Article VI, of the pending destruction or diversion to peaceful purposes of the agents and others as specified under paragraph I of this Article on each such occasion.

3. The States Parties to this Convention shall, in carrying out the destruction or diversion to peaceful purposes of the agents and others as specified under paragraph 1 of this Article, invite the International Verification Agency to send observers.

4. The International Verification Agency shall forthwith communicate the notification under paragraph 2 of this Article to each State Party to this Convention.

5. The destruction or diversion to peaceful purposes of the agents and others as specified under paragraph 1 of this Article shall be reviewed at a conference or conferences of States Parties to this Convention provided for in Article XVII.

6. In implementing the provisions of paragraph 1 of this Article all necessary safety precautions shall be observed to protect populations and the environment.

Article III

Each State Party to this Convention undertakes not to transfer to any recipient whatsoever, directly or indirectly, and not in any way to assist, encourage, or induce any State, group of States or international organizations to manufacture or otherwise acquire any of the agents, weapons, equipment or means of delivery specified in Article I.

Article IV

Notwithstanding the provisions of Articles I and II, the States Parties to this Convention may take provisional measures provided for in the Annex I of this Convention until further agreements, including those on effective verification measures, are reached.

Article V

1. Each State Party to this Convention shall take any necessary measures to ensure the fulfilment of its obligations deriving from this Convention, and notify the International Verification Agency of its national organ or organs responsible for taking such necessary measures.

2. Each State Party to this Convention shall submit to the International Verification Agency periodic reports on the state of the fulfilment of its obligations deriving from this Convention in accordance with the provisions of the Annex II.

3. The functions of the national organ referred to in paragraph 1 of this Article shall include the following:

(a) observation as well as supervision of the national activities related to the subject matter of this Convention;

(b) collection of statistical and other information thereon;

(c) preparation of periodic reports to the International Verification Agency;

(d) co-operation with the International Verification Agency such as presentation thereto of requested statistical and other documents or information, and acceptance of inspection.

Article VI

1. In order to promote the realization of the provisions of this Convention and the fulfilment of obligations assumed by the States Parties under this Convention, the States Parties to this Convention shall establish an International Verification Agency.

2. The functions of the International Verification Agency shall include the following:

(a) to analyse and evaluate periodic reports and statistical and other documents or information submitted by each State Party;

(b) to request explanation and conduct inquiries as under Article VIII;

(c) to conduct inspection as under Article IX;

(d) to send notifications and reports as under Article X;

(e) to consult and co-operate with the national organs;

(f) to make recommendations for amendments to the Annexes;

(g) to send observers as under Article II;

(h) to carry out decisions which may be made at the conference of States Parties to this Convention.

3. Details pertaining to the composition and functions of the International Verification Agency shall be provided for in Annex III.

Article VII

The States Parties to this Convention undertake to consult one another directly or through the International Verification Agency and co-operate in solving any problems which may arise in relation to the objectives of, or in the application of the provisions of, this Convention.

Article VIII

1. Any State Party to this Convention which suspects that any other State Party is acting in breach of obligations deriving from the provisions of this Convention may request, directly or through the International Verification Agency that State Party to provide explanations. This request should include a list of all the evidence that roused the suspicion.

2. Request for explanations as under paragraph 1 may also be made by the International Verification Agency, when it deems it to be necessary.

3. The State Party which is requested to provide explanations under paragraphs 1 and 2 of this Article shall comply with such request in good faith. This State Party may request the International Verification Agency to conduct an inquiry. This request should include evidence which it considers sufficient to remove suspicion.

Article IX

1. A State Party which has been requested to provide explanations as under paragraphs 1 and 2 of Article VIII may at any time invite the International Verification Agency to conduct an inspection in its territory.

2. If the State Party which is requested to provide explanation as under paragraphs 1 and 2 of Article VIII fails to provide adequate explanations, the International Verification Agency may notify such State Party of an impending inspection to be conducted in its territory.

3. The State Party which is notified by the International Verification Agency of inspection as under paragraph 2 of this Article shall make every effort to accept, as

soon as possible, such inspection in its territory. The State Party which finds it impossible to accept such inspection in its territory shall provide adequate reasons to the International Verification Agency why the State Party finds it impossible to accept the inspection.

Article X

1. The International Verification Agency shall notify each State Party to this Convention of the results of analysis and evaluation as under paragraph 2(a) of Article VI, of explanation or inquiry as under Article VIII, and of inspection as under Article IX.

2. The International Verification Agency may, when it is deemed necessary, report the contents of the notification as under paragraph 1 of this Article to the Security Council of the United Nations.

Article XI

Each State Party to this Convention undertakes to provide or support assistance, in accordance with the Charter of the United Nations, to any Party to this Convention which so requests, if the Security Council decides, upon notification as provided for in Article X, that such Party has been exposed to danger as a result of violation of this Convention.

Article XII

Nothing in this Convention shall be interpreted as in any way limiting or detracting from the obligations assumed by any State under the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, signed at Geneva on 17 June 1925, as well as under the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction.

Article XIII

Each State Party to this Convention undertakes to continue negotiations in good faith with a view to achieving an agreement, as soon as possible, which will make it possible to eliminate the provisional measures referred to in Article IV.

Article XIV

1. The States Parties to this Convention undertake to facilitate and have the right to participate in the fullest possible exchange of equipment, materials and scientific and technological information for the use of chemical agents for peaceful purposes. Parties to this Convention in a position to do so shall also co-operate in contributing individually or together with other States or international organizations to the further development and application of scientific discoveries in the field of chemistry for peaceful purposes.

2. This Convention shall be implemented in a manner designed to avoid hampering the economic or technological development of States Parties to the Convention or international co-operation in the field of peaceful chemical activities, including the international exchange of chemical agents and equipment for the processing, use or production of chemical agents for peaceful purposes in accordance with the provisions of this Convention.

Article XV

The Annexes referred to in this Convention shall constitute an integral part of this Convention.

Article XVI

Any State Party may propose amendments to this Convention. Amendments shall enter into force for each State Party accepting the amendments upon their acceptance by a majority of the States Parties to this Convention and thereafter for each remaining State Party on the date of acceptance by it.

Article XVII

1. Three years after the entry into force of this Convention, a conference of States Parties to this Convention shall be held at Geneva, Switzerland, to review the operation of this Convention, with a view to assuring that the purpose of the preamble and the provisions of this Convention are being realized. At intervals of three years thereafter, further conferences shall be held with the same objective of reviewing the operation of this Convention, if a majority of the Parties to this Convention submit a proposal to this effect to the International Verification Agency. Such review shall take into account any new scientific and technological developments relevant to this Convention.

2. The International Verification Agency shall convoke a conference of States Parties to this Convention as provided for in paragraph 1 of this Article.

Article XVIII

1. This Convention shall be of unlimited duration.

2. Each State Party to this Convention shall, in exercising its national sovereignty, have the right to withdraw from this Convention if it decides that extraordinary events, related to the subject matter of this Convention, have jeopardized the supreme interests of its country. It shall give notice of such withdrawal to all other States Parties to this Convention, the International Verification Agency and to the Security Council of the United Nations three months in advance. Such notice shall include a statement of the extraordinary events it regards as having jeopardized its supreme interests.

Article XIX

1. This Convention shall be open to all States for signature. Any State which does not sign this Convention before its entry into force in accordance with paragraph 3 of this Article may accede to it at any time.

2. This Convention shall be subject to ratification by signatory States. Instruments of ratification and instruments of accession shall be deposited with the Governments of ( ), which are hereby designated the Depositary Governments.

3. This Convention shall enter into force after the deposit of the instruments of ratification by ( ) Governments, including the Governments designated as Depositaries of this Convention.

4. For States whose instruments of ratification or accession are deposited subsequent to the entry into force of this Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.

5. The Depositary Governments shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or of accession and the date of the entry into force of this Convention, and of the receipt of other notices.

6. This Convention shall be registered by the Depositary Governments pursuant to Article 102 of the Charter of the United Nations.

Article XX

This Convention, the Chinese, English, French, Russian and Spanish texts of which are equally authentic, shall be deposited in the archives of the Depositary Governments. Duly certified copies of this Convention shall be transmitted by the Depositary Governments to the Governments of the signatory and acceding States.

IN WITNESS whereof the undersigned, duly authorized, have signed this Convention.

Done in _____ copies at _____,
this _____ day of _____, _____.

Annex I (Alternative A)

1. States Parties to the Convention may suspend the application of Articles I and II of the Convention with regard to the chemical agents which come under the categories in the schedule to this Annex.

2. States Parties to the Convention desiring to invoke the provisions of paragraph 1 above shall so notify the Depositary Governments at the time of, or within ( ) days from, the deposit of their instruments of ratification or accession.
The Depositary Governments shall forthwith communicate these notifications to all signatory and acceding States and the International Verification Agency.

3. Any State Party to the Convention may propose amendments to the schedule to this Annex. The text of any such amendment and the reasons therefor shall be communicated to the International Verification Agency which shall communicate them to the States Parties.

4. If a proposed amendment circulated under paragraph 3 above has not been rejected by any State Party within ( ) months after it has been circulated, it shall thereupon enter into force. If however a proposed amendment is rejected by any State Party, the International Verification Agency may decide, in the light of comments received from States Parties, whether a conference shall be called to consider such amendments.

Annex I (Alternative B)

1. States Parties to the Convention may exclude from prohibition the chemical agents to which they consider it impossible to apply forthwith Articles I and II of the Convention. However, the agents listed in the schedule to this Annex shall never in any circumstances be excluded from the prohibition.

2, 3 and 4. (same as paragraphs 2, 3 and 4 of Alternative (A))

Schedule to Annex I

Annex II

Annex III

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/427 + Corr.1
2 July 1974

Original: ENGLISH

SWEDEN

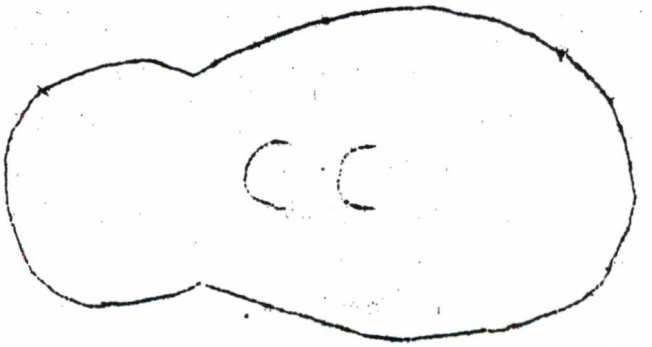
Some observations on the Draft Convention on the Prohibition of the Development, Production and Stockpiling of Chemical Weapons and on their Destruction presented by the Delegation of Japan on 30 April 1974 (CCD/420)

The value of a future convention prohibiting development, production and stockpiling of chemical weapons will depend both on the final scope and on the temporary suspensions which may be prescribed. The final scope is established in Article I of the draft convention presented by the Delegation of Japan. The question of the more immediate scope is dealt with in Article IV, which presents two main alternatives. Before discussing these two alternatives it might be helpful to present a general framework for reference to the different categories of chemical compounds.

A Method for Categorization

Each known chemical compound can be assigned to one point in a bounded surface (CC), as illustrated in the figure below.

CC = Chemical Compounds

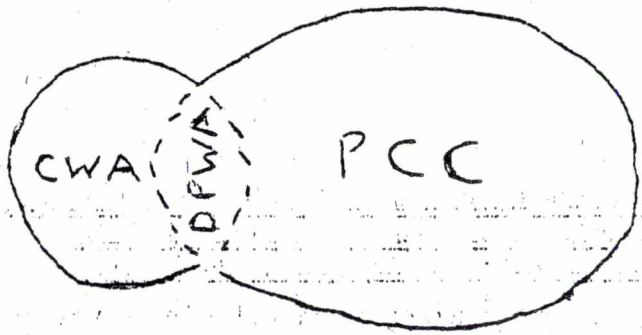


The concern of the present discussion is chemical warfare agents (CWA), represented in the figure below by a smaller bounded surface within the category of chemical compounds. Those chemical compounds which have peaceful uses are designated PCC. As some compounds or agents have both peaceful and warfare uses, the two areas PCC and CWA overlap to some extent. Thus, the figure shows the areas CWA and PCC as well as the overlap area DPWA, which represents the dual purpose agents.

CWA = Chemical Warfare Agents

DPWA = Dual Purpose Chemical Warfare Agents

PCC = Chemical Compounds for Peaceful Use



By this presentation it is possible to categorize the chemical compounds covered - or not covered - by a convention. In this way, it is possible to describe the scope more illustratively.

The surfaces are of course not proportional to reality, since the whole surface represents millions of chemical compounds, while the chemical warfare agents[x/] conceivably are only some few thousands compounds.

Interpretations of the Japanese draft convention

In the following we shall try to apply this method to the Japanese draft convention in the hope that this could possibly be of some assistance as to its proper understanding and further clarification. The figure below is intended to illustrate the present interpretation of the Swedish Delegation in regard to the provisions of scope in the draft convention. Article I (a): "Chemical agents of types that have no justification for ..... peaceful purposes"..... is interpreted to mean that the overall scope of the draft excludes the DPWA and corresponds to the area CWA, in the figure above.

In addition Article I (a) by its reference: "Chemical agents.... in quantities that have no justification .... for peaceful purposes" implies that unwarranted large quantities of DPWA are forbidden. (This sentence in Article I could also be said to cover unwarranted quantities of such CWA, which are retained for research and development of protective measures).

In the Swedish interpretation of Annex I (A) 1, the area marked CSB inside the CWA area represents chemical warfare agents temporarily suspended from the ban by the schedule to this Article.

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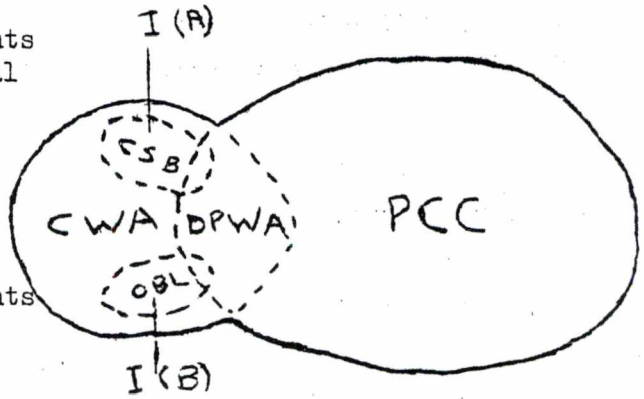
x/ Chemical warfare agents are here taken to be chemical substances, whether gaseous, liquid, or solid, which might be employed because of their direct toxic effects on man, animals and plants.

CWA = Chemical Warfare Agents
DPWA = Dual Purpose Chemical Warfare Agents
PCC = Chemical Compounds for Peaceful Use
CSB = Compounds suspended from the ban
OBL = Obligatorily Banned Chemical Warfare Agents



The proposal of the Delegation of Japan means - it would seem - that the schedule to this Annex could include a suspension of the ban in Article I (a) also on unjustified quantities of dual purpose agents. This interpretation is illustrated in the figure above by that part of the area marked CSB which juts into the area DPWA.

The second sentence of Annex I (B) indicates that the schedule to that Annex lists obligatorily banned compounds, which would correspond to the area marked OBL in the figure above.

It seems to the Swedish Delegation that the first sentence of Annex I (B) 1 only reiterates Annex I (A) 1. One consequence of this interpretation would be that a convention using alternative Annex I (B) 1, must have two schedules. One schedule would list those chemical agents, which could never be excluded from the ban ("the obligatories"), the other schedule would list suspensions. However, the existence of a schedule listing suspensions also in Annex I (B) is not apparent in the draft convention.

One would also have to discuss to what categories components for binary chemical warfare agents belong, how yet undiscovered chemical warfare agents would be covered by the draft convention etc.

This working paper deals only with the chemical compounds covered by the convention, but the same method of analysis could also be applied to the activities and the equipment covered by the draft convention, according to Article I.

Questions

With reference to the analysis above the Swedish Delegation would like to pose the following questions which could usefully be discussed at the meeting with experts on July 17, 1974.

(1) Are there any special intentions behind the use of the very comprehensive term "chemical agents" in the draft convention CCD/420 Article I (a)?

(2) Would it be possible instead to use the expression "chemical warfare agents", as defined in the footnote above and illustrated in the figure as the area CWA?

(3) Are components for binary production of chemical warfare agents clearly covered by the draft convention?

(4) Are dual purpose agents covered by means of the quantity criterion in the draft convention, Article I (a)?

(5) Although toxins are covered in the B-convention, would it not be necessary to state explicitly that they are covered also by a chemical convention?

(6) Will the schedule of Annex I (A) be valid for all Parties or will every Party have its own list of exemptions to be accepted by other Parties?

(7) Should a dual purpose agent (DPWA) be exempted in the schedule of Annex I (A) by a Party who intends to retain it, or produce it, as a chemical warfare agent?

(8) Shall the schedule of unconditionally prohibited CW-agents in Annex I (B) comprise both <u>classes</u> of agents, such as supertoxic agents, and <u>individual</u> agents, such as e.g. one particular nerve gas?

(9) Should Annex I (B) have a list like Annex I (A) of exempted agents (CSB)?

(10) Should it be possible to make both additions and subtractions in the schedules of Annex I (A) and I (B), after the schedules have been agreed upon?

In comparison with the earlier Japanese working paper CCD/413 the draft convention CCD/420 is more comprehensive and less discriminatory, as it covers all activities, i.e., development, production, stockpiling and other ways of acquiring chemical agents, weapons, ammunition, equipment, means of delivery etc.

However, this construction has another side as well. It seems that if a chemical warfare agent is exempt from the ban, the exemption automatically covers all activities connected with this chemical agent. Against this background also the following question could be discussed:

(11) Should particular activities under Article I (b) be subject to explicit exemptions from the ban under Annex I (A) and possibly I (B)?

CCD/430
12 July 1974
Original: ENGLISH

JAPAN

Working Paper containing views of Japanese experts on the scope of prohibition and on the verification for organophosphorus compounds for the informal meetings with participation of experts of the CCD in 1974

I. The scope of prohibition

Annex I, deriving from Article IV of the "Draft Convention on the Prohibition of the Development, Production and Stockpiling of Chemical Weapons and on Their Destruction" which was submitted by the delegation of Japan on April 30, 1974 (CCD/420), is expected to list, in the schedule, chemical agents provisionally suspended from the prohibition (Alternative A) or chemical agents to be prohibited from the beginning (Alternative B). Therefore, the content of the schedule will cause the scope of prohibition to vary at the first stage; however the scope should be determined by the adequacy of applied verification. In this connexion, in view of the present feasibility of effective verification measures, which is to be discussed in part II of this working paper, it will be realistic to list super-toxic organophosphorus compounds, among others, as chemical agents to be prohibited from the beginning, whether or not we adopt I (A) or I (B). Our views on the schedule of Annex I are as follows:

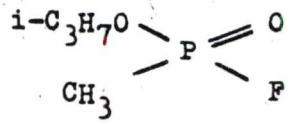
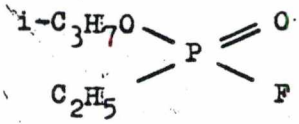
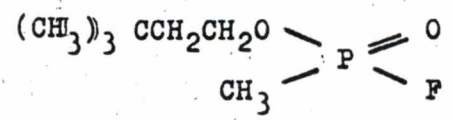
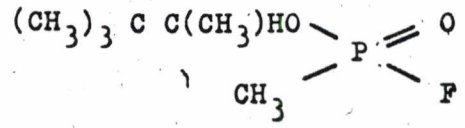
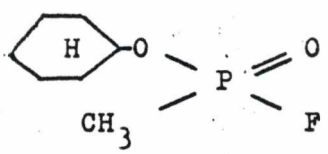
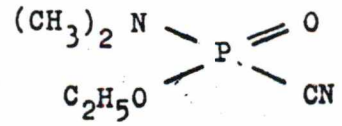
1. Annex I (A) will list chemical agents provisionally suspended from the prohibition, namely, chemical agents other than the super-toxic organophosphorus compounds which are not used for peaceful purposes. One way of selecting these chemical agents may be to adopt the toxicity level of chlorine as a lower threshold, as suggested in the Canadian working paper (CCD/414) and in the Swedish working paper (CCD/427) and to list dual purpose chemical agents, placing organophosphorus compounds having the equivalent toxicity level of Lct_{50} = 20,000 mg. min/m^3 on a lower threshold. However it must be noted that there is a difficulty in adopting this way in that few data have been disclosed concerning the inhalent toxicity value of organophosphorus compounds. This difficulty will be eliminated if more data are disclosed in some way or another or if it is agreed to replace it with the toxicity value determined by some other administration route such as the toxicity value determined by intraperitoneal administration, about which many data have already been published.

2. Annex I (B) is to list the chemical agents to be prohibited from the beginning, i.e., certain super-toxic organophosphorus compounds. In listing these, it is necessary to take into consideration three criteria: (i) a toxicity level (LD_{50} = 0.62 mg/kg i.p., LD_{50} = 0.50 mg/kg S.O.) that Japan has suggested as an objective criterion; (ii) chemical formulae; (iii) whether or not chemical agents have no peaceful use. Mainly by the first two criteria, we have chosen, from published data, super-toxic organophosphorus compounds to be prohibited from the beginning and listed some of them as an example in Table I.

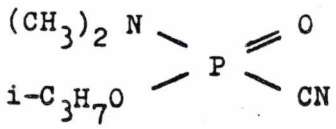
In selecting the agents falling in these criteria, questions may arise concerning the ways of dealing with high toxic chemical agents used for peaceful purposes and not known to be used at present for military purposes, but which could potentially be used for the latter (e.g., Echothiophate used for medicine). It may seem illogical to list chemical agents for peaceful purposes in the schedule insofar as Article I adopts purpose criteria, but, on the other hand, it may also be argued that they should be listed as dual purpose chemical agents in view of their potentiality of being used for military purposes. In any case, whether or not we list them under the category of the prohibited chemical agents depends upon our judgement concerning the degree of their potentiality of being used for military purposes.

With regard to the toxicity level, the problem of international standardization concerning procedures of estimating lethal dose has yet to be solved. However, it will be made possible to make a list of chemical agents to be prohibited by selecting the lowest LD_{50} value, measured under the condition that the same species and the same administration routes are employed, out of LD_{50} values which have been reported and may be reported in the future.

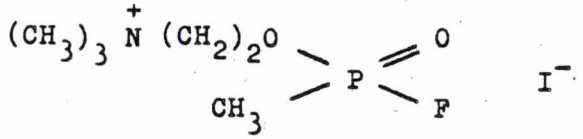
Table 1. Some supertoxic organophosphorus compounds to be listed in the schedule to Annex I (B)

No.	Chemical Name (Code Name) Chemical Formula
1.	Isopropyl methyl phosphonofluoridate (Sarin, GB) 
2.	Isopropyl ethyl phosphonofluoridate (Ethyl Sarin,GE) 
3.	3,3-Dimethylbutyl methyl phosphonofluoridate 
4.	Pinacolyl methyl phosphonofluoridate (Soman) 
5.	Cyclohexyl methyl phosphonofluoridate (GF) 
6.	Ethyl N,N-dimethyl phosphoramidocyanidate (Tabun) 

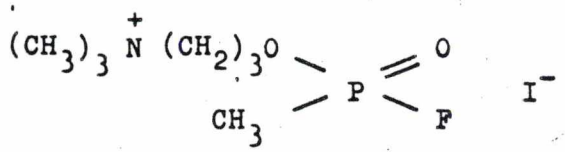
7. Isopropyl N,N-dimethyl phosphoramidocyanidate



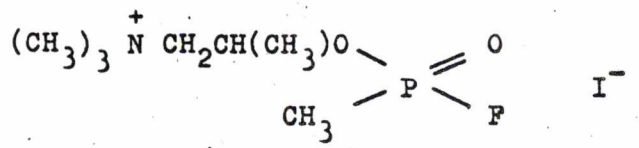
8. 2-Trimethylammoniumethyl methyl phosphonofluoridate iodide



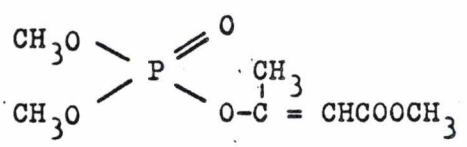
9. 3-Trimethylammoniumpropyl methyl phosphonofluoridate iodide



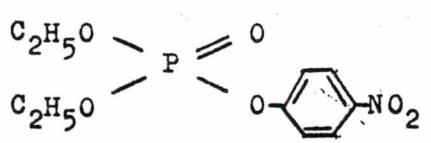
10. 2-Trimethylammonium-1-methylethyl methyl phosphonofluoridate iodide



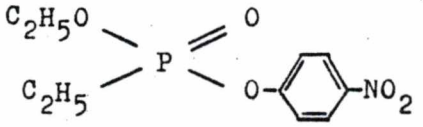
11. Dimethyl 1-methyl-2-carbomethoxyvinyl phosphate (α -phosdrin)



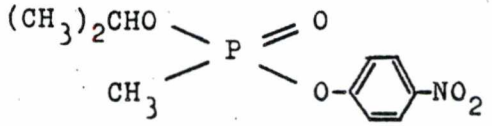
12. Diethyl 4-nitrophenyl phosphate (Paraoxon, E-600, Mintacol)



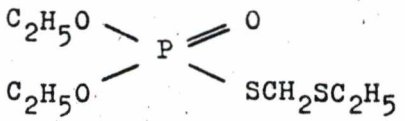
13. Ethyl 4-nitrophenyl ethylphosphonate (Armin)



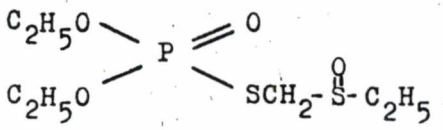
14. Isopropyl 4-nitrophenyl methylphosphonate



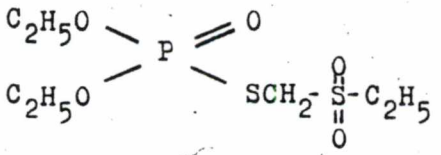
15. O,O-Diethyl S-ethylthiomethyl phosphorothioate



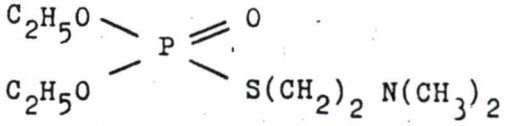
16. O,O-Diethyl S-ethylsulphinylmethyl phosphorothioate



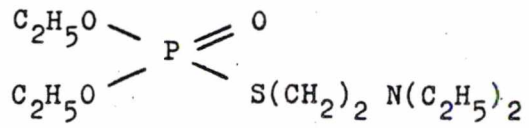
17. O,O-Diethyl S-ethylsulfonylmethyl phosphorothioate



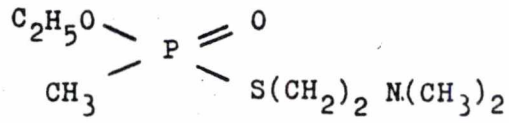
18. O,O-Diethyl S-(2-dimethylaminoethyl) phosphorothioate (217 AO)



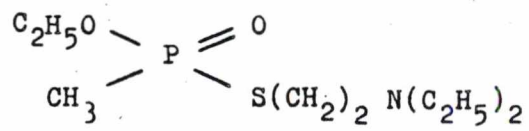
19. O,O-Diethyl S-(2-diethylaminoethyl) phosphorothioate (Tetram, DSDP)



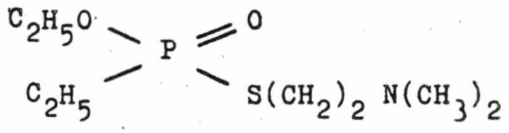
20. O-Ethyl S-(2-dimethylaminoethyl) methylphosphonothiolate (33 SN)



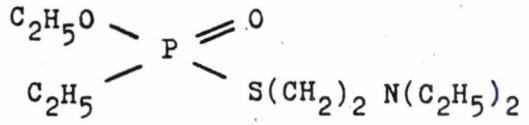
21. O-Ethyl S-(2-diethylaminoethyl) methylphosphonothiolate (Edemo, VM)



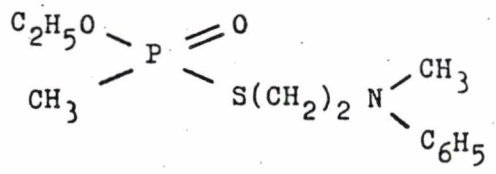
22. O-Ethyl S-(2-dimethylaminoethyl) ethylphosphonothiolate



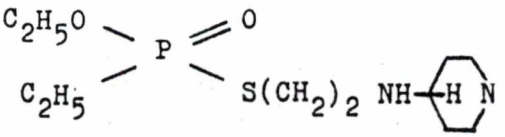
23. O-Ethyl S-(2-diethylaminoethyl) ethylphosphonothiolate (VE)



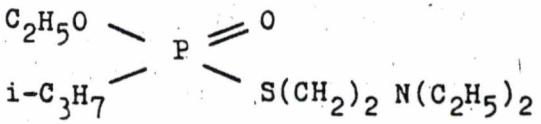
24. O-Ethyl S-(2-methylphenylaminoethyl) methylphosphonothiolate (GT 23)



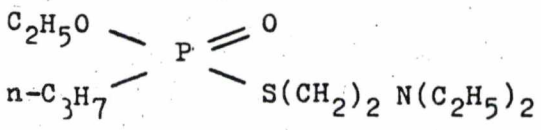
25. O-Ethyl S-(2-piperidylaminoethyl) ethylphosphonothiolate



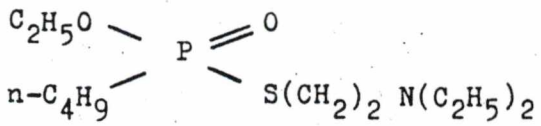
26. O-Ethyl S-(2-diethylaminoethyl) i-propylphosphonothiolate



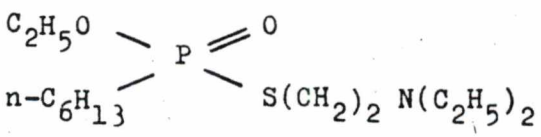
27. O-Ethyl S-(2-diethylaminoethyl) n-propylphosphonothiolate



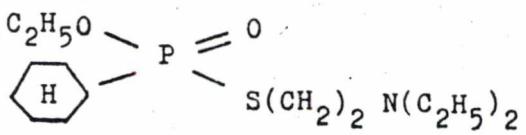
28. O-Ethyl S-(2-diethylaminoethyl) n-butylphosphonothiolate



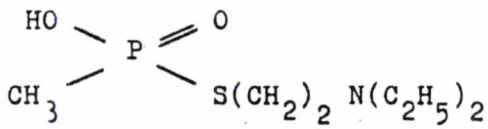
29. O-Ethyl S-(2-diethylaminoethyl) n-hexylphosphonothiolate



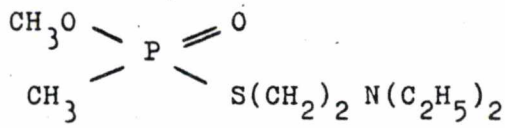
30. O-Ethyl S-(2-diethylaminoethyl) cyclohexylphosphonothiolate



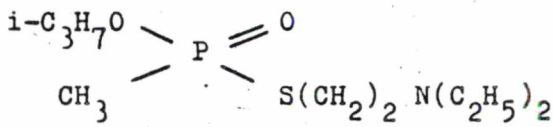
31. O-Hydrogen S-(2-diethylaminoethyl) methylphosphonothiolate (S 27)



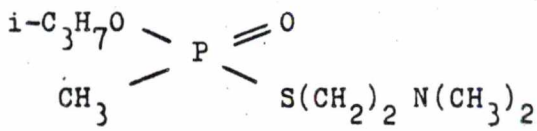
32. O-Methyl S-(2-diethylaminoethyl) methylphosphonothiolate



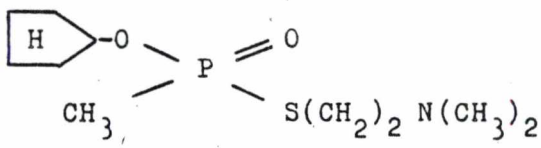
33. O-Isopropyl S-(2-diethylaminoethyl) methylphosphonothiolate (37 SN)



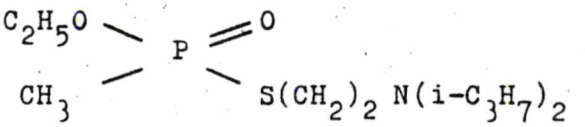
34. O-Isopropyl S-(2-dimethylaminoethyl) methylphosphonothiolate



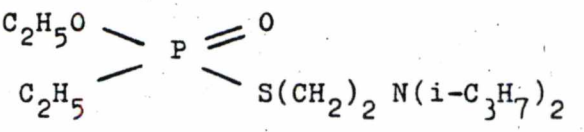
35. O-Cyclopentyl S-(2-dimethylaminoethyl) methylphosphonothiolate



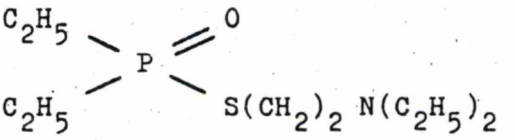
36. O-Ethyl S-(2-diisopropylaminoethyl) methylphosphonothiolate



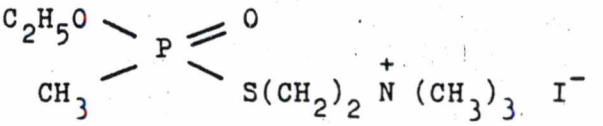
37. O-Ethyl S-(2-diisopropylaminoethyl) ethyl-phosphonothiolate (VS)



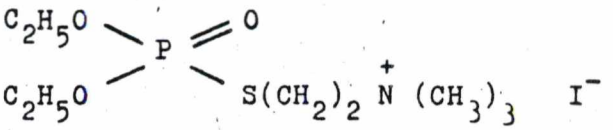
38. 2-Diethylaminoethylthio diethyl phosphine oxide



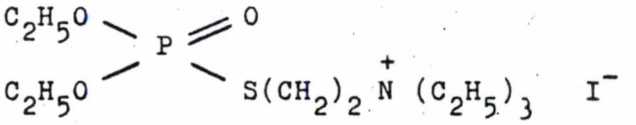
39. O-Ethyl S-(2-trimethylammoniumethyl) methyl-phosphonothiolate iodide



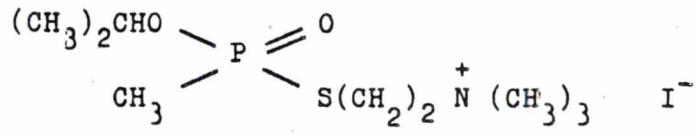
40. O,O-Diethyl S-(2-trimethylammoniumethyl) phosphorothioate iodide (Echothiophate, Phospholin)



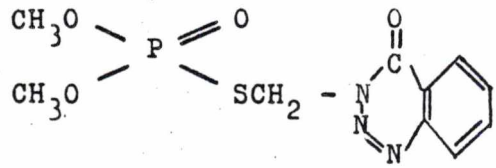
41. O,O-Diethyl S-(2-triethylammoniumethyl) phosphorothioate iodide



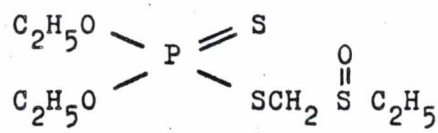
42. O-Isopropyl S-(2-trimethylammoniumethyl) methylphosphonothiolate iodide



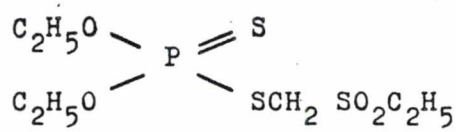
43. O,O-Dimethyl S-(4-oxo-3-H-1,2,3-benzotriazine-3-methyl) phosphorothioate (Guthion)



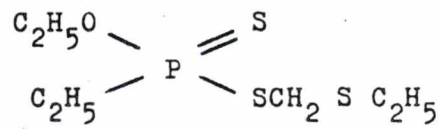
44. O,O-Diethyl S-ethylsulphinylmethyl phosphorodithioate



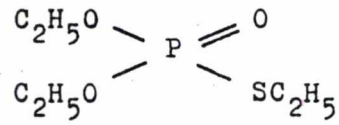
45. O,O-Diethyl S-ethylsulfonylmethyl phosphorodithioate



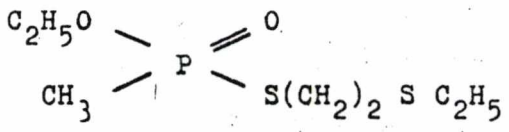
46. O-Ethyl S-(ethylthiomethyl) ethylphosphonodithioate



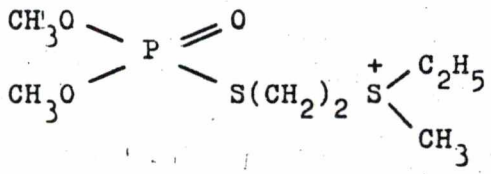
47. O,O-Diethyl S-ethyl phosphorothioate



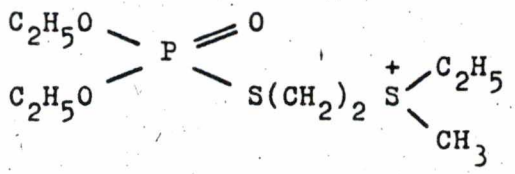
48. O-Ethyl S-(2-ethylthioethyl) methylphosphonothioate



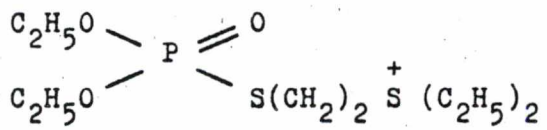
49. O,O-Dimethyl S-[2-(S'-methyl-S'-ethylsulfonium) ethyl] phosphorothioate



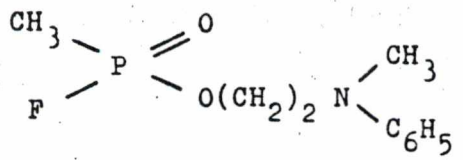
50. O,O-Diethyl S-[2-(S'-methyl-S'-ethylsulfonium) ethyl] phosphorothioate



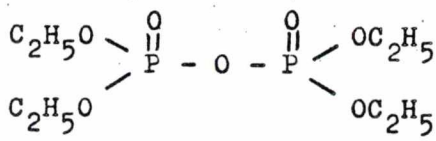
51. O,O-Diethyl S-[2-(S'-diethylsulfonium)ethyl] phosphorothioate



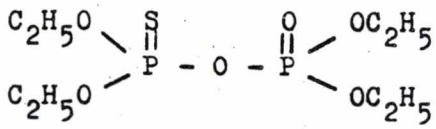
52. O-(2-N-methyl-N-phenylamino)ethyl methyl phosphonofluoridate



53. Tetraethyl pyrophosphate (TEPP)



54. Tetraethyl monothionopyrophosphate



II. Verification of super-toxic organophosphorus compounds.

1. Various methods of verification which have so far been suggested in working papers and other forms by many countries can be classified and summarized in the following table.

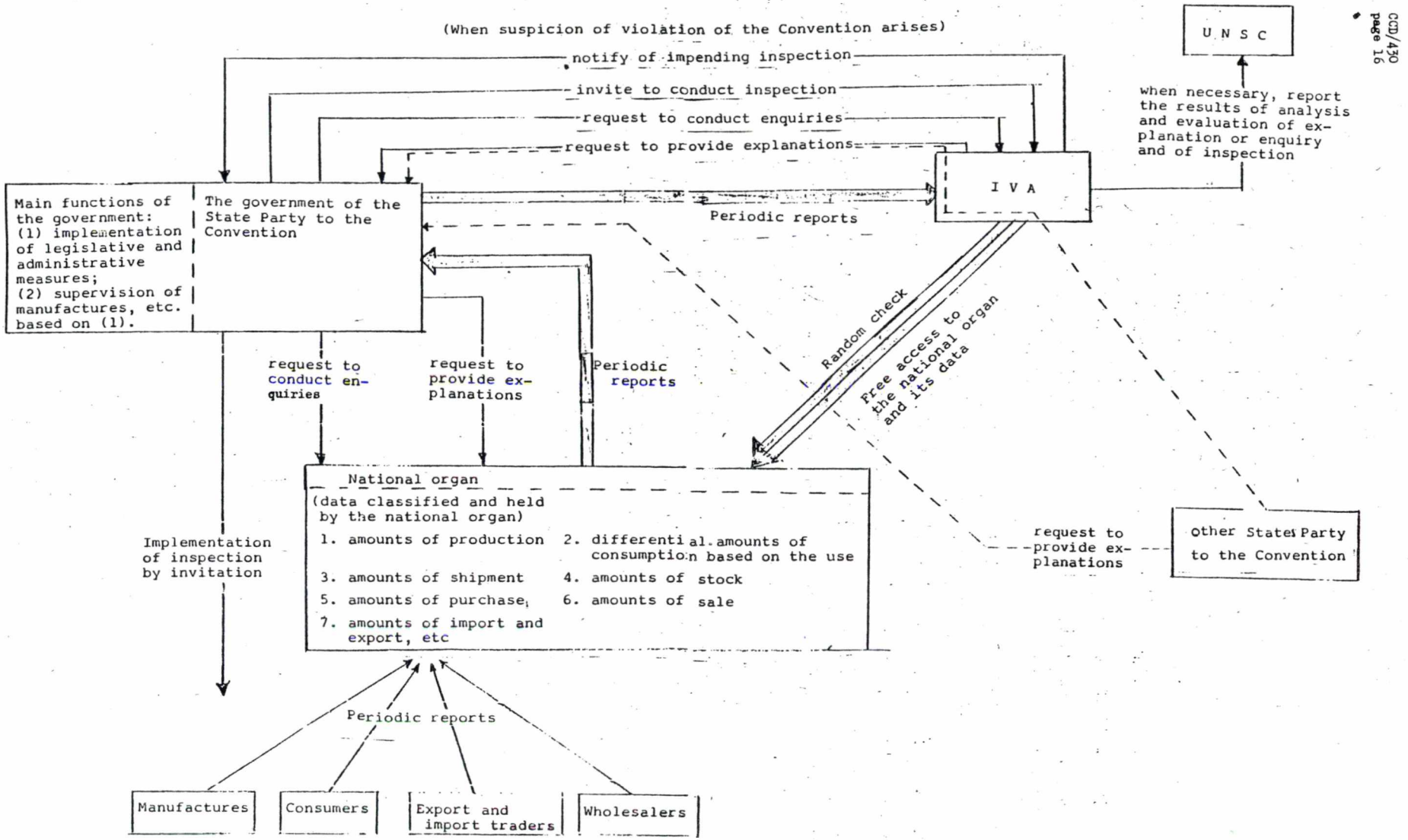
Table 2. Relationship between Verification Modes and Verification Techniques

Verification Modes		Details of Verification Technique
On-site Inspection	Methods of Verification	Example
(I) Direct Inspection (II) Indirect Inspection (III) Inspection by Invitation	(1). Investigation of Production, Equipment and Facilities etc.	Experts from, for example, the IVA, etc., will investigate: the production-process, their equipment and facilities, and production control etc.
	(2). Investigation of safety control on production etc.	Experts from, for example, the IVA, etc., will investigate: the safety control on production equipment and facilities, and workers health control (e.g., measurement of cholinesterase activities) etc.
	(3). Sampling and subsequent analysis	Application of the following analytical techniques: Gas-chromatography, Infrared- and Ultraviolet-spectrophotometry, other chromatographic techniques (T.L.C. etc.), Nuclear-magnetic resonance, Mass-spectrometry, etc.
	(4). Investigation of records and data	Investigation of the following records and data; (1). the amounts of production, consumption, and loss in industry of the raw-materials and intermediates for CW-agents. (2). records of budgets for production (3). records of accidents in factories
	(5). Oral inquiry and questionnaires	Oral interrogation of and questionnaires answered by industry workers, managers, administrators. etc.
	(6). Investigation of the surroundings of industries.	(1). Sampling and subsequent analysis of the surroundings of industries. (2). Questionning the inhabitants of the surrounding areas of industries. (3). External observation of industries by photographic reconnaissance. etc.
Verification methods other than on-site Inspection	(1). Remote Observation (remote sensors)	Monitoring by satellite and by neighbouring countries, etc.
	(2). Statistical Reporting Systems	(1). Analysis of economic data involving the amounts of production, consumption, exports and imports for the raw-materials and the intermediates of CW-agents. (2). Analysis of the related data which should be submitted, etc.
	(3). Surveillance of literatures	Surveillance of related information, as well as various literatures, including patent literature, such as chemical engineering, pyrotechnics, meteorology and military equipment, etc.
	(4). Budgetary Investigation (5). Inquiry of records and data (6). Inquiry by questionnaire	Investigation and inquiry of the records and data which the national organ has, and interrogation by questionnaire of all employees, e.g., administrators, managers, technicians, workers, etc., of the national organ. etc.
	(7). Others	

2. By choosing a good combination of the verification measures shown above or by taking certain steps which would supplement one verification measure, the most effective results in checking violations will be obtained. This has been recognized by a SIPRI publication as well as by the working papers of Japan (CCD/301), the United States (CCD/311, CCD/368), Italy (CCD/373), Yugoslavia (CCD/377), Sweden (CCD/395) and the Socialist Countries (CCD/403).

However, the crux of the matter lies in the need to satisfy two conflicting requirements: to obtain verification results reliable enough to be able to deter the non-compliance of the Convention and at the same time to minimize the burden of States Parties to the Convention. From this point of view the Japanese draft convention (CCD/420) places its major emphasis upon verifications other than inspection, considering non-intrusive verifications as supplementary measures. As for "Remote Observation (sensors)" in "Verification methods other than on-site inspection", of the Table 2 shown above, it depends much upon further technological development. Therefore, of the "verification methods other than on-site inspection", (2) to (6) are expected to play a major role for the time being. An example of verification measures which the Japanese draft convention foresees can be depicted in the following chart.

Chart of an example of verification measures



3. As shown in the above chart, the reporting system of statistical data constitutes the keystone of the draft convention (CCD/420). However, as pointed out in the United States' working paper (CCD/311, CCD/368), this reporting system involves the following problems:

(1) Errors of statistical data are unavoidable;

(2) Statistical data vary irregularly in the course of years;

(3) Methods of collecting data differ depending upon countries;

(4) There exists time lag in data collected.

In addition, there is the more important problem of ensuring the credibility of data.

(1) and (2) above are essentially unavoidable and accordingly, have to be left aside tentatively. (3) and (4) can be solved to some extent through the unification by the International Verification Agency (IVA) of the methods of collecting and reporting data. As for the credibility of data, in the field of statistics, the credibility of data is obtained through the method of random check, and hence, it would be necessary to adopt this method in banning chemical weapons. In this sense, it would be necessary to ensure the right of free access by the IVA to various data possessed by the national organ.

In order that the reporting system may be adopted as one of the verification measures, study on its concrete contents must first be made. (For instance, a SIPRI Monograph entitled "Chemical Disarmament: Some Problems of Verification" provides excellent guidance as a concrete example of useful verification measures. By the same token, working papers of the socialist countries (CCD/403), the United States (CCD/311) and Italy (CCD/373), etc., contain useful suggestions). Generally speaking, among activities involving chemical weapons -- development, production, stockpiling, destruction, etc., production is considered to be the most susceptible to verification measures. This is because production covers considerably wide areas, normally from the unloading of raw materials or intermediate products to the loading of the end products, and also because production contains many aspects which become the objects of verification such as administration of production, safety, and labour and such as measures for preventing environmental contamination. In other words, production contains a variety of elements which can be used for verification. Accordingly, in studying the reporting system on organophosphorus compounds, emphasis should be placed on production. (This

assertion is also made in working papers and in suggestions concerning verification so far put forward to the CCD by many countries. Outside the CCD, likewise, detailed study was made regarding the possibility of verifying the production of organophosphorus compounds at the symposium held by SIPRI in 1971).

Based on these considerations, the report to be submitted from each State Party to the IVA must grasp the movement from the unloading of raw material or intermediates to the loading of end products -- of the following 7 substances, which are thought to be closely related to the production of organophosphorus chemical warfare agents: (This is also suggested in Japan's working paper (CCD/301 of 1970, which proposed verification measures including the establishment of the reporting system.

(1) Yellow phosphorus; (2) phosphorus trichloride; (3) phosphorus oxychloride; (4) phosphorus pentachloride; (5) phosphorus pentasulfide; (6) dimethyl phosphite; (7) methyl phosphoryl dichloride.

At the CCD in the summer of 1971, Japan tabled a working paper (CCD/344) introducing statistical data which indicated the amounts of final respective uses of phosphorus trichloride and phosphorus oxychloride as well as their proportions to the whole amount. According to this working paper, the amounts of respective uses of phosphorus trichloride were; agricultural and sterilizing chemicals 2714t; vinyl chloride stabilizer 1229t; dyestuffs 642t; medicine 99t; others 353t. They totaled 5037t. Furthermore, the latest rough figures obtained unofficially and from disclosures at academic symposiums have led to the analysis of the "others" mentioned above as fire-resistent chemicals, antioxidant, catalyzer, agent for chlorination, etc., which amounted to 316-356t, thus identifying more than 90 per cent of the "others".

In view of the above, the Japanese experts propose the formulation of the Figure "Differential amounts of consumption based on the use of raw material and intermediates" and Table 3 "Statistical data of production, imports, consumption and shipment of raw materials and intermediates". The aforementioned Figure would be useful immediately in checking the amounts of raw material and intermediates; how the raw material and intermediates are used is not entirely known. Likewise, Table 3 would be useful in checking the balance between the input and output of raw material and intermediates. Logically, this Figure and Table 3 are mutually related and the overall evaluation of them is expected to strengthen the credibility of the economic data and could serve as an effective means of verification. In order

to further increase the credibility, the economic data to be reported from each State Party to the IVA should include, in addition to the items indicated in the Figure and in table 3, the list of facilities producing the aforementioned 7 types of raw material and intermediates and the production capabilities of States; priority consideration should be given to the inclusion of this list.

Admittedly, more careful study should be made concerning the contents of the report, mainly with a view to increasing the credibility of statistical data. At the same time, the data to be possessed by the national organ in formulating the report must be those which are tenable as the basis of data or items reported to the IVA and which can render the report convincing. Accordingly, the national organ would be required to receive a monthly report containing considerably detailed data from the facilities dealing with the above-mentioned 7 types of raw material and intermediates. The minimum content of such a monthly report would be as follows:

(1) Importers; amounts imported.

(2) Producers; amounts produced, amounts loaded, amounts in stock, and production capabilities.

(3) Wholesalers; amounts purchased, amounts sold.

(4) Users; amounts purchased.

(5) Exporters; amounts shipped.

The IVA must be given the right of free access to the national organ so that it may check the above-mentioned records and data.

In order to enhance the verification effects as much as possible, studies should be made as to how these data can be made as detailed and timely as possible and also as to the use of some parameters for the purpose of cross-checking in the fields of software, such as environmental protection, labour administration, etc.

Figure Differential amounts of consumption based on the use of raw material and intermediates

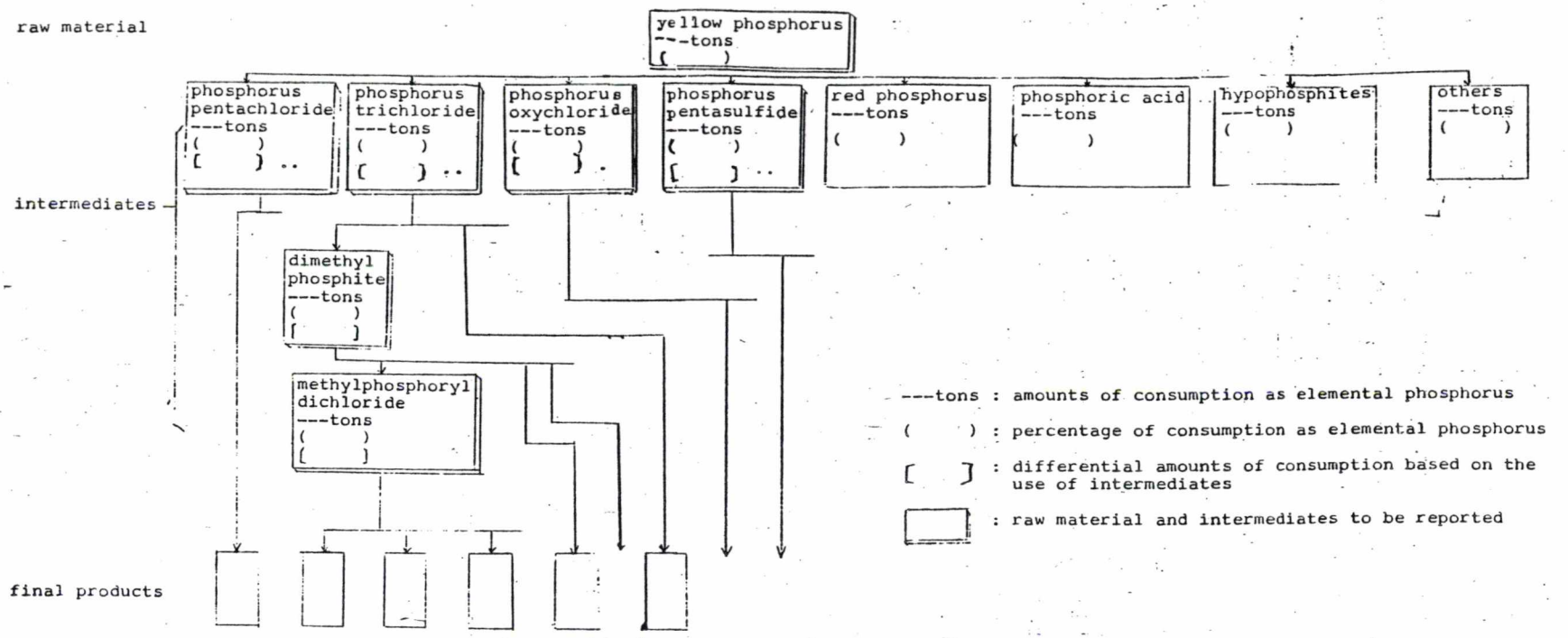


Table 3. Statistical data of production, imports, consumption & shipment of raw material & intermediates.

(ton/year)

amounts of seven substances		year			
		X	x + 1	X + 2	X + 3
yellow phosphorus	amount of stock at the end of the previous financial year amount of production amount of imports				
	total				
	amount of consumption amount of shipment amount of stock at the end of the present financial year				
	total				
phosphorus trichloride	the same as above				
phosphorus oxychloride					
phosphorus pentachloride					
phosphorus pentasulfide					
dimethyl phosphite					
methylphospho-ryl dichloride					

CCD/432
16 July 1974

Original: ENGLISH

LETTER DATED 12 JULY 1974 FROM THE PERMANENT REPRESENTATIVE OF FINLAND TO THE SPECIAL REPRESENTATIVE OF THE SECRETARY-GENERAL TO THE CONFERENCE OF THE COMMITTEE ON DISARMAMENT TRANSMITTING A WORKING PAPER BY THE GOVERNMENT OF FINLAND

ON METHODOLOGY FOR CHEMICAL ANALYSIS AND IDENTIFICATION OF CW AGENTS - PROGRESS OF A FINNISH RESEARCH PROJECT

Upon instructions from my Government, I have the honour to enclose a Working Paper by the Government of Finland to the Conference on Disarmament with the request that you would take appropriate steps to have it distributed in the Conference of the Committee on Disarmament.

Enclosed please find also a matrice for the printing of some illustrative figures attached to the Working Paper.

(Signed) Klaus A. Sahlgren
Permanent Representative
of Finland

GE.74-67423

WORKING PAPER BY THE GOVERNMENT OF FINLAND TO THE CCD

Methodology for chemical analysis and identification of CW agents

- Progress of a Finnish research project

1. In 1972, the Government of Finland announced a project on creation on a national basis of a CW control capacity for possible future international use (CCD/381). This working paper noted that at least initially the work would focus mainly on organophosphate nerve agents while some work would also be done on mustards. In a subsequent working paper (CCD/412) the Finnish Government described in some detail the scientific activities connected with the project, the instrumental methods used and the laboratories engaged in this research. One of the goals of the project was to be an analytical handbook for CW verification, a compilation of standardized data for the identification of various CW agents, especially organophosphates and mustards, as well as their precursors, metabolites and degradation products.

This paper presents a more detailed description of the methods chosen and illustrates with a few examples the data obtainable by these methods. The figures included in this working paper also suggest a format for the presentation of such data for verification purposes.

2. The need for national verification activities and their international standardization has been stressed in several working papers of the CCD, e.g., the draft convention (CCD/361) and the working paper (CCD/403) submitted by the socialist states, while the need and role of international verification has been stressed, e.g., in the working paper of the non-aligned countries (CCD/400) and the recent draft convention submitted by Japan (CCD/420).

3. Among the different verification methods in the context of a CW-treaty, chemical analyses have obviously an essential role among the verification techniques. For this purpose national and international control laboratories capable of analysing previously unknown components even at ppm or ppb level in multicomponent mixtures are needed. Such requirements can be met by combining the techniques of environmental residue studies with modern methods of structure analyses. Whatever the solution of the verification question or the agreed combination of national and international means of verification, such data must be obtained by internationally agreed, standardized methods and reported in an internationally agreed, unambiguous format to fulfill the requirements of international comparability and criticality.

Concerning the nerve agents (sarin, VX etc.) the enzymatic method for detection of anticholinesterase compounds is the most sensitive indicator. If, however, there is need for more knowledge of the structure of the agent or if some other kind of CW agent (e.g., a mustard) is in question, other methods must apply. In many cases the compound to be identified is not even the agent itself but a metabolite, degradation product or precursor of it. The methods of classical chemical analysis often demand too much time or material, but the modern physical methods -- mass spectrometry, infrared spectrometry (IR), and nuclear magnetic resonance spectrometry (NMR) -- have been found more suitable.

By preparation of the samples the reactivity of the agents has to be taken into account, so that the extraction and the purification have to be made with caution, the physical methods like chromatography, ion exchange and gel filtration being the methods of choice.

In order to find out the suitability of these analytical methods in respect of CW verification, each research group engaged in the Finnish project has concentrated on the study of one of them. In addition, various organophosphorus esters, halogenides and other model compounds have been synthezised, and the kinetics of the formation and decomposition reactions have been studied.

4. In analysis of CW agents gas, liquid and thin layer cromatography are perhaps the most used methods. The detection level of a picogram may be reached using electron capture and alkali salt flame ionization detectors and also by the use of photoelectric detectors (sensitive to phosphorus and sulfur compounds). Chromatograms are suitable for quantitative evaluation when the agents in question is previously known. The identification of an unknown compound from a chromatogram peak needs more structure analytical measures; the retention time of a component alone is not a very realiable evidence.

5. At present, mass spectrometry connected to gas chromatography is the most sensitive method for structure analysis of components in an unknown mixture of organic compounds; spectra from nanogram quantities are obtainable. By using glass capillary columns in gas chromatograph-mass spectrometer also a very efficient separation of the components can be performed. Time needed for the analysis is quite short if an ON LINE computer connected to the mass spectrometer is available. As an example a spectrum of sarin is presented in Figure 1.

6. NMR spectrometry, especially the ^{13}C and ^{1}H resonances, is perhaps the most effective method for obtaining knowledge of the structure of an unknown organic compound without reference material. Concerning nerve gases, also ^{31}P and ^{19}F resonances are very valuable. The main limitation of the use of NMP in residue analyses has been the low sensitivity. The present fast progress in this field will remove part of this limitation. At present, proton and fluorine megnetic resonance spectra from microgram samples are obtained by using pulse Fourier techniques with ON LINE computer. As an example ^{1}H and ^{13}C spectra of sarin are illustrated in Figures 2 and 3.

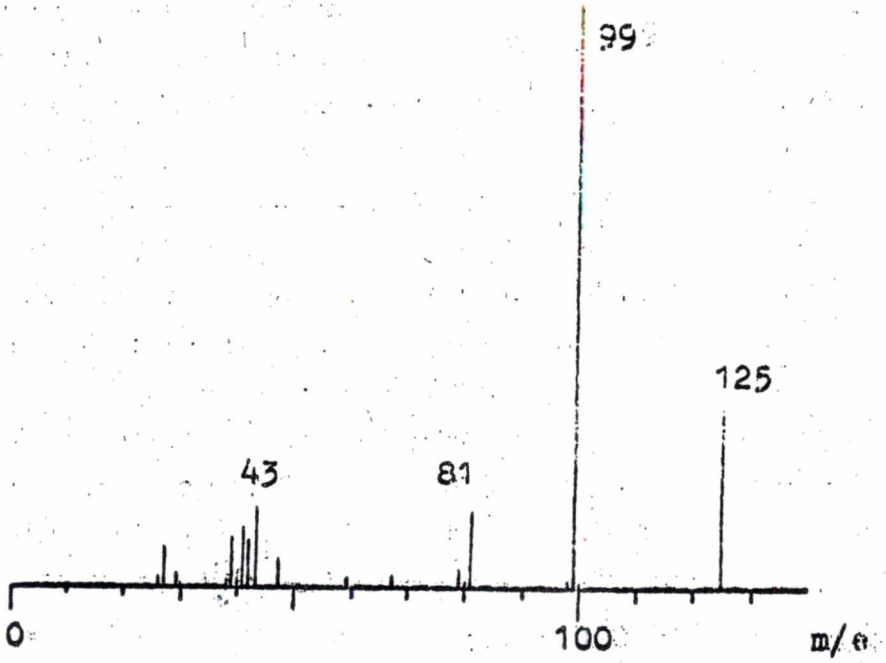
7. Infrared spectrometry (IR) is an analytical method which gives structural information about skeleton type and functional groups of previously unknown molecules. Alone it is a useful method of identification when large reference collections like the Sadtler or the Hummell & Scholl Catalogues are available. Without such collections IR often is not able to give the final structural formula but it is a fast and cheap method for fingerprint classification of unknown materials. There are now available data for over 5600 organophosphorus compounds and their empiric correlations. IR gives further straight information on the bonds of molecules in some cases where mass spectrometry and NMR spectrometry can give only secondhand information, for instance in thiono -- thiolo isomerism. It is possible to extend the sensitivity of IR spectrometry down to microgram level by using special techniques. Samples of pure components can be collected by preparative chromatography. In addition to low instrumental expenses another advantage of the infrared spectrometry is that it is also suited for the mobile laboratory purposes. In Figure 4 the IR spectrum of sarin is presented.

8. For the chemical control work it is extremely important to know how these compounds behave in different open air conditions. Therefore the Finnish project has investigated the hydrolysis and alcoholysis reactions of phosphoromono- and dichloridates after they have first been synthesized. For this purpose a quick, safe and sensitive method was developed, in which conductivity changes caused by hydrogen chloride are measured during the reaction. A model reaction is presented in Figure 5, where the shares of different components are plotted against reaction time. It is evident from the figure that the reaction rate of the chlorine atoms are not equivalent. The reaction scheme is given in the Figure, too.

In respect of the enzymatic detection method for anticholinesterase agents the toxicology-group has confirmed, using the method of Ellman, that in cases of toxification caused by organophosphorus compounds the cholinesterase activity of human blood and cerebellum is remarkably diminished and well verifiable. In animals, the cholinesterase activity of blood is too weak for realiable evaluation of alterations, whereas in small animals as rats and mice, the activity of brain (cerebrum or/and cerebellum) is sufficient for studying the effects of anticholinesterase poisons.

10. It is evident that none of the analytical methods examined will be satisfactory alone. One has to choose several of the best methods, or maybe use all of them to complement each other. In any case, however, a large collection of reference data will be very helpful even if not quite necessary. For this purpose the Finnish project has started to collect all the analytical information obtained during the work concerning chemical agents, e.g., the chromatographic and kinetic information as well as mass-, IR- and NMR-spectra of the compounds. As mentioned earlier (CCD 412/73) a handbook containing such information would be helpful for verification purposes both in its national and international aspects. It is hoped that the Finnish project will make a contribution towards that end.

Fig. 1. Mass spectrum of the nerve agent sarin with a proposed scheme for the fragmentation



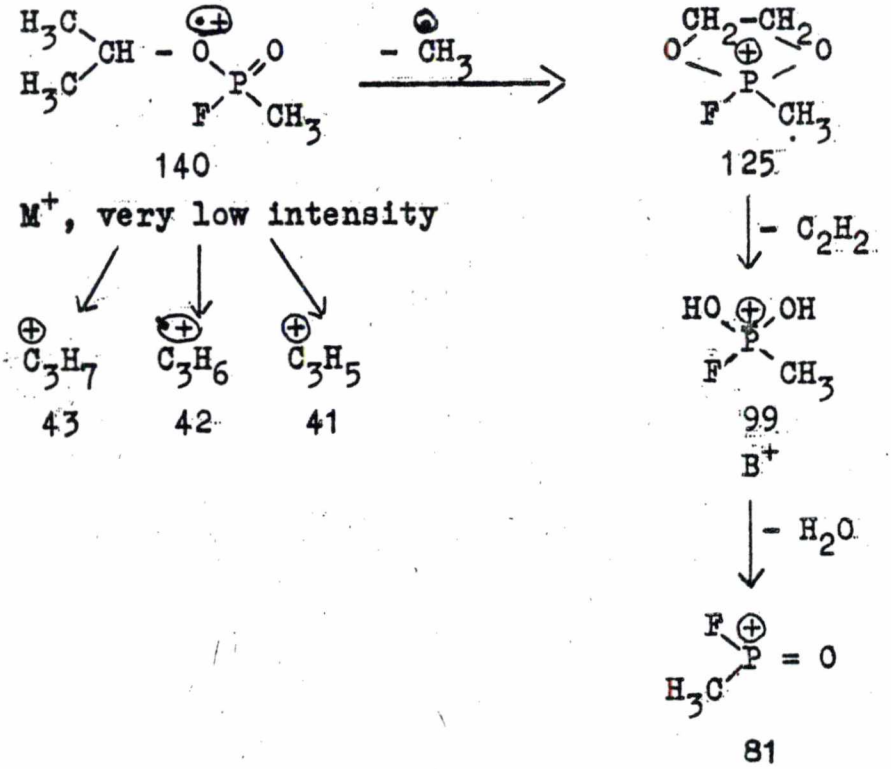


Fig. 2. ^{1}H resonance spectrum of sarin in deuterochloroform

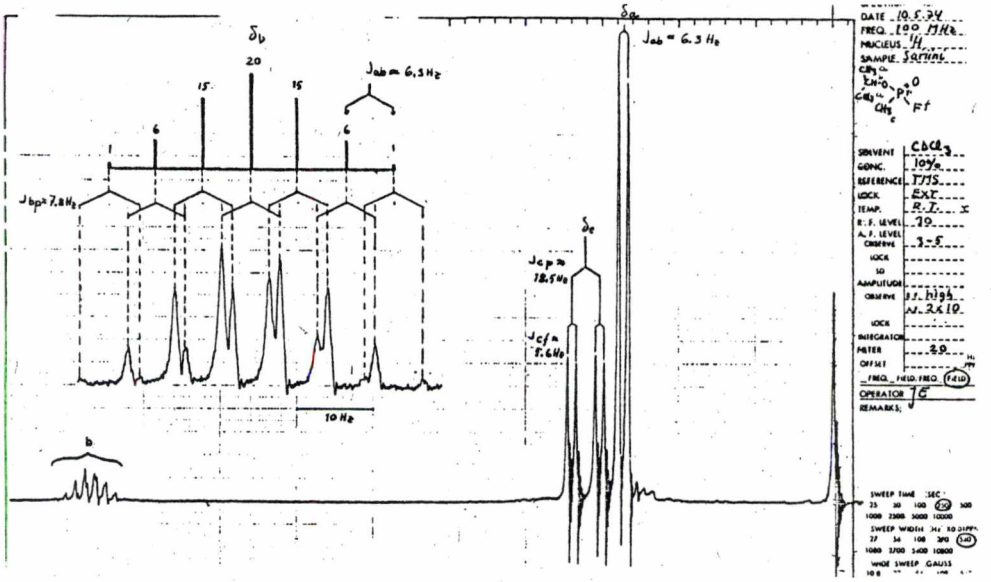


Fig. 3. ^{13}C resonance spectrum of sarin in deuterochloroform

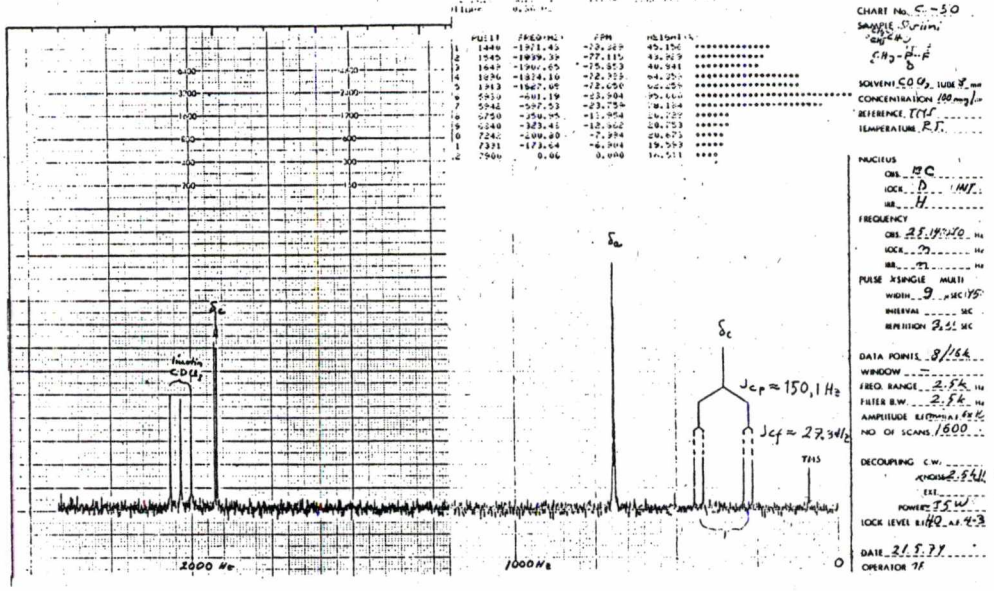


Fig. 4. Infrared spectrum of sarin, solventfree film between KBr plates

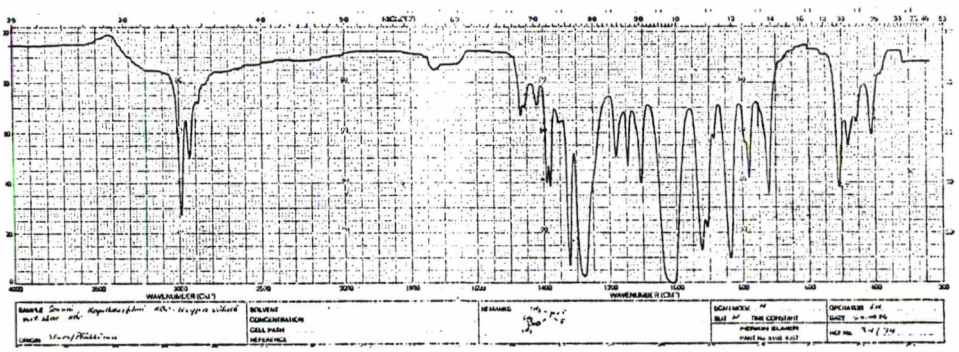
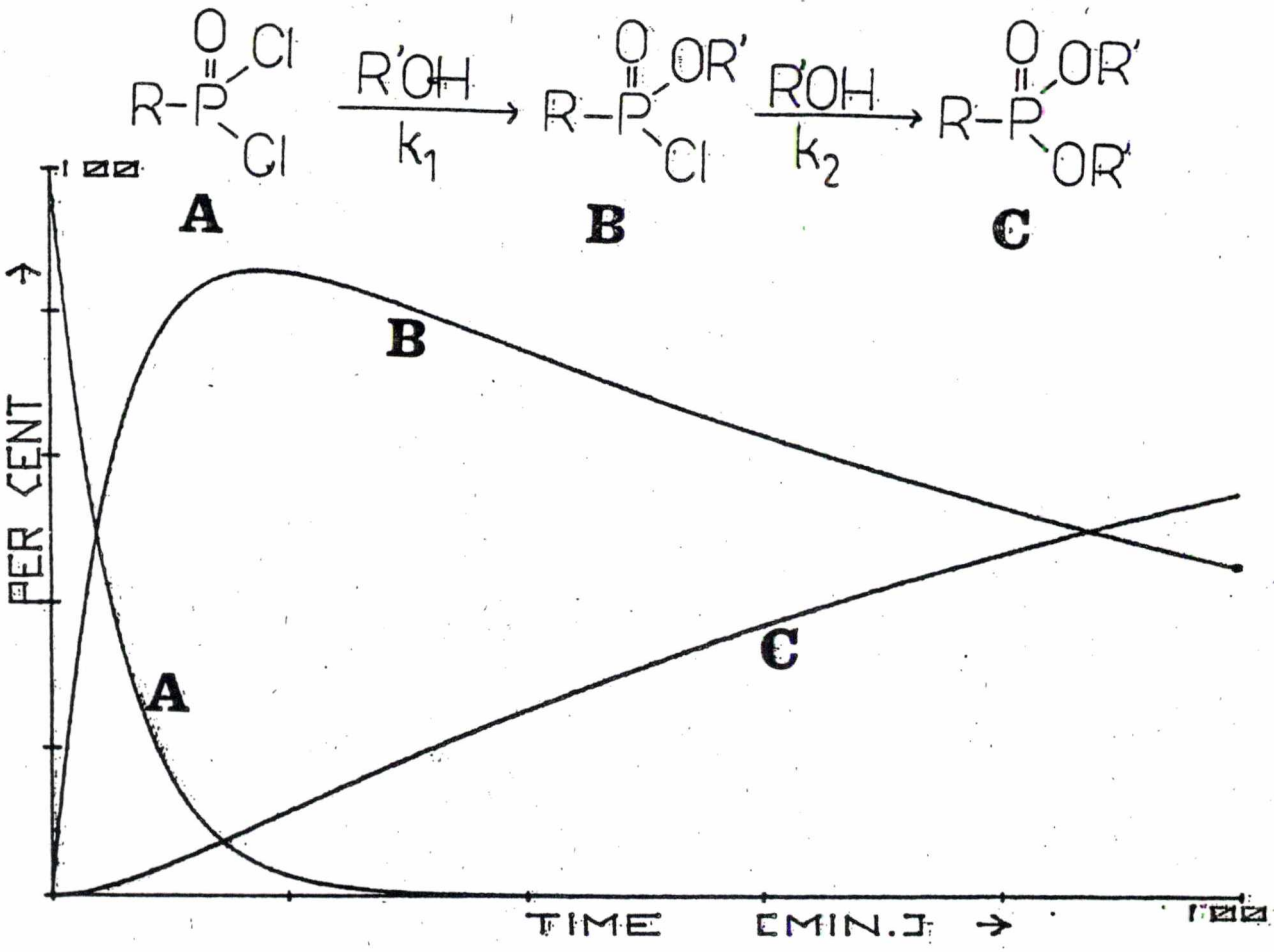


Fig. 5. Kinetics of the alcoholysis of an alkylphosphonodichloride



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Original: ENGLISH

CANADA

The problem of defining compounds having military significance as irritating and incapacitating agents

Introduction

1. This paper is to be considered as a supplement to CCD/414 in that the same scheme of definition has been applied to those chemical substances that depend primarily on their irritating or incapacitating effect for their possible military utility.

Non-lethal Agents

2. Attention is drawn to the meaning of some of the terms used in this paper:

harassing or irritating means having a physiological effect which will render individuals incapable of normal concerted physical effort during exposure and only for a very short period of time (minutes) after exposure ceases.. These are generally known as riot control agents;

incapacitating means having physiological or mental effects which will render individuals incapable of normal concerted physical or mental effort or both for a significant period of time after exposure. Such agents resemble riot control agents in that the effects are temporary and without permanent damage but are different in that the effect may last for hours or in extreme cases for days.

3. It is necessary to stress the difference in agents that cause the above effects: the first are those that are immediately and physically irritating (e.g. tear gas), and whose effects last only for a short period after exposure. The second type are those that are mentally or physically incapacitating for a significant period of time after exposure ceases. Because of the lack of perceptible signs of the presence of such agents, the effects of these agents may not be observed until after an incapacitating dose has assimilated.

4. Some agents generally categorized as harassing agents have a toxicity which would place them above the lower threshold of toxicity set out in Table I.[1/] The military

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1/ As in CCD/414 but amended.

utility of harassing and incapacitating agents is related, however, not to their possible lethal effects, but to their irritating and incapacitating effect. It remains to determine, therefore, a threshold of irritating or incapacitating effectiveness above which these chemical substances can be considered as having military utility.2/

5. **Annex III** of the Report of the Secretary-General of the United Nations on Chemical and Bacteriological Weapons (Document A/7575 or S/9292) tabulates the effectiveness of the irritating agents in terms of a tolerance limit. For the purpose of this paper, a different quantitative unit is used, the effective median dosage, in order to be consistent with the dosage used for lethal agents. The dosage of those that are known is shown in Table II. From this it can be seen that a threshold can be drawn at a value of about 200 mg.min/m^3 for the median dosage. Because those at present available are relatively cheap and simple to manufacture, the incentive to produce new non-lethal agents may not be great. It cannot be ruled out, however, that new agents might be discovered that would not be as efficient as those at present known. To allow for this, it is proposed to lower this threshold to a value of 500 mg.min/m^3, the same level as for the upper threshold of the lethal agents. Since all these agents are single purpose, this suggests that these substances could then be described as a class of "super effective" single purpose non-lethal agents. It is difficult to say whether this threshold value should be lowered even further. However, it is perhaps instructive to note that 80 proof whisky has an equivalent median incapacitating dosage of about 1,500 mg.min/m^3. Since alcohol is not an efficient weapon of war, it seems reasonable to state that the threshold for non-lethal agents is probably somewhere between the values of 1,500 and 500 and is probably close to 500 mg.min/m^3 for practical purposes.

6. Therefore, as a suggested definition, it is possible to state that: a chemical compound or element can be considered as a potential agent of war if it has a median incapacitating or irritating dosage of less than 500 mg.min/m^3.

Use of agent definitions in establishing scope of prohibition

7. Thresholds have been suggested which separate those chemical substances which have military potential based on their effectiveness to incapacitate or irritate from those that do not have such a potential. (Some of the chemical substances thus defined as being potential agents of war also have recognized peaceful uses.)

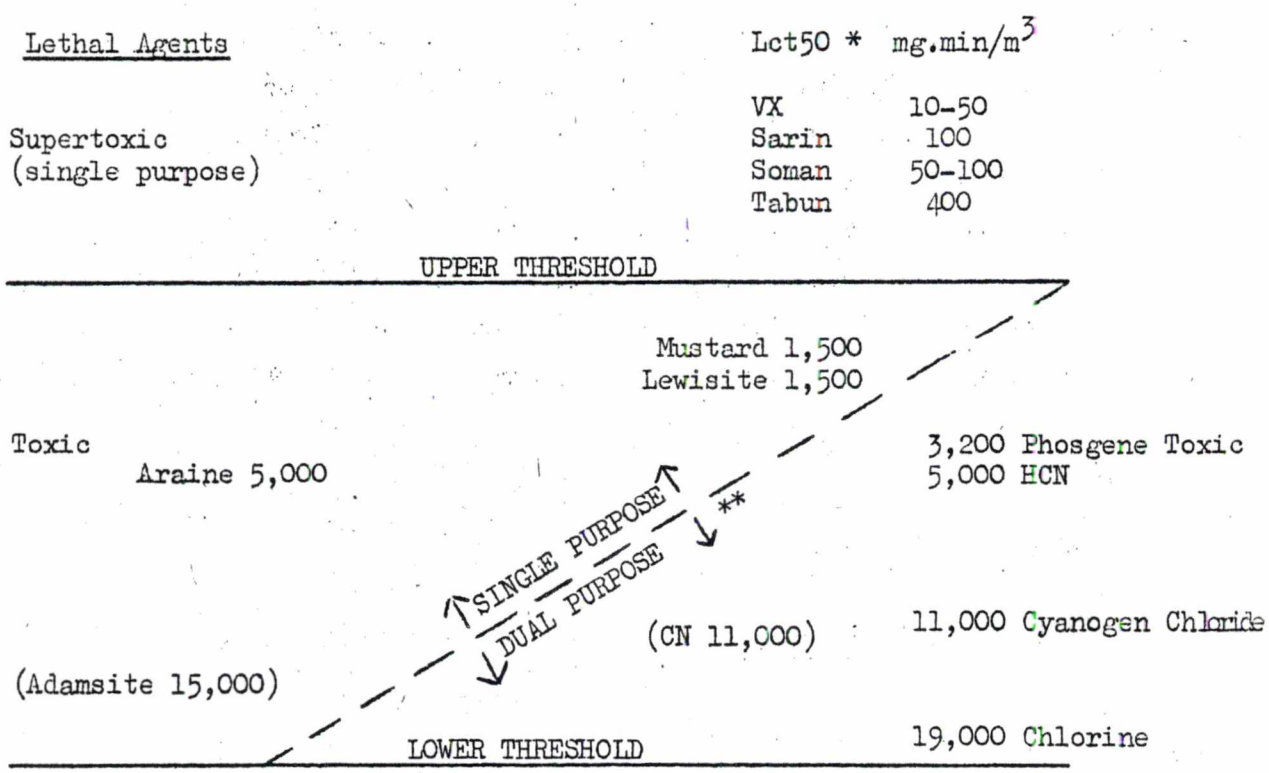
2/ Non-lethal agents are discussed in the Report of the Secretary-General of the United Nations on Chemical and Bacteriological Weapons (Document A/7575 or S/9292) where they are described in the broad category of incapacitating agents. (This working paper restricts the meaning to that given in the introduction in which the qualification, "for a significant period of time", is important.)

8. The non-lethal agents can be defined, according to the duration of their effects on exposed personnel, as being either irritating or incapacitating.

9. In the case of harassing or irritating agents which are widely recognized as essential for civil riot control because of their quick reaction and short duration without injury, it is unlikely that governments would be preared to ban their continued development, production and stockpiling. It might on the other hand be generally accepted that the development, production and stockpiling of incapacitating agents could be prohibited. This acceptance would stem from the unreliability and unpredictable effects of incapacitating agents, particularly the psychochemicals. It would seem unlikely that governments would wish to retain such agents for civil police use. In the event of there being a disposition to prohibit incapacitating agents but to allow irritating agents for civil use, an expert review committee could determine into which category fell those chemicals above the agreed threshold of effectiveness.

TABLE I

Classification of some chemical compounds and elements based on toxicity including sub-groups based on purpose



All other chemicals that have no significant military value

* Dosage vapour concentration multiplied by time of exposure lethal to 50 per cent of exposed personnel.

** Chemicals having both military and civil use.

TABLE II

Classification of some chemical compounds based on Irritiating and Incapacitating dosages

Non-lethal Agents

Irritating CT50 **	mg.min/m^3	Incapacitating Ct50 **
CS 10-20		
Arsine Derivatives 10-30		
CN 80		
		BZ > 200

THRESHOLD

Effectiveness of chemicals in this range not of military interest

** Dosage vapour concentration multiplied by time of exposure Irritating or Incapacitating to 50 per cent of exposed personnel.

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CANADA

Destruction and disposal of Canadian stocks of World War II Mustard Agent

Historical background

1. Shortly after the outbreak of the Second World War, many countries, including Canada, produced a supply of chemical warfare agents in anticipation of their possible use during the war in retaliation of enemy gas attacks. Gas warfare was never employed, and while most chemical stocks were destroyed in Canada, some quantities of mustard agent remained in storage.

Present Status

2. In Canada approximately 700 tons of mustard agent in bulk liquid form have been retained since 1942 at the Canadian Defence Research Establishment Suffield, at Ralston, Alberta. This material has been stored in reinforced concrete, lead-lined vaults, and no appreciable degradation of the vaults or the mustard has occurred up to the present time. The mustard was primarily HS (2,2'-dichloro-diethyl sulfide) of approximately 70 per cent purity, with a small stock of a more persistent type of mustard referred to as HT. For many years, Canadian Government policy has been to maintain no offensive capability or weaponry in chemical warfare; consequently the mustard was of no use to the Canadian Forces, and a decision was made several years ago to find a safe, effective, clean and economical method of disposing of it.

Methods for destruction of Mustard

3. A number of possible methods for disposing of the mustard were considered. These included: burning the mustard in open pits (as was done in a number of countries after the Second World War) -- this was environmentally undesirable because of the resultant air pollution; dumping it in the ocean -- this was unacceptable for several reasons, including international agreements on ocean dumping; burning the mustard in an existing or specially designed incinerator and scrubbing or dispersing air pollutants from the exhaust gas stream -- this was technically feasible, but very costly and involving some handling hazards; and chemical processes to convert the mustard to a less hazardous or innocuous form, and disposal of the resultant product in an acceptable manner.

4. The last approach appeared most promising. In the laboratory, mustard was converted to a solid (dithiane) by reaction with sodium sulfide. The solid was easier to handle and less hazardous, but the process was abandoned because of the cost of the sodium sulfide, the environmental problems of disposing of the large volume of dithiane produced, and the engineering problems of avoiding the trapping of unreacted mustard in the solid end product. Conversion of the mustard by hydrolysis to a relatively harmless liquid was also investigated, along with disposal methods for the liquid product. This approach was successful in the laboratory and pilot-plant scale experiments, and was considered technically feasible for bulk destruction.

5. It was generally known that mustard/water mixtures were non-reactive, since hydrolysis did not occur to any significant degree; yet other measurements indicated that mustard which was dissolved in water reacted quickly, with a reaction time equivalent to a mustard half-life of 8-10 minutes at 25°C. A detailed study of this apparent discrepancy led to the discovery that, with the addition of a base to control pH, elevation of the temperature above ambient, and turbulent mixing, water and mustard would react readily to produce a non-vesicant mixture of salts and thiodiglycol. This process was optimized in laboratory experiments, and in pilot-plant scale batch experiments involving up to 50 gallons of mustard per batch. A number of bases were studied for pH control and calcium hydroxide was chosen as the optimum and least expensive. A plant has been designed and built to hydrolyze up to about 7 tons of mustard per batch under the control of a two-man crew.

6. This plan is now operational, and mustard is being destroyed. Full scale trials have demonstrated that the process is non-hazardous and fully effective in destroying the mustard.

Disposal of Mustard Hydrolysate

7. The hydrolysate produced during experimental destruction of batches of mustard contained water, thiodiglycol, calcium salts (primarily calcium chloride) and some polysulfides. Disposal methods studied for this hydrolysate included: incorporation of the hydrolysate in concrete to form a solid; incorporation in landfill; spreading on soil with natural biodegradation; microbial deterioration in a reaction vessel; and high temperature incineration. While natural biodegradation processes appeared promising, insufficient time was available to optimize and prove the environmental acceptability of the method. Studies were therefore concentrated on thermal destruction processes. Several thousand gallons of hydrolysate were incinerated successfully in an existing high-temperature furnace, which was originally designed to burn DDT (as

DDT/kerosene solutions) and which included a scrubbing tower. Using natural gas as an auxiliary fuel, the hydrolysate was incinerated, and the resultant gaseous effluents, except for a small quantity of sulfur dioxide, were removed in the scrubbing tower. A smokestack was erected to disperse the remaining sulfur dioxide into the atmosphere so that clean air standards could be met. The scrubbing tower water was neutralized with calcium hydroxide and recirculated.

Final Mustard disposal system

8. In the destruction process which is now underway, the mustard hydrolysis is being carried out in the specially designed remotely controlled facility which has been mounted directly on top of the storage vaults. The reaction of each batch (about 7 tons of mustard) is complete in about six hours. One batch can thus be destroyed in one working day. The process is economical, efficient and non-hazardous.

9. Following laboratory verification of reaction completion, the hydrolysate is drained into an interim storage tank, or directly into trailer-mounted tanks for hauling to the incinerator, which is located approximately one mile from the reactor.

10. At the incinerator, the hydrolysate is pumped under pressure into an atomizing nozzle and dispersed into a natural gas flame. Combustion rates of up to 2½ gallons per minute may be achieved under optimum conditions. Thermal destruction of the hydrolysate at the rate of about 35 tons (mustard equivalent) per week is expected.

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Working Paper on toxicity of chemical warfare agents

Modern lethal chemical warfare agents are exceedingly toxic substances, much more toxic for the most part than the chemicals in common industrial use. Because of this difference, it has been suggested that the degree of toxicity is a logical choice as one possible criterion for defining chemical warfare agents for the purpose of an arms control agreement.

As noted in the work programme presented by the United States delegation (CCD/360), there are several different approaches to the question of definition, each with its own advantages and disadvantages. A criterion based on a toxicity limit would have the advantage of being directly related to the potential danger from a particular substance. It would be applicable to known super-toxic substances or any super-toxic substance discovered in the future. However, compounds which are less toxic might still have utility either as chemical warfare agents or agent precursors. Among these are mustard-type compounds, dual-purpose agents such as phosgene (carbonyl chloride), hydrogen cyanide, and cyanogen chloride, and binary precursors. If a prohibition is to cover all lethal agents it might be necessary to adopt a general-purpose criterion and perhaps other criteria in addition to a toxicity criterion.

Considerable progress has already been made in working out the technical aspects of a practical toxicity criterion. Concrete proposals for a toxicity criterion have already been presented by the delegations of Japan (CCD/301, CCD/374) and Canada (CCD/387, CCD/414). Both delegations adopted a similar approach by proposing a criterion based on the toxicity of a particular agent. Soman was suggested as a "boundary agent" by the Japanese delegation and tabun by the Canadian delegation.

As our delegation and others have noted, a toxicity value for a compound is meaningful only if the experimental conditions under which it was measured are specified in detail. For this reason, in order to establish a practical toxicity criterion, it would be necessary to define not only the toxicity level, but also the animal to be used for measurement and the route by which the chemical is administered.

Experimental Animal

The military utility of CW agents is related to toxicity to humans. Theoretically a toxicity criterion would be based on human reactions to chemical agents. Obviously, however, experimental animals must be used instead to measure the toxicity values.

In general, the assumption that a compound that is super-toxic to experimental animals will will also be very dangerous to humans is a sound one. In toxicological studies, a variety of different animals are commonly used. As noted in Table 1, toxicity values vary somewhat from one species to another. Therefore, a toxicity threshold must be tied to a specific animal.

Table 1. Toxicity of Tabun to Experimental Animals*/

Animal	LD_{50} (mg/kg)**/
Mouse	0.35 - 0.40
Rat	0.16
Guinea Pig	0.13 - 0.3
Rabbit	0.3 - 0.5
Cat	0.10
Goat	0.3

*/ Subcutaneous administration: United States Army data

**/ The LD_{50} is the dose which is lethal to 50 per cent of a group of animals (median lethal dose).

Route of Administration

The toxicity of an agent may vary depending on the route by which it is administered to the test animal. Chemicals are commonly administered orally or by inhalation or introduced directly by injection ("parenteral" administration). The most common parenteral routes of administration are into a blood vein (intravenous), into the abdominal fluid (intraperitoneal), into a muscle (intramuscular) or beneath the skin (subcutaneous). Percutaneous administration involves application on the skin. The variation in toxicity with route of administration is illustrated for tabun in Table 2.

Table 2. Influence of Route of Administration on Toxicity of Tabun */

Route of Administration	LD_{50} (mg/kg)
Intravenous	0.10 - 0.15
Intraperitoneal	0.66 - 0.9
Subcutaneous	0.35 - 0.40
Percutaneous	1.0 - 2.8

*/ Taking a mouse as the experimental animal; United States Army data.

Unfortunately, it is not possible to convert the value obtained by one route of administration to an equivalent value for a different route. As shown in Table 3, the relative values for different routes of administration vary from compound to compound.

Since the military potential of super-toxic compounds is often closely related to their inhalation toxicity, it would seem logical to establish a criterion based on inhalation toxicity as proposed in CCD/414. Some chemicals, however, are not super-toxic when inhaled, but would be extraordinarily toxic if they were carried into the body by a projectile which penetrated the skin. Included in this category are super-toxic carbamates. For this reason a criterion based on inhalation toxicity would not be sufficient.

The toxicity criteria proposed in CCD/374 are based on subcutaneous or intra-peritoneal injection. These routes of administration are generally applicable to any compound and are less difficult from a technical standpoint than administration by the respiratory route.

It would be possible to supplement a criterion based on inhalation toxicity with one derived from parenteral toxicity. However, it would be simpler to rely on parenteral toxicity alone, since any compound that is super-toxic on inhalation will also be super-toxic by a parenteral route.

To some extent the selection of a particular experimental animal and a given parenteral route of administration in defining the criterion is arbitrary. The choice might best be made simply according to the relative amount of data available for the different situations. It appears that more data, particularly on known CW agents, are available for the mouse (subcutaneous administration) than for other animals and other routes of administration listed in Table 4.

Judging from the data in Table 4, there appears to be little overlap between single-purpose super-toxic CW agents and dual-purpose chemicals. Ideally, the toxicity criterion should be defined so as to separate the two groups cleanly. It probably will be impossible to do so. However, establishing an LD_{50} value of 0.50 mg/kg (mouse; subcutaneous administration) as the limit, as suggested in CCD/301, or a value close to 0.50 mg/kg, may be the optimal solution to the problem of selecting a suitable level.

Experimental Variability

In order for toxicity measurements from different laboratories to be consistent with each other, the detailed experimental procedures must be standardized. Some of the conditions which would have to be established are listed in CCD/374. If general agreement were reached to adopt a prohibition based on a specific toxicity threshold, the precise experimental procedures could undoubtedly be worked out by experts in toxicology.

Table 3. Relative Toxicity Values for Several Results of Administration */

Route of Administration	Procaine		Isoniazid		DFP **/		Pentobarbital	
	LD_{50} (mg/kg) (Mouse)	Relative Value	LD_{50} (mg/kg) (Mouse)	Relative Value	LD_{50} (mg/kg) (Rabbit)	Relative Value	LD_{50} (mg/kg) (Mouse)	Relative Value
Intravenous	45	1	153	1.0	0.34	1.0	80	1.0
Intraperitoneal	230	5	132	0.9	1.00	2.9	130	1.6
Intramuscular	630	14	140	0.9	0.85	2.5	124	1.5
Subcutaneous	800	18	160	1.0	1.00	2.9	130	1.6
Oral	500	11	142	0.9	4 to 9	11.7 to 26.5	280	3.5

*/ from T.A. Loomis, Essentials of Toxicology, Lea and Febiger, Philadelphia, 1968.

**/ DFP = diisopropylfluorophosphate

Table 4. Mouse Toxicity Data (Subcutaneous Administration)

Compound */	Toxicity (LD_{50}, mg/kg)	Source
3152 CT (carbamate)	0.005 (i.v., dog)	Funke, Depierre and Krucker, 1952
VX	0.022	U.S. Army
VE	0.025	U.S. Army
VM (edemo)	0.035	U.S. Army
VS	0.035	U.S. Army
GB (sarin)	0.04	CCD/374
GB (sarin)	0.06 - 0.15	CCD/374
GD (soman)	0.1	CCD/374
GF	0.11 - 0.20	U.S. Army
GD (soman)	0.125	U.S. Army
GB (sarin)	0.15	U.S. Army
VG (amiton, tetram)	0.155 (male)	U.S. Army
GB (sarin)	0.173	CCD/374
GB (sarin)	0.2	CCD/374
GB (sarin)	0.214	Askew, 1957
GB (sarin)	0.22	CCD/374
GE (ethly sarin)	0.301	U.S. Army
GA	0.35 - 0.40	U.S. Army
neostigmine (prostigmine) **/	0.42	U.S. Army
echothiophate **/	0.50	Schaumann, 1960
neostigmine methylsulfate **/	0.51	Brown et al, 1950
neostigmine iodide **/	0.55	Brown et al, 1950
paraoxon **/	0.6 - 0.8	CCD/374
paraoxon **/	0.7	Augustinsson, 1953; Schaumann, 1960
neostigmine (prostigmine) **/	0.8	Toxic Substances List, 1973
TEPP (tetraethylpyrophosphate) **/	0.85	U.S. Army
HN-1	1.1 - 2.05	U.S. Army
physostigmine salicylate **/	1.24	Brown et al, 1950
paraoxon-ME **/	1.4	CCD/374
HN-3 **/	2.01 (HCl)	U.S. Army
colchicine **/	2.3 - 3.8	U.S. Army

Mouse Toxicity Data (Subcutaneous Administration)

Compound	(Toxicity (LD_{50}, mg/kg)	Source
metasystox (methyldemeton) **/	2.9 - 3.3	CCD/374
potassium cyanide **/	2.9 - 6.0	U.S. Army
DFP **/	3.2 - 4.7	U.S. Army
DFP **/	4	Toxic Substances List, U.S. Dept. of HEW, 1973
HN-2 **/	4.5	U.S. Army
methyl fluorcacetic acid **/	5 - 19	U.S. Army
sulfotepp **/	8	CCD/374
parathion **/	10 - 12	CCD/374
parathion **/	"	Holmstedt, 1963
mustard gas (H)	20 - 30	U.S. Army
methylparathion **/	30	Helmstedt, 1963
cyanogen chloride (CK) **/	39	U.S. Army

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*/ The structures of military CW agents listed here are given in CCD/365.

**/ Commercial chemicals

However, even if procedures are standardized, there will be a certain amount of variability in the measurements. It is to be expected that two laboratories using identical samples of chemical will still obtain slightly different toxicity values. This is because it is difficult to control precisely all the variables involved in making toxicity tests on animals.

In making toxicity measurements, a range of 20 per cent on either side of the average value is usually considered good. Studies on the reproducibility of oral toxicity values have demonstrated that a broader range should normally be expected. The ratio of the highest to lowest value is likely to be between 1.5 and 3 for oral toxicity values and may be as high as 10. (For parenteral toxicity values, the range may be somewhat smaller). Usually, the LD_{50} value reported is the average of a range of values.

The variability of toxicity values could pose a problem in applying a treaty prohibition in certain cases. Normally only one or two independent values will be available, and it is quite possible that these values will differ greatly from the average value that would be obtained from a large number of independent determinations. For a particular compound, one laboratory might report the compound to be more toxic than the limit while a different laboratory might conclude that it is less toxic.

This difficulty may be illustrated by assuming that the toxicity criterion has been defined to be an LD_{50} of 0.50 mg/kg (mouse; subcutaneous administration) and that a standardized experimental procedure has been adopted. For a compound with an average LD_{50} value of 0.36 mg/kg, which is below the limit, the possible results from different laboratories range approximately from 0.18 mg/kg to 0.54 mg/kg. If the value reported is greater than 0.50 mg/kg, it might be argued that the compound should not be prohibited. Analogously, for a compound which would have an average LD_{50} value of 0.80 mg/kg, which is well above the 0.50 mg/kg limit, a single laboratory might report a value as low as 0.40 mg/kg. In this case, prohibition might well be advocated.

Obviously, some differences may arise about application of the prohibition to a specific compound even if a toxicity criterion is established. One possible way to help resolve such differences would be to have an appropriate independent laboratory measure the toxicity.

Super-Toxic Dual-Purpose Compounds

As noted above, it is unlikely that a toxicity criterion can be found that will cleanly separate single-purpose super-toxic CW agents from dual-purpose chemicals. A few dual-purpose compounds are likely to be more toxic than the limit established by the toxicity criterion. The data in Table 4 indicate that most of these compounds will be drugs. Strict application of the toxicity criterion would lead to a ban on

these super-toxic dual-purpose compounds. However, super-toxic drugs are produced in very small quantities and are not well suited as chemical warfare agents. It might be useful to consider application of the criterion in such a way that super-toxic drugs would not be prohibited. This might be accomplished by allowing super-toxic chemicals to be produced in quantities necessary for legitimate use as a drug if the use as a drug had been demonstrated beforehand.

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Working Paper on chemical agent destruction

In a previous working paper (CCD/367) the United States delegation described the environmental protection and safety procedures involved in current United States operations for demilitarizing limited quantities of chemical weapons. The example discussed was the planned demilitarization and disposal of nerve agent cluster bombs.

This paper describes in detail the actual procedures employed in disposal of mustard gas at Rocky Mountain Arsenal near Denver, Colorado, an operation that was completed in March 1974. Possible methods of verification of the disposal operation are also discussed. We hope that this information on the characteristics of actual disposal operations will be useful to the Committee in its consideration of verification of chemical agent destruction.

Background

In the fall of 1968 the Department of the Army decided to dispose of certain chemical agents and munition stocks, including the mustard agent stored at Rocky Mountain Arsenal near Denver, Colorado. These mustard stocks amounted to 3701 tons and were stored as bulk in containers which hold approximately 0.9 ton of agent.

In response to an Army request a proposed plan for disposal at sea was reviewed in the Summer of 1969 by a panel of experts under the auspices of the National Academy of Sciences. These experts, drawn primarily from leading industrial, educational and research institutions, recommended that the bulk mustard agent at Rocky Mountain Arsenal be destroyed by incineration.

This recommendation was adopted by the Army. A plan for disposal by incineration was prepared and made public. It was reviewed by interested agencies, as required under the National Environmental Protection Act and revised. A final statement of the plan was made public in early July 1971.

Small-scale disposal operations were initiated shortly after the final statement was filed. During this stage of the operations, the disposal equipment was tested and minor changes in the disposal plan were made in order to resolve the few difficulties encountered. Full scale disposal operations began in September 1972.

Outline of Disposal Plan

Mustard gas decomposes rapidly at about 425°C to produce three gases - sulphur dioxide, carbon dioxide and hydrogen chloride. In the disposal operation, the mustard was destroyed by incineration. The incineration products were removed from the exhaust stream and converted to harmless salts.

Steps of the Disposal Plan

(1) Transfer of agent containers. The agent containers were stored in the toxic agent area at Rocky Mountain Arsenal. This area was under continuous security guard surveillance and the mustard containers were visually inspected for leakage by depot personnel (daily during warm weather and every three days during cool weather. Prior to removal from the area, the containers were checked for any possible liquid leakage by using a standard detection paper that changes color when exposed to mustard. They were then loaded on a flat bed truck and were transported under security guard escort to the mustard plant area for disposal. As a safety precaution a decontamination truck followed the loaded truck.

(2) Unloading and Thawing. Upon arrival at the mustard disposal facility, the containers were unloaded and placed in a thaw room where they remained for at least 48 hours at a temperature between 40°C and 60°C. The thaw room, as well as other areas of the facility where a potential hazard from mustard vapor existed, were maintained under a negative pressure. Since mustard gas freezes between 5° and 15°C it was heated in the thaw room to get as much as possible of the solid residue from the bottom of the container into solution. The rare liquid leaks that occurred during this 2-day period were trapped in a sump where they were decontaminated with a standard military decontaminant that reacts rapidly with mustard and achieves complete decontamination in about five minutes. These liquids were subsequently checked to ensure absence of mustard, added to the spent scrubber brine, and spray dried.

Any vapors which were generated were vented through the duct in the floor of the thaw room and removed from the air by an absolute filter system with essentially 100 per cent efficiency.

(3) Draining of Containers. From this thaw room the containers were taken to the unloading booths by overhead crane, placed inside the booths and remotely attached to an evacuating hose. The mustard then was drawn off under vacuum. Determination of the quantity of mustard removed from the container was accomplished by weighing the container before and after the operation.

(4) Incineration of Agent. The mustard which had been removed from the container was pumped into a holding tank from which it was later pumped to the incinerator. It arrived at the incinerator through double-walled piping and was sprayed into the incinerator where it was heated to temperatures of 750° to 875°C for 0.3 second, thus thermally decomposing it completely. At peak effeciency the disposal rate was over 7 litres per minute.

(5) Scrubbing of Effluent Gases. In the incineration process sulphur dioxide and hydrogen chloride are generated. To wash these pollutants out of the effluent gases, the gases were passed through a scrubber system where they were brought into contact with a solution of sodium hydroxide, a strong caustic. This resulted in a brine solution of inorganic salts: sodium sulphate, sodium sulphite, sodium chloride, and sodium carbonate. This salt solution was then evaporated to dryness and the residue of salts compacted. A test was performed periodically to verify that the salts contained no mustard.

The effluent gases were then passed through an electrostatic precipitator to remove particulate matter (mostly ferric oxide resulting from corrosion of the steel containers) before being exhausted from the stack.

(6) Disposal of Salts. The compacted salts were transported in lined 55-gallon drums to a warehouse where they remain in storage pending final disposition. No decision has yet been made on the best method for disposal of the salts. Approximately 4000 tons of salt were generated during the operation.

(7) Decontamination and Disposal of Containers. Prior to removal from the booth where it was emptied, each container was inspected and externally decontaminated if required. It was then moved to a temporary storage area. During the incineration of the bulk agent a separate incinerator furnace was used to decontaminate the containers.

In this process a container was removed from the storage area. Upon arrival at the furnace area, two holes were remotely punched in the container to provide ventilation and release of combustion gases in lieu of removing valves and plugs. Following this operation, the containers were placed in the furnace, where any residual mustard and impurities were incinerated. The amount of time that each container remained in the furnace depended on the amount of residue it contained initially; however, the average was about 2 hours at temperatures in excess of 425°C. The effluent from the incinerator operation was passed through a scrubber (sodium hydroxide solution) to remove the combustion products sulphur dioxide and hydrogen chloride.

Following cooling, quality control personnel checked the container with standard detection material to assure that all traces of mustard had been removed before it was transported to the holding area. The containers will be recycled as scrap metal.

Verification of Agent Destruction

In the disposal process described in the preceding sections, opportunities for verification appear to exist at several points. It must be kept in mind, however, that the characteristics of the disposal process may vary according to the type of agent being destroyed, whether the agent is stored in bulk or in munitions, and the safety and environmental regulations which must be followed.

Verification of disposal might be conducted in a variety of ways, depending upon the degree of access accorded verification personnel. At one extreme, verification might be limited to remote observation via closed-circuit television with no access to the facilities themselves. At the other extreme, unrestricted inspection of the disposal site might be permitted, including unrestricted access to all buildings and records and analysis of chemical samples.

In the paragraphs that follow, verification of disposal will be discussed using the United States procedure for disposal of bulk mustard agent as an illustration.

(a) Steps 1 and 2: Transfer of agent containers; unloading and thawing. In these steps there may be several indicators that toxic chemical agents are being handled. A few of the most recognizable indicators are:

a. Decontamination equipment readily available.

b. Workers in protective clothing and equipped with protective masks.

c. Toxic agent warning sign attached to vehicle.

d. Security measures, including a security escort front and rear when travelling.

By their nature these indicators would be easily observed. However, they could also easily be staged and their value for verification is therefore questionable.

(b) Step 3: Draining of Containers. This step provides the first opportunity for positive assurance that a toxic chemical agent is present. This assurance can be achieved, however, only if full access to the facility is allowed. During the draining phase of the process, it would be feasible to tap the drain line to the storage tank. A small (10 ml) sample of liquid could be withdrawn and analysed to determine the type and concentration of agent. This would provide positive verification that agent was being drained from the container.

(c) Step 4: Incineration of Agent. Verification at this step could provide the best assurance that toxic chemical agent is actually being destroyed. In the destruction of the mustard agent, the agent is transferred from the storage tank to the furnace

through a single pipe. A tap valve could be installed in this pipe at the point just before the mustard is injected into the furnace for burning. As in the previous step, a sample could be withdrawn and analysed as to the type of agent and its concentration. Data over a period of time could be compared with data from the previous step to ensure the agent had not been diluted (part diverted and another liquid substituted).

Analysis of the salts could provide another method of verification. This might be considered less intrusive than sampling and analysis of the agent itself. A mustard gas molecule contains one sulphur atom and two chlorine atoms. No other chlorine or sulphur compounds are involved in the disposal process. As a result, there should be a 2 : 1 ratio between chlorine and sulphur atoms in the salts. The salts resulting from mustard disposal at Rocky Mountain Arsenal have been analysed and found to have the approximately expected ratio.

A third method of verification might be to try to obtain a materials balance. Records would be needed for the quantity of agent to be destroyed, amount of caustic being added, and total weight of the end product salts. It is possible to calculate the amounts of salts which should be produced from disposal of a given quantity of a specific agent. For this method to work, there would have to be no loss of gases, liquid or solids, from the system. In other words, the system would have to be totally contained. This was not the case at Rocky Mountain Arsenal. As is typical of incineration, minor losses of gases were anticipated and did occur in the process (mostly sulphur dioxide being exhausted from the stack), which altered somewhat the total weight of salts produced as well as the relative quantities of the different compounds.

To assist in the materials balance procedure it would be useful to have a flowmeter in the line transferring agent from the holding tanks to the furnace.

(d) Steps 5-7: Scrubbing of Effluent Gases; Disposal of Salts; Decontamination and Disposal of Containers. In the case of mustard disposal, these steps did not appear to provide any important additional opportunities for verification of destruction.

Preliminary Comments and Conclusions

(1) There are several indicators which could provide some assurance to observers that disposal operations were being carried out.

(2) A number of means for misleading observers exist, including the staging of indicators and substitution of an industrial chemical for agent.

(3) A high degree of assurance that no evasion is taking place during the disposal process could be obtained through technical methods of inspection.

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Working Paper on diversion of commercial chemicals for weapons

As many delegations, including our own, have noted, there are three major categories of substances related to chemical warfare:

(1) Single-purpose agents. These agents have no large-scale use for prophylactic, protective or other peaceful purposes. This category includes the super-toxic organophosphorus nerve agents, as well as some less toxic agents which have no important peaceful applications.

(2) Dual-purpose agents. Chemicals in this category have important civilian applications, but might also be used as CW agents. Many of the CW agents used in World War I are in this group, including phosgene (carbonyl chloride), chlorine and hydrogen cyanide.

(3) Precursors. Chemical compounds used as intermediates in the production of super-toxic agents may or may not have civilian application. For example, phosphorus trichloride, a key precursor in the production of organophosphorus nerve agents, is widely used as an intermediate in the manufacture of pesticides and plasticisers. On the other hand, another important precursor, methylphosphonic dichloride, is not currently used in producing commercial organophosphorus chemicals (but could be in the future).

This suggests that verification of a ban on production of CW agents has two major aspects: (a) ensuring that single-purpose CW agents and single-purpose precursors are not being produced and (b) making certain that dual-purpose agents and dual-purpose precursors are not being diverted to non-peaceful purposes.

Several delegations have suggested that statistical monitoring of chemical production could play an important role in deterring diversion of dual-purpose chemicals to prohibited military uses. Under this approach, data on the production and consumption of raw materials and intermediates would be analysed to ensure that no diversion occurred. The United States delegation presented some preliminary conclusions

and comments on this approach in a previous working paper (CCD/311, 25 August, 1970). At that time we noted that there were certain problems and disadvantages to be overcome, particularly in regard to identifying deliberate attempts at deception.

The United States has continued its research on economic data monitoring in an effort to overcome some of the shortcomings identified in CCD/311. This paper is based on a study sponsored by the US Arms Control and Disarmament Agency, entitled "The Role of Phosphorus Control in Verification of a Ban on Nerve Agent Production: An Economic and Technical Analysis", carried out by Midwest Research Institute (Kansas City, Missouri).

Control System for Phosphorus

Among the potential CW agents, super-toxic organophosphorus compounds are generally considered to pose the greatest danger. The structure of these agents and possible processes for producing them may vary widely; however, phosphorus is the one substance which is a key input for manufacture of any organophosphorus agent. This suggests that production of such agents might be prevented by establishing controls over elemental phosphorus and any phosphorus compounds which could serve as precursors ("divertible" phosphorus compounds). Controls would not cover "non-divertible" compounds.

A control system might be established to monitor the production, storage, transportation and use of all phosphorus compounds which can be used in the production of a nerve agent. The objective would be to ensure that all consumption of divertible phosphorus compounds could be traced to legitimate activities. To accomplish this task, the industrial enterprises which handle these materials would be required to maintain detailed internal records and to prepare periodic reports on all relevant activities. In addition, all transfers between plants of this kind would have to be documented by records prepared by the shipper, the carrier and the consignee. To ensure the accuracy of these industry-level reports, several types of checks would be incorporated into the system.

The administration and operation of the control system could be divided among several levels -- industry, national control agencies and an international control agency. Industrial enterprises would be required to follow authorized material handling procedures, maintain adequate accounting records and report to the national control agency. The national body would have primary responsibility for applying the controls to enterprises which are within the territory of the state involved, or are under its jurisdiction or under its control anywhere. Verification that all industrial establishments have complied with all provisions of the control system would be provided

by the national body to the international control agency. The international agency would oversee the entire system, analyse and audit reports from each national agency and monitor the international trade of controlled materials.

Verification

In order to provide a reasonable degree of assurance that no diversion is occurring, such a control system would need to be designed so that the accuracy of reports from industrial establishments and from the national control agencies could be verified. There appear to be three basic verification techniques which could be used by the control agencies to determine the accuracy of reports: (1) analysis of statistical information presented in the reports, (2) examination and analysis of records, and (3) technical inspection. In this paper the discussion will focus on the verification activities of the international control agency.

The first step taken by the international control agency to verify the system's reporting accuracy would be analysis of the reports submitted by the national control agencies and perhaps by certain industrial enterprises. This would include review of the statistical data to ensure that all quantities balanced and that they were in line with those expected.

Periodically the international control agency would audit relevant records of national control agencies. In addition they would have the authority to conduct audits of national control agencies and individual industrial enterprises at any time to resolve discrepancies. While the procedures which would be followed are very similar to those employed in conducting a financial audit, they would, of course, be concerned with quantities of phosphorus and their disposition.

It would be necessary to develop a reliable system based on technical inspection for detecting false records. The types of technical inspection which could be employed are: (1) visits to certain chemical plants, (2) technical analysis of plant operating data, (3) analysis of samples of phosphorus-containing chemicals which are in inter-plant transit, and (4) monitoring of metering devices which provide independent information on plant production rates.

Evasion

There are two principal ways in which evasion could occur. Either the phosphorus material would be diverted from within the system or it would be obtained from sources outside the system's control. For evasion techniques which operate within the system, records and reports at the industry and national level would be changed to avoid detection from discrepancies, or imbalances, in the reports. By definition, evasions outside the system have no effect on the records and would have to be detected by other means.

Possible Methods of Evasion Within The Control System

The possible means of evasion within the control system which have been identified in our studies are summarized below:

1. An elemental phosphorus plant understates the production of phosphorus and diverts the excess to an agent plant.

2. A multi-product plant reports an incorrect production mix between divertible and non-divertible phosphorus compounds.

3. A plant overstates the production of a non-divertible item and diverts an equivalent amount of input material.

4. The amount of phosphorus in a product is overstated by a plant.

5. An establishment reports high loss rates of divertible material or low efficiencies in production processes which use divertible materials.

6. A plant uses wet process phosphoric acid (not produced from elemental phosphorus) to produce material and reports the production as using "furnace acid" (phosphoric acid produced from elemental phosphorus).

7. A country diverts small amounts of phosphorus from a large number of plants.

8. A plant fails to register its phosphorus recovery process.

9. A nerve agent plant registers as a legitimate industrial phosphorus user.

A detailed examination of the United States phosphorus industry has revealed the following concerning potential evasions within the control system:

1. The greatest potential for obtaining phosphorus for CW agent production appears to be diversion of elemental phosphorus. Diversion from the phosphorus production plant would require less record modification and would be more difficult to detect than other diversion methods.

2. Exports of elemental phosphorus and production of white phosphorus munitions, the only major end uses of phosphorus in the elemental (white) form, are also potentially major points for diversion.

3. Recovering significant quantities of phosphorus for agent production by reprocessing chemical end products appears to be the least feasible of the evasion procedures considered.

Evasions Outside of the Control System

Evasion might occur outside the control system in several ways:

1. An elemental phosphorus plant does not register with the control agency.

2. Nerve agent precursors are produced directly from phosphate rock, rather than from elemental phosphorus.

3. Phosphorus material for agent is recovered from an end use product.

4. Phosphorus material is imported from a country which is outside of the control system.

5. Phosphorus or phosphorus-containing precursors are stockpiled prior to agreement.

6. Demilitarization of obsolete chemical munitions or agents which are not entered into the system.

Preliminary Evaluation of Effectiveness

The verification technique discussed in this paper differs significantly from the economic data monitoring technique discussed previously (CCD/311) in that provisions for technical inspection have been incorporated. In the new approach, statistical data provide the background for combined use of audit and technical inspection procedures. This technique increases the utility of economic data monitoring since the audit and technical inspection procedures complement one another.

While conventional on-site inspections would be useful in some circumstances, they would not be highly effective in detecting some very important kinds of evasion within the system. For example, diversion of phosphorus from an elemental phosphorus plant is unlikely to be detected by observation of plant activities. At the time of the inspection the plant authorities most probably would not try to divert any phosphorus.

However, an unconventional kind of technical inspection might be effective in detecting certain kinds of diversion, including that illustrated in the previous example. This technique would combine a technical analysis of plant operating records with conventional records auditing procedures. The technical analysis would consist of a correlation of reported production figures with such data as (a) consumption of starting materials, (b) production of by-products, and (c) electrical power consumption. This type of audit would not necessarily be performed on-site; however, access to complete plant records would be required.

Two other kinds of technical inspection could also be very useful: (a) the analysis of samples obtained from inter-plant shipments, and (b) the metering of the production of elemental phosphorus and phosphoric acid. These techniques might help detect certain kinds of diversion that could not be detected any other way. For example, production metering would be the best way to prevent an attempt to divert phosphorus at an elemental phosphorus plant by understating actual production. Chemical analysis of samples of phosphoric acid would help forestall efforts to substitute "wet process" acid (produced from phosphate rock) for "furnace" acid

(produced from elemental phosphorus) and then divert the unused phosphorus to agent production. "Wet process" acid contains relatively large amounts of impurities, which are not present in "furnace" acid.

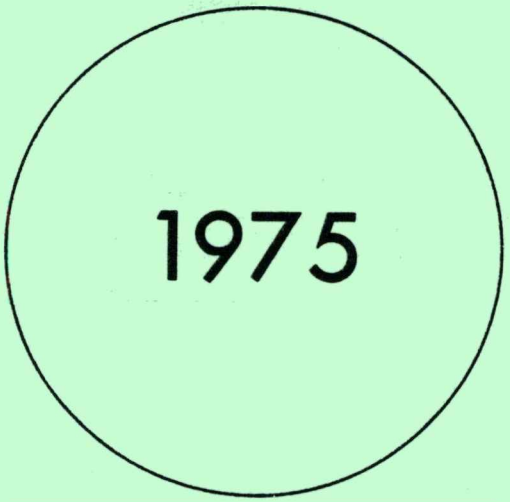
For the control system to provide any deterrent to the diversion of phosphorus to nerve agent production, three specific measures should be provided in the operation of the system. First, the international control agency should have access to reports from individual enterprises. This is important because the statistical analysis of the reports submitted by an individual plant is one of the principal methods of detecting the diversion of phosphorus material. National reports would not contain sufficient detail to enable the international agency to detect statistically the material diverted by several of the possible evasion methods.

Second, the international control agency should be allowed to conduct an investigation of a plant's records. Unless an independent investigation is possible, evasion of the system would not be difficult. The risk of detection by an investigation could substantially increase the deterrent effectiveness of the system.

Third, technical inspection should be an integral part of the data validation procedure. A standard records audit would not be sufficient to verify the accuracy of the records.

A phosphorus control system, with the verification provisions discussed in this paper, could probably ensure that large quantities of phosphorus-containing chemicals were not being diverted from commercial channels to weapons purposes. In itself this capability would not be sufficient to provide adequate assurance of compliance. Diversion of some significant quantities could still be accomplished by a determined evader. In all likelihood, however, phosphorus would not be diverted from commercial channels but rather obtained from sources not subject to the control system.

Phosphorus monitoring could play a useful role in verifying compliance with a production ban, although further verification measures would also be needed.


1975

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/452
8 April 1975
Original: ENGLISH

JAPAN

Modification of the wording used in a draft convention (CCD/420) on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction

The Japanese delegation wishes to make the following modifications to the wording used in the Japanese draft convention on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction, document CCD/420, which was submitted to the Conference of the Committee of Disarmament on April 30, 1974.

1. To substitute the words "chemical warfare agents" for "chemical agents" stipulated in Article 1 (a) and Annex 1 (Alternatives A and B) of the above draft convention,
2. And also substitute the words "chemical substances" for "chemical agents" stipulated in paragraphs 1 and 2 of Article XIV of the above draft convention.

GE.75-64096

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/453
4 July 1975
Original: ENGLISH

LETTER DATED 2 JULY 1975 FROM THE PERMANENT REPRESENTATIVE OF FINLAND TO THE ACTING REPRESENTATIVE OF THE SECRETARY-GENERAL TO THE CONFERENCE OF THE COMMITTEE ON DISARMAMENT TRANSMITTING A WORKING PAPER BY THE GOVERNMENT OF FINLAND

ON METHODOLOGY FOR CHEMICAL ANALYSIS AND IDENTIFICATION OF CW AGENTS - PROGRESS OF A FINNISH RESEARCH PROJECT

Upon instructions from my Government, I have the honour to enclose a Working Paper by the Government of Finland to the Conference on Disarmament with the request that you would take appropriate steps to have it distributed in the Conference of the Committee on Disarmament.

(Signed) Klaus A. Sahlgren
Permanent Representative
of Finland

GE.75-67137

WORKING PAPER BY THE GOVERNMENT OF FINLAND TO THE CCD

Methodology for chemical analysis and identification of CW agents - Progress of a Finnish research project

1. In 1972, the Government of Finland announced a project on creation on a national basis of a CW control capacity for possible future international use (CCD/381). Development of the project has been described in two working papers (CCD/412/14.8.73 and CCD/432/16.7.74). This paper presents the progress made during the last year.

2. Training of personnel has continued with focus on the following aspects: (1) proper choice, collection and packing of environmental samples (soil, water, biological materials); (2) preconcentration of organophosphates and other compounds of interest and their decomposition products from environmental samples to a concentrated solution, suitable for subsequent instrumental analysis; (3) analysis of organophosphates and other CW agents by infrared spectrometry; gas chromatography-mass-spectrometry, NMR-spectrometry and other methods.

3. Instrumentation has been expanded by new acquisitions. A phosphorus unit which has been acquired for the multinuclear high resolution NMR-spectrometer has proved particularly effective. It can be used for detection and identification of minute amounts of phosphorus-containing compounds even in quite complex mixtures. Analysis can be performed without laborious and, when warfare agents are concerned, potentially dangerous handling of the samples.

4. Preparation of standard spectra for an analytical manual has been continued as described in the previous working paper (CCD/432). For this purpose over 50 model compounds have been synthesized and the NMR spectra of these as well as of about 30 phosphorus-containing pesticides have been recorded. By comparing these spectra it has been possible to find out typical features for compounds of different classes. By using this reference material an unknown compound can be identified, sometimes even when only some of its degradation products are available.

5. In the course of the work it has become more and more evident that the quality and representativeness of the samples will be of utmost importance. The value of even most sophisticated analysis cannot exceed the reliability of the sample from which it has been made. Therefore, verification of chemical warfare agents requires samples which are taken in a technically correct way and the origin of which can be rigorously proved. Thus detailed instructions are needed on how the samples shall be collected and examined, how they shall be stored, packed and transferred for further analyses.

6. Using the previously developed and reported quick and safe micro method for the study of hydrolysis and alcoholysis reactions of halogenated phosphorus compounds and of spectroscopic methods reactivity of these compounds, of related model compounds, their precursors and their reaction products, have been studied. It has been possible to derive new semi-empirical rules which are of value in evaluating decay schemes and chemical stabilities of organophosphorus compounds under various environmental conditions. Thus the influence of substituents of the reacting compounds, of catalysts, of solvents and of other parameters, may be predicted roughly from these rules.

7. Studies on decreased cholinesterase activity in biological materials (blood, brain) due to organophosphate poisoning have been continued. Hen's small brains have been found to contain a highly active esterase, which allows a much higher sensitivity than the previously used enzyme preparations. The method has been used in a case of human suicidal propoxur poisoning.

8. Detailed results of the project will be published in scientific journals. As before, the Finnish Government will also keep the CCD informed about the future progress of the project.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/458
22 July 1975
Original: ENGLISH

FEDERAL REPUBLIC OF GERMANY

Working paper on the definition and classification of chemical warfare agents

I. Aim and Method of Approach

This Working Paper is intended to contribute towards solving the problem of defining and classifying chemical agents. Taking into account previous proposals, an attempt has been made to develop an evaluation method by which it will be possible, on the basis of objectively measurable criteria largely eliminating subjective evaluations, validly to assess the suitability of a chemical substance for use as a warfare agent.

Extending earlier proposals, the proposed method uses various toxicity categories and introduced additional (secondary) criteria indicating the suitability of agents for military use with a view to confining the number of substances to be banned to a realistic limit.

Both the toxic properties and the additional criteria are quantified. Finally, a simple mathematical formula for calculating evaluation numbers is described by which chemical substances can be classified according to military suitability.

II. Evaluation Criteria

1. Toxicity - the Primary Criterion

Proceeding from a number of proposals made in the past (e.g. Japan: CCD 374; Canada: CCD 414; USA: CCD 435) toxicity is used as the primary criterion of the suitability of a chemical substance for use as a warfare agent. In view of the different physiological effects of the various chemical agents, it is suggested that the following toxicity categories*/ be used:

Category 1 - respiratory toxicity

Category 2 - percutaneous toxicity

Category 3 - skin lesion

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*/ The use of further categories of toxicity - as routinely determined for new substances (intravenous, intraperitoneal, oral toxicity) - in the first evaluation of a substance might be considered. These toxicities would then have a sort of monitoring function and would provide first indications of the possibly dangerous nature of substances. The collection and evaluation of toxicity data through animal experiments was extensively discussed in an earlier contribution to the CCD (USA: CCD 435).

Introducing these three categories as separate criteria appears necessary because the toxicity of an agent may vary considerably between these three toxicity categories.

A number of substances will produce toxic effects of more than one category. For example, mustard gas which causes severe skin lesion is also highly toxic if inhaled, and VX is both a respiratory and a percutaneous agent.

Category 1, or respiratory toxicity is expressed as LCT_{50} ($mg \cdot min \cdot m^{-3}$) for a minute volume of 20 litres of air. Tentatively, 10 toxicity intervals have been defined and assigned index figures from 0 to 9 as follows:

Index figure IT	LCT_{50}
0	$>$ 20,000
1	$\sim$ 20,000
2	$\sim$ 10,000
3	$\sim$ 4,000
4	$\sim$ 1,000
5	$\sim$ 500
6	$\sim$ 250
7	$\sim$ 100
8	$\sim$ 30
9	$<$ 10

Category 2, or percutaneous toxicity is expressed as LD_{50} ($mg \cdot kg^{-1}$). Again, as in the case of Category 1, 10 toxicity intervals have been tentatively defined and assigned index figures from 0 to 9 as follows:

Index figure PT	LD_{50}
0	$>$ 100
1	$\sim$ 100
2	$\sim$ 80
3	$\sim$ 50
4	$\sim$ 20
5	$\sim$ 5
6	$\sim$ 1
7	$\sim$ 0.5
8	$\sim$ 0.1
9	$<$ 0.1

Category 3 effects, i.e. skin lesions, are characterized and indexed as follows:

Assuming a dose of 1 mg of substance per square centimetre of skin, the various symptoms have been tentatively assigned index figures as follows:

Index figure DT	Symptom
2	erythema
4	superficial blisters
6	deep blisters
8	necrotic ulceration

2. Secondary Criteria

Many substances, though highly toxic, are not suitable for military use. To determine the military suitability of substances additional easily quantifiable criteria should be applied. As a working hypothesis, the following secondary criteria have been established:

Shelf life

Perceptibility

Volatility

Explosion stability

Resistance to atmospheric influences

The secondary criteria may take the values 0.1, 1 or 2. The factor 0.1 was chosen for practical reasons. Since a factor zero in a multiplication makes the product zero, the individual secondary criterion would be overweighted if zero were introduced as a factor into the calculation proposed in Section III below.

The shelf life (SL) of a substance indicates its tendency to decompose as a result of intermolecular or intramolecular reactions, its sensitivity to changes in temperature, its aptness to corrode containers and the possibility of chemically stabilizing it through additions. The characteristic shelf life of a substance has been defined as the time it takes, in a 20°C environment, for 50 per cent of it to be destroyed.

Ratings:

Shelf life of under 30 days	SL = 0.1
Shelf life of up to 2 years	SL = 1
Shelf life of over 2 years	SL = 2

The perceptibility (P) of an agent indicates the concentration at which its odour, colour or irritant effects will betray its presence.

Ratings:

Under 10 mg/m^3	P = 0.1
Up to 1,000 mg/m^3	P = 1
Over 1,000 mg/m^3	P = 2

The volatility of a toxic substance limits its suitability for military use. The degree of volatility largely depends on the boiling point which can usually be easily determined. The boiling point (BP) is defined in degrees Centigrade for 760 torr.

Ratings:

Boiling point under 0° C	BP = 0.1
Boiling point under 60° C	BP = 1
Boiling point over 60° C	BP = 2

Explosion stability (ES) is a measure of the stability of an agent in the event of an explosion of the carrier. It is expressed as the percentage by weight of the filler that remains effective after an explosion (a test would have to be agreed).

Ratings:

Under 10 per cent	ES = 0.1
Under 50 per cent	ES = 1
Over 50 per cent	ES = 2

The resistence to atmospheric influences (RA) indicates to what extent a substance is resistant to hydrolysis, the oxidizing effect of air and photochemical reactions caused by sunlight. It is expressed as the percentage by weight of a quantity of agent released which becomes ineffective within 1 minute.

Ratings:

Over 50 per cent	RA = 0.1
Up to 1 per cent	RA = 1
Under 1 per cent	RA = 2

III. Calculation

By combining toxicity data with quantified applicability criteria through a simple mathematical operation characteristic evaluation numbers are to be established for each individual substance.

The evaluation number N takes into account the suitability of a substance as a respiratory agent N1, as a percutaneous agent N2, and as a skin agent N3, and is obtained by addition as follows:

$N = N1 + N2 + N3$

The suitability numbers (N1, N2, N3) are obtained through multiplying the respective toxicity numbers by the product of the secondary criteria ratings.

Thus the number N is calculated by means of the following formula:

$$N = N1 + N2 + N3$$
$$= (IT \cdot SL \cdot P \cdot BP \cdot ES \cdot RA)$$
$$+ (PT \cdot SL \cdot P \cdot BP \cdot ES \cdot RA)$$
$$+ (DT \cdot SL \cdot P \cdot BP \cdot ES \cdot RA)$$

The separate evaluation of a number of aspects provides a clear indication of the properties and the toxicity of a substance so that a characteristic military suitability profile will be obtained for each substance.

IV. Illustrative Examples

To test the viability of the method described above the military suitability numbers of 30 substances ranging from highly toxic commercial chemicals to agents whose data are available from scientific literature have been computed.

	IT	PT	DT	SL	P	BP	ES	RA	N1	N2	N3	N
Chlorine	1	0	0	2	1	0.1	2	2	0.8	0	0	0.8
Mustard gas (H)	3	1	8	2	1	2	2	2	48	16	128	192
Nitrogen mustard gas (HN)	3	2	8	1	1	2	2	2	24	16	64	104
Lewisite (L)	4	2	6	1	1	2	2	2	32	16	48	96
Chloropicrin (PS)	1	0	2	2	0.1	2	2	2	1.6	0	3.2	4.8
Arsine (SA)	3	1	-	1	1	0.1	1	1	0.3	0.1	0	0.4
Hydrogen cyanide (AC)	3	1	-	1	1	1	1	2	6	2	0	8
Cyanogen chloride (CK)	2	1	-	1	0.1	1	1	1	0.2	0.1	0	0.3
Phosgene (CG)	3	0	-	2	1	1	2	2	24	0	0	24
Diphenylcyanoarsine (DC)	4	1	-	2	0.1	2	2	2	6.4	1.6	0	8
Tabun (GA)	5	1	-	2	2	2	2	2	160	32	0	192
Sarin (GB)	7	3	-	2	2	2	2	2	224	96	0	320
Soman (GD)	7	7	-	2	2	2	2	2	224	224	0	448
VX	8	8	-	2	2	2	2	2	256	256	0	512
Q-mustard [1,2-bis-(2-chloroethyl-thio)ethane]	6	3	8	2	1	2	2	2	96	48	128	272
T-mustard [bis(2-chloroethyl-thioethyl)ether]	5	2	8	2	1	2	2	2	80	32	128	240
Phosgene oxime	2	2	6	1	0.1	2	1	1	0.4	0.4	1.2	2
Diphosgene	3	0	0	2	1	2	2	2	48	0	0	48
Diisopropylphosphorofluoridate (DFP)	2	2	0	2	2	2	2	2	64	64	0	128
Iron pentacarbonyl	1	0	0	1	1	2	1	1	2	0	0	2
Nickel tetracarbonyl	2	0	0	2	2	1	1	1	8	0	0	8

	IT	PT	DT	SL	P	BP	ES	RA	N1	N2	N3	N
Carbon monoxide	2	0	0	2	2	0.1	2	2	3.2	0	0	3.2
∝-Chloroacetophenone (CN)	2	0	4	2	0.1	2	2	2	3.2	0	6.4	9.6
∝-Bromobenzylcyanide (BBC)	3	0	2	2	0.1	2	2	2	4.8	0	3.2	8
Diphenylchloroarsine (DA)	2	0	0	2	0.1	2	2	2	3.2	0	0	3.2
Ethyldichloroarsine (ED)	3	3	6	2	0.1	2	2	2	4.8	4.8	9.6	19.2
Methyldichloroarsine (MD)	3	3	6	2	0.1	2	2	2	4.8	4.8	9.6	19.2
Phenyldichloroarsine (PD)	3	3	6	2	0.1	2	2	2	4.8	4.8	9.6	19.2
Mustard-lewisite (HL) HL = 63% lewisite; 37% mustard gas	4	3	8	2	1	2	2	2	64	48	128	240
Adamsite (DM) DM = diphenylaminochloroarsine	2	0	2	2	0.1	2	2	2	3.2	0	3.2	6.4

V. Conclusions

The approach described in this Working Paper should provide a practicable method of distinguishing between chemical warfare agents and other toxic substances.

As the table shows, the substances evaluated so far fall into two clearly distinguishable groups, one with high and one with low N values, the threshold value of the former being around 100. Substances whose N values exceed 100 might be described as particularly liable to be employed militarily. Irrespective of that, substances might be considered particularly suspicious if one of the three numbers, N1, N2 or N3, is higher than 50. Of course, the limits can be defined differently.

Thus the proposed approach would provide a sound basis both for a limited initial scheme banning only certain supertoxic agents and for a broader scheme covering a wider range of substances.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/461
29 July 1975
Original: ENGLISH

SWEDEN

Working paper on a model for delimitating chemical warfare agents in an international treaty

Introduction

During the negotiations on a prohibition against development, production and stockpiling of chemical weapons, it was realized almost from the outset that it would be a difficult task to obtain meaningful and useable delimitations between different types of chemicals.

The need for differentiation stems from the obvious facts that, relatively speaking, only a few chemicals are useful as chemical warfare agents and that the overwhelming amount of chemicals have no actual or potential warfare use. It would obviously be unnecessary, or even damaging, to have too extensive a ban on chemical production. However, no self-evident principles are available for delimitation.

Many attempts have been made during the years of negotiations to solve the problem. Few attempts have been made to analyze more closely the concepts involved (see however CCD/414, 21 August 1973) and to relate them to each other. It goes without saying that various suggestions on delimitation have been presented, each connected with some special application. In the practical negotiation work it has turned out to be an increasingly difficult task to try to sort out and to remember to what extent and on what grounds the different approaches do or do not cover each other. A first attempt was made in the Swedish working paper CCD/427, 2 July 1974.

The present working paper is an attempt at a more detailed analysis of the matter indicating some common trends in international conventions which might be useful in disarmament discussions. A model for an overall view of the problem is presented. Efforts have also been made to give the model some dynamic properties, in view of possible future alterations and of alternative outcomes of negotiations. 1/

A comprehensive model

Earlier attempts

The presentation of the Japanese draft treaty CCD/420, 30 April 1974 with the explicit introduction of alternatives of exempted or absolutely prohibited chemical agents made it necessary to try to get a comprehensive view of all the criteria and delimitation concepts. In the attempt made at this in the Swedish working paper

1/ Further discussions and references are given in J. Lundin "Description of a model for delimitating chemical warfare agents in an international treaty". FOA Reports, vol. 9, No. 4, 1975

CCD/427 a so called Venn diagram (Fig. 1) was used[2/], covering the concepts of Chemical Warfare Agents, Dual-Purpose Warfare Agents, and the Chemical Compounds for Peaceful Use. The relationship between the proposed Japanese annexes and these concepts was demonstrated. This model turned out to be useful during informal discussions between experts and non-experts in chemistry.

It still seems to be widely felt that the chemical field is too complex to be covered by a treaty banning production of chemical weapons. Therefore, a wider application of the model will be made in the following, with the aim to show that this pessimism need not be justified.

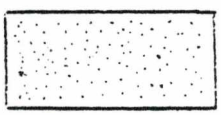
Application of a comprehensive model

A model presented in the Swedish working paper CCD/427 did not treat all the criteria discussed earlier in the CCD nor did it indicate the dynamic aspects to be considered, i.e. a model must also describe the function and effects of a treaty over a time span. The concepts discussed in the CCD are listed in Table 1. In Fig. 1 an attempt has been made to analyze how these concepts interfere with each other and how their coverages overlap.

Table 1. Concepts, criteria and conditions constituting means of delimitation of chemicals to be covered by a treaty prohibiting development, production and stockpiling of chemical weapons.

Purpose (of use)	Supertoxic, Toxic and Low-toxic (non-toxic)
Quantity (of production)	
Verifiable production	
Dual-purpose and Single-purpose	Exemptions from a prohibition listed in a treaty annex
	Absolutely prohibited production of chemicals listed in a treaty annex
	Conditional and unconditional - prohibition

2/ Named after the mathematician Venn. The Venn diagram implies (in this case) that each chemical compound can be assigned to a point within a bounded surface, see figure below.



The areas allotted to the various concepts in Fig. 1 are not intended to represent the actual relations in size between the different groups. Instead, they are meant to indicate whether many or few chemicals can be expected to be found in a group. The capital letters in the figure denote the various concepts and show, in another way, where the different areas in Fig. 1 b, c, d and f represent several concepts.

The consequences of the need for verifiability presented in the Japanese draft are illustrated in Fig. 1 e and f. The letter combinations in the appropriate areas show that all the combinations from Fig. 1 d are covered.

Fig. 1 g and h illustrates what the combination of the concepts of conditional and unconditional prohibitions and annexed lists of exempted and absolutely prohibited chemical warfare agent production might look like when a treaty comes into force.

Fig. 1 h shows how possible changes, after a number of years and after continued negotiations, e.g. at future review conferences, have resulted in a treaty which is comprehensive from all practical points of view. The annexed list of exemptions has diminished, and the list of absolutely prohibited chemical warfare agent production has grown as large as might be possible from a practical point of view. The possible direction in which this growth might have taken place is indicated by a corresponding increase of the screened field covering the various areas. It should be noted that possible future developments are marked in the model (the dots in Fig. 1 h).

The principally important feature of Fig. 1 g and h is the demonstration of a simple and easily understandable way to construct a treaty prohibiting development, production and storage of chemical weapons.

(1) Production of temporarily exempted chemicals, listed in an annex, is allowed when necessary for various reasons (thinly hatched area in Fig. 1 g and h).

(2) Unconditionally prohibited chemical warfare agent production is listed in an annex and is made dependent on the degree of verifiability (screened area in Fig. 1 g and h).

(3) Production etc. whether controllable or not, of all chemical warfare agents and weapons which are not specifically mentioned in one of the two lists of the annex, is prohibited according to the general purpose and quantity criteria of the treaty text, (conditional prohibition, densely hatched area in Fig. 1 g and h).

It might be possible to diminish the number of agents exempted by mentioning only those dual-purpose agents which actually have been used, or might become suitable, as chemical warfare agents and perhaps also single chemical warfare agents, explicitly needed or not yet destroyed e.g. for deterrence by retaining a limited capacity for retaliation in case effective verification measures are still being built up. It might also be necessary to make exemptions for agents which were not yet destroyed.

It should be observed that all agents, also those listed as exemptions, might still be subject to verification measures, in order to make comprehensive verification of, i.a. organophosphorus compounds.

A particular merit of such a list of examptions would be that the number of agents would eventually decrease, subject to subsequent agreements to the effect that an increasing number of exceptions either be transferred to a list of absolutely prohibited agents, or become prohibited merely according to a general purpose criterion (see fig. 1 h).

These advantages were discussed by Sweden in the CCD (CCD/PV.652 15 August 1974). The simplicity of the model may by some seem to be jeopardized by the risk that extensive and unmanageable lists of substances will result. Before discussing this aspect it might be illuminating to look at some other international agreements regarding chemicals, with consideration to their relation to the model discussed here.

Figure 1

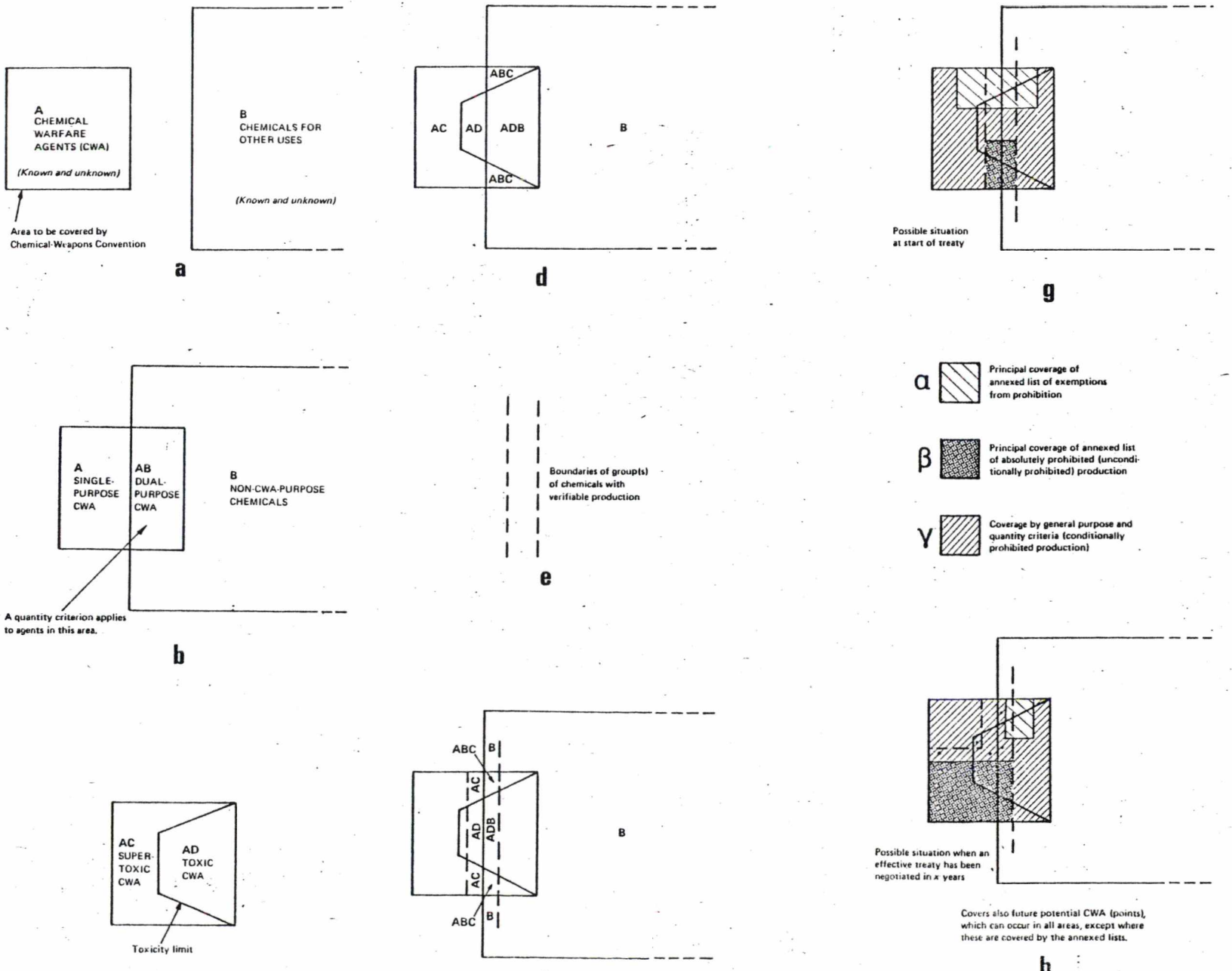

A
CHEMICAL
WARFARE
AGENTS (CWA)
(Known and unknown)
Area to be covered by
Chemical-Weapons Convention
B
CHEMICALS FOR
OTHER USES
(Known and unknown)
a
ABC
AC
AD
ADB
B
ABC
d
Possible situation
at start of treaty
g
A
SINGLE-
PURPOSE
CWA
AB
DUAL-
PURPOSE
CWA
B
NON-CWA-PURPOSE
CHEMICALS
A quantity criterion applies
to agents in this area.
b
Boundaries of group(s)
of chemicals with
verifiable production
e
α
Principal coverage of
annexed list of exemptions
from prohibition
β
Principal coverage of annexed list
of absolutely prohibited (uncondi-
tionally prohibited) production
γ
Coverage by general purpose and
quantity criteria (conditionally
prohibited production)
AC
SUPER-
TOXIC
CWA
AD
TOXIC
CWA
Toxicity limit
c
ABC
B
AC
AD
ADB
B
AC
ABC
B
f
Possible situation when an
effective treaty has been
negotiated in x years
Covers also future potential CWA (points),
which can occur in all areas, except where
these are covered by the annexed lists.
h

Fig.1. Representation of a model for delimitation of chemical warfare agents (CWA) in a comprehensive chemical disarmament treaty. The treaty is assumed to prohibit development, production and storing of chemical weapons, the provisions covering all CWA.

(a) Chemical substances are represented by two areas covering chemical warfare agents, denoted A and chemicals for other uses, donoted B. To indicate the vastness of the latter area the boundary is not closed.

(b) When applying the purpose criterion to the chemicals covered by the two areas A and B, respectively, it appears that some chemicals have purpose only as chemical warfare agents. They are single-purpose agents and still belong to area A. Others have also other purposes than as chemical warfare agents. They are thus dual-purpose and belong also to area B, i.e. part of A and part of B together cover the same chemicals, and the corresponding area can be denoted AB. In this area the quantity criterion applies. All other chemicals without any use for chemical warfare are covered by the remaining part of area B.

(c) If a toxicity criterion (C) is used to differentiate between more or less toxic chemical warfare agents one might get one sub-group of supertoxic chemical warfare agents (AC) and one group of less toxic agents (AD), separated by the agreed toxicity limit.

(d) The figure shows the result when the three previously discussed criteria are applied jointly.

(e)-(f) The verifiability criterion implies that only the production of those chemical warfare agents the (non-)production of which can be verified (e), shall be absolutely prohibited. Application of this criterion, gives the result shown in (f). It should be noted that parts of all the previously discussed areas can be covered by the verifiability criterion. This means that if the production of a particular group of chemicals (e.g. the organophosphorus compounds, to which the nerve gases belong) can be verified. This is illustrated in the model by showing all types of chemical compounds of such a group being covered by the verifiability criterion, even those belonging only to area B.

(g)-(h) Areas covered by proposed lists (in an annex to the treaty) of ( ) exemptions of substances from production prohibition, and ( ) of substances absolutely (or unconditionally) prohibited to produce are marked by thinly hatched and screened areas, respectively. Densely hatched areas ( ) cover chemicals which are not mentioned in the envisaged lists, but which are still prohibited to produce according to the purpose and quantity criteria (conditional prohibition).

(g) The situation when a treaty enters into force. A large list of exemptions can be conceived of. The list of absolutely forbidden agents will probably be relatively small.

(h) Shows how the content - but not the comprehensive scope - of the treaty may have changed over x years of continuing negotiations or review conferences, and with respect to new technical developments. The result is a small list of, military probably insignificant, exemptions and an extended list of substances the production of which is absolutely prohibited. The increase in the content of the latter list may be the result of improved verification methods or other means which may facilitate their transfer to the list of absolutely prohibited agents. The model also indicates that the new CWA can be discovered or developed (dots in densely hatched area) and may instigate further negotiations.

Application of the model to other conventions

Several times during this century, regulations of the use, production and handling of chemicals detrimental to human beings or to the environment have been agreed upon internationally. An analysis of the construction of these regulations shows that nearly all delimitation criteria dealt with in this working paper have been used in one or another of these earlier treaties. Table 2 sums up the content of some treaties in this field.

TABLE 2. Types of criteria used in some international trea

Treaty see also list of references	Year	Purpose	Quantity
Geneva Protocol prohibiting use of CWA	1925	Yes	-
Brussels Treaty of the WEU prohibiting production of BWA and CAW	1954	Yes	Yes
Biological Convention of prohibiting production of BWA and toxin weapons	1972	Yes	Yes
Codex Alimentarius Commission for the FAO/WHO Food Standards Program (Voluntary membership)	1962	Yes (handling)	-
Single convention on narcotic drugs	1961	Yes	Yes
Convention on psychotropic substances	1971	Yes	Yes
Protocol relating to intervention on the high seas in cases of marine pollution by substances other than oil	1973	Yes (handling)	-
Draft treaty of Japan in CCD prohibiting development, production and stockpiling of chemical weapons (CCD 420, 1974)	1974	Yes	Yes

treaties covering use and production of chemicals.

Applied criteria (see also text)		
Types of property or description	Graded or amendable prohibition (measures)	Verification needs
Asphyxiating, poisonous, physical properties	-	No
BWA: harmful insects, other living or dead organisms, toxic products CWA: asphyxiating, toxic, irritant, paralysant, growth regulating, antilubricating, catalyzing B & CWA: lists of substances and key products, general formulas for chemicals	Yes	Verifies non-production
Microbiological, other biological means, toxins	Yes	-
Extensive description of properties and measures for handling food additives of listed substances	Yes	No verification, national acceptance of recommended standards
Schedules of drugs grouped according to degree of dangerousness and actual use	Yes	Yes
Schedules of drugs grouped according to degree of dangerousness and actual use	Yes	Yes
Lists of substances for different uses and of different properties, in appendix	Yes	Yes
Alternative lists of exempted or absolutely prohibited substances, respectively, in appendix	Yes	Yes

It should be observed that the list comprises treaties on the abuse of chemicals in peacetime as well as on the use of chemical weapons in war. Among both types of agreement provisions occur for international verification measures and for international organizations to apply such measures, by making suggestions to member-states of the treaties. The number of substances actually covered by a treaty is substantially different for different treaties, varying from the general descriptions in the Geneva protocol and the Biological Weapons Convention, via the few chemicals mentioned in the Brussels Treaty (1954), to the several hundred agents covered in the Single Convention on Narcotic Drugs (1961) and the Codex Alimentarius (1969).

At present there is a strong trend towards monitoring both national and international agreements relating to the environment.

The United Nations Environmental Program is investigating the possibilities for building up an extensive International Register of Potentially Toxic Chemicals (IRPTC) and an International Reference Service (IRS) on environmental information. OECD has completed a project concerning Unintended Occurrence of Pesticides in the Environment discussing also international co-operation regarding toxicological information.

On the efforts on the national level, only those in Japan and Sweden will be mentioned here. Japan has instituted the Law Concerning Examination of Chemical Substances and Control of their Manufacture, effective 16 April 1974 and the consequence here on the compilation of a List of Names of Existing Chemical Substances to be used in Japan as a basis for further toxicological investigations especially about long time effects of some of these substances. The list of 1974 comprised some 20 000 substances.

In Sweden a data-based information system on properties of chemicals to be allowed in production and in the environment is being set up. The Swedish Environmental Protection Agency will then license the production and use only of such chemicals as are not detrimental to Man and Nature. Special laboratories will be charged with analyzing products as a basis for the licensing. The system is expected to cover several thousands of chemicals. Many other countries are actively working along similar lines.

Altogether it is thus obvious that the trend today of watching the production and use of all kinds of chemicals is deliberate and purposeful. Consciousness about chemical weapons is, however, necessary, also among those who only work on the problem with peaceful activities.

Discussion of the implications of the model

The analysis presented in this paper of existing attempts to construct the scope of a treaty prohibiting the development, production and stockpiling of chemical weapons has aimed at showing that no principal technical difficulties need arise in the fulfilment of this task.

As a means for this analysis a model has been constructed which shows how different suggestions discussed so far in the CCD are iterrelated and can be looked upon as parts of a common concept.

One special feature of the model presented is that it allows for a dynamic view on a production ban. It does so by showing that changes in the coverage of the treaty can be foreseen:

(a) the number of dual purpose agents and perhaps even warfare agents that may initially have to be exempted from the ban will diminish with time;

(b) the number of chemical warfare agents the production of which shall be unconditionally prohibited will rise along with improving conditions for verification.

The dynamic approach also ensures the possibility that the treaty can be built-up gradually without loss to the over-all aim of reaching a comprehensive ban.

Comparisons with other international treaties regulating the use and control of chemicals show that they apply, to varying degrees, the same criteria as those discussed in the model. It can also be observed that some of these treaties manage to cover a large number of chemicals.

The model indicates that, in principle, both international and national measures have to be taken in order to ensure a meaningful treaty. Such measures obviously concern verification and forms for continuous evaluation of changing conditions, etc. Although no political steps are identified by the model, the comparison with other international treaties shows that the necessary steps have been taken before, with respect to chemicals in general as well as to chemical warfare agents.

Conclusions

It should be possible to construct, on technical grounds, the scope of a comprehensive treaty banning development, production and stockpiling of chemical weapons in a manner meeting the political objections raised against previous attempts to this end.

The difficulties due to the fact that the chemical field is complicated and that a great number of chemicals might have to be considered when constructing the treaty can be alleviated considerably by applying to it the dynamic properties of the model described in this paper.

Likewise, the verification mechanism can be built up continuously allowing adaptative expansion to meet the demands expressed from time to time.

CONFERENCE OF THE COMMITTEE ON DISARMAMENT

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Working Paper concerning the scope of chemical agents that have justification for peaceful purposes and an example of the national verification system

1. The scope of chemical agents that have justification for peaceful purposes

(1) The draft convention on banning chemical weapons (CCD/420) submitted by Japan in April 1974, and revised subsequently (CCD/452), prescribes in its article 1 (a) the scope of chemical agents to be banned as "Chemical warfare agents of types and in quantities that have no justification for protective or other peaceful purposes". In other words, the article means that, among chemical agents which have justification for peaceful purposes, (a) the chemical agents whose level of toxicity is so low that they are not suitable for use as chemical warfare agents (CWAs) should be excluded from the ban unconditionally, and (b) the dual purpose agents which can be used as CWAs should be excluded from the ban but the quantities of these agents excluded from the ban should be below the level that have justification for peaceful purposes. So, it follows that the delimiting of the scope of the chemical agents that have justification for peaceful purposes would contribute to delimiting in turn more precisely the scope of the chemical warfare agents (CWAs) which should be banned, and thus contribute to the early conclusion of a convention banning chemical weapons. Delimiting the scope of chemical agents that have justification for peaceful purposes is even necessary since article 1 of the Japanese draft convention adopts the purpose criteria to define the scope of the CWAs to be banned eventually. That is to say that article 1 of the Japanese draft convention covers not only (a) single purpose CWAs which should be banned from the beginning but also (b) dual purpose agents which can be used both for warfare and peaceful purposes, and (c) the unknown and undisclosed chemical agents which may be discovered in future or which exist without our knowledge; accordingly, while this purpose criteria has the merit of universal and permanent application, it has the demerit of leaving the problem of deciding practically whether a certain chemical agent comes under the ban or not. To help solve this problem, this working paper attempted in Table 1 to clarify the scope of

chemical agents that have justification for peaceful purposes on the basis of the current practice in Japan of controlling chemical substances.

(2) In Japan, chemical substances with a toxicity exceeding a certain level have been placed under control since 1950 to protect human health and hygiene. The laws being enforced for this purpose are: (a) the Poison and Deleterious Substance Control Law, (b) the Narcotics Control Law and (c) the Stimulating Drugs Control Law. The control exercised under these three laws extends to approximately 200 kinds of chemical substances. Meanwhile, the number of chemical substances in use has considerably increased due to the recent progress of the chemical industry, and it is clear that these laws are insufficient to meet the need of ensuring human health from a long-term point of view. Among the new chemical substances, harmful ones such as PCB were found to be useful for industrial purposes but also to be hard to decompose when left in the environment, to accumulate in the human body after eating sea foods and thus to endanger health. For the purpose of controlling these harmful chemical substances, a new law, "The Law concerning the Screening of Chemical Substances and Regulation of their Manufacture, etc.", was enforced in October 1973, as has been referred to in the Swedish working paper (CCD/461) of 29 July 1975. This law is intended to screen prior to its production or import chemical substances which require control and to place necessary controls on the substances thus screened in order to prevent pollution of the environment by the chemical substances which have characteristics such as being hard to decompose and have the likelihood of being detrimental to human health. As it was necessary to include all chemical substances at the time of the entry into force of this law, approximately 19,500 chemical substances which were not controlled then as poison or deleterious substances, as narcotics or as stimulating drugs were sorted out and were recorded in the "List of the Existing Chemical Substances", which was attached to the law as an appendix. Since Japan does not possess CBR weapons, all of the chemical substances enumerated in this list and those referred to in (a) the Poison and Deleterious Substance Control Law, (b) the Narcotics Control Law and (c) Stimulating Drugs Control Law are used for peaceful purposes.

Since it is difficult for practical reasons to introduce here all the chemical substances which number approximately 20,000, of these only the phosphorous compounds have been selected and shown in Table 1 of the working paper. This table corresponds to Table 2 of the Annex I of the Japanese draft convention which shows the phosphorous compounds which should be banned from the outset. Part I of the table lists the chemical substances with comparatively high toxicity and Part II lists those with low toxicity.

With chemical warfare agents (CWAs) and chemical compounds for peaceful uses (PCCs) in the phosphorous family thus clarified, what is necessary to do is to sort out the dual purpose agents (DPWAs) which appear in both these two categories, and delimit the boundaries of CWAs, PCCs and DPWAs. If consensus can be reached at the Committee on Disarmament concerning criteria such as those of toxicity and of structural formulae for the purpose of delimiting respective boundaries, a remarkable contribution would be made towards the conclusion of a convention banning chemical weapons.

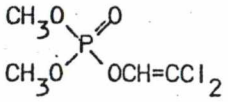
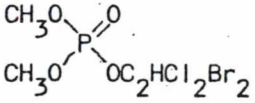
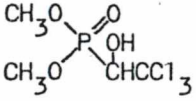
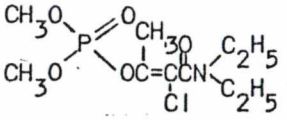
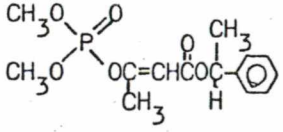
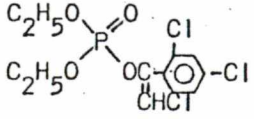
2. An example of the national verification system

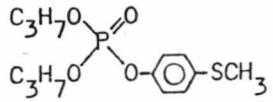
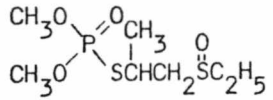
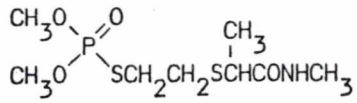
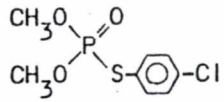
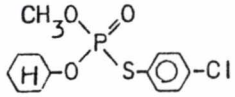
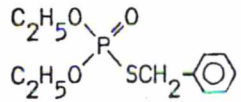
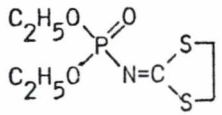
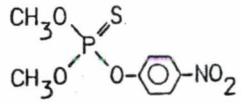
The control system contained in the aforementioned "Law concerning the Screening of Chemical Substances and Regulation of their Manufacture, etc." may offer an example of the functions of the national organ as suggested in the Japanese draft convention (CCD/420) as well as working paper (CCD/430) for the purpose of ensuring the compliance with the obligations of CW convention. The law provides for (a) examination at any time when the need is felt of any chemical substance which appears in the list of nearly 20,000 items enumerated in its appendix, and (b) obligation to report in advance of the intended production or import of any chemical substances which do not appear in the aforementioned list and prior examination thereupon. This system is illustrated in Table 2 of this working paper. In the latter case ((b) above), the new chemical substances are to be classified depending upon results of the examination into "harmless chemical substances" and "specified chemical substances", and these "specified chemical substances" are to be kept under observation. If it is difficult to classify the substance during the first examination, a second examination is to be conducted, and depending on further needs, the matter would be referred to the Consultative Board on Chemical Substances consisting of experts before reaching a decision.

TABLE 1

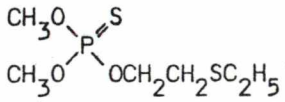
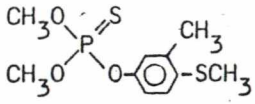
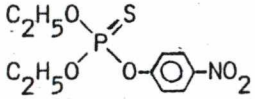
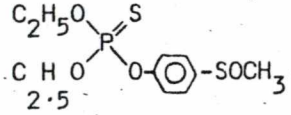
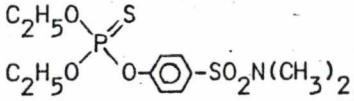
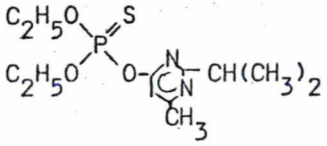
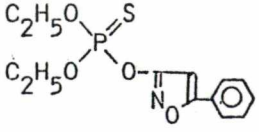
Compounds Containing Phosphorus

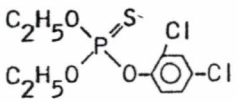
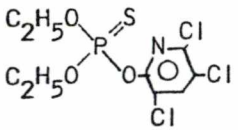
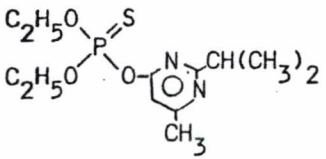
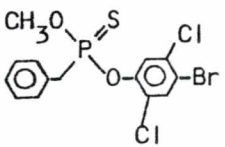
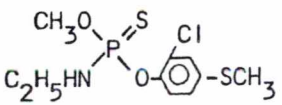
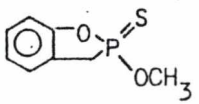
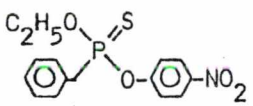
Part I From Poison and Deterious Substance Control Law

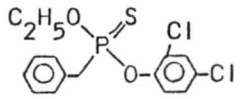
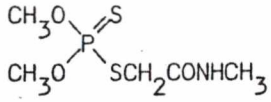
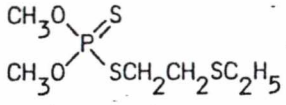
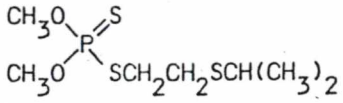
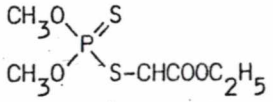
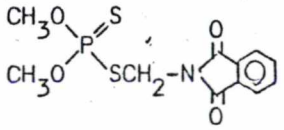
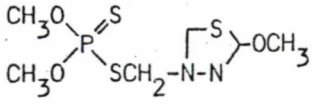
Chemical structure	Name	LD50 mg/kg		
Zn_3P_2	Zinc phosphide	mouse	p.o.	49.8
$(C_4H_9S-)_3P=O$	Tributyl trithiophosphate ($(n\text{-}C_4H_9S-)_3P=O$	rat	p.o.	1272)
	Dimethyl 2,2-dichlorovinyl phosphate	mouse rat	i.p. p.o.	29 50
	Dimethyl dibromodichloroethyl phosphate	mouse rat	p.o. p.o.	120 430
	Trichlorohydroxyethyl dimethyl phosphate	mouse rat	i.p. p.o.	500 450
	Dimethyl diethylamide-1-chlorocrotonyl phosphate	mouse mouse	p.o. s.c.	11.2 6.2
	Dimethyl-[2-(1'-methylbenzyloxycarbonyl)-1-methyl-ethylen] phosphate	rat rat	p.o. p.c.	66 447
	Diethyl 1-(2,4-dichlorophenyl)2-chlorovinyl phosphate	mouse mouse	p.o. p.c.	65 336

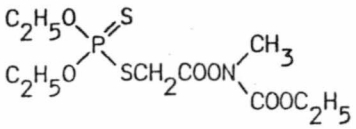
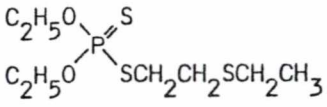
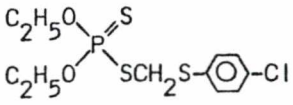
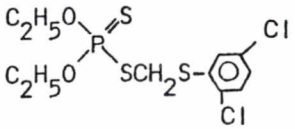
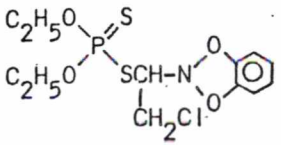
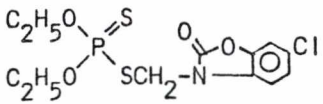
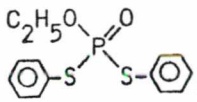
	Dipropyl 4-methylthiophenyl phosphate	mouse	p.o.	90
	Dimethyl ethylsulfinylisopropyl thiophosphate	mouse mouse	p.o. p.c.	57.8 264
	Dimethyl methylcarbamylethylthioethyl thiophosphate	mouse mouse	p.o. s.c.	42.2 20.8
	Dimethyl S-p-chlorophenyl thiophosphate	mouse rat	p.o. p.o.	94 125
	Methyl cyclohexyl 4-chlorophenyl thiophosphate	mouse mouse	p.o. s.c.	60 13
	Diethyl S-benzyl thiophosphate	mouse mouse	p.o. s.c.	237.7 203.7
	Diethyl-(1,3-dithiocyclopenthylidene) thiophosphoramide	mouse mouse	p.o s.c.	35.1 51.2
	Dimethyl p-nitrophenyl thiophosphate	mouse rat rat	p.o. p.o. p.o.	20 14 ♂ 24 ♀

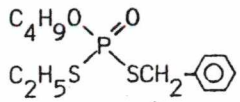
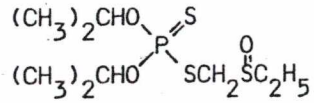
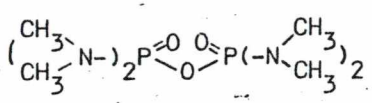
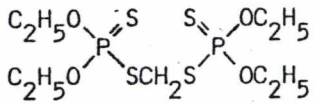
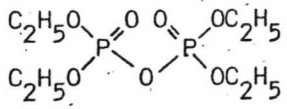
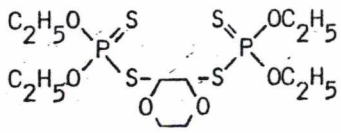
2

	Dimethyl ethylmercaptoethyl thiophosphate	rat	p.o.	16.7
	Dimethyl 4-methylmercapto 3-methylphenyl thiophosphate	mouse rat	p.o. p.o.	88.1 215
	Diethyl p-nitrophenyl thiophosphate	mouse mouse rat	p.o. i.p. p.o.	6 5.5 5
	Diethyl 4-methylsulfinylphenyl thiophosphate	mouse mouse	p.o. s.c.	13.2 45.5
	Diethyl p-dimethylamino-sulfonylphenyl thiophosphate	mouse	p.o.	23.1
	2-Isopropyl 4-methylpyrimidil 6-diethyl thiophosphate	mouse mouse rat	p.o. i.p. p.o.	48 65 108
	Diethyl-(5-phenyl-3-isoxazolyl) thiophosphate	mouse	p.o.	75

	Diethyl-(2,4-dichlorophenyl) thiophosphate	mouse rat	p.o. p.o.	270 250
	Diethyl 3,5,6-trichloro-2-pyridyl thiophosphate	mouse mouse	p.o. p.c.	70 120
	2-Isopropyl 4-methylpyrimidyl 6-diethyl thiophosphate	mouse rat	p.o. p.c.	65 76 ♀
	Methyl-(4-bromo 2,5-dichlorophenyl)thionobenzene phosphonate	mouse mouse	p.o. 67 133 p.c.120 156	
	N-ethyl methyl(2-chloro 4-methylmercaptophenyl) thiophosphoramide	mouse mouse	p.o. p.c.	33 174
	2-Methoxy 1,3,2-benodioxaphosphoryno-2-sulfide	mouse mouse	p.o. s.c.	91 82
	Ethyl p-nitrophenyl thionobenzenephosphate	rat rat	p.o. p.o.	142 ♂ 144 ♀

	Ethyl 2,4-dichlorophenylthionobenzene phosphonate	mouse mouse	p.o. s.c.	274.5 783.8
	Dimethyl N-methylcarbamylmethyl dithiophosphate	mouse rat	p.o. p.o.	53.3 50
	Dimethyl ethylmercaptoethyl dithiophosphate	mouse rat	p.o. p.o.	64 100
	Dimethyl isopropylthioethyl dithiophosphate	mouse	p.o.	33
	Ethyl dimethyl-dithiophosphoryl-phenyl acetate	rat	p.o.	200
	Dimethyl phthalylimidomethyl dithiophosphate	mouse rat	p.o. p.o.	34 113
	3-Dimethyl dithiophosphoryl-S-methyl-5-methoxy-1,3,4-thiadiazolin-2-on	mouse	p.o.	54

	Ethyl N-(diethyl-dithiophosphorylacetyl) N-methylcarbamate	mouse rat	p.o. p.o.	92 15
	Diethyl S-(ethylthioethyl) dithiophosphate	mouse mouse rat	p.o. i.p. p.o.	14 5.6 5
	Diethyl 4-chlorophenylmercaptomethyl dithiophosphate	mouse rat	p.o. p.o.	55.6 24
	Diethyl 2,5-dichlorophenylmercaptomethyl dithiophosphate	mouse	p.o.	182
	Diethyl S-(2-chloro 1-phthalimidoethyl) dithiophosphate	rat	p.o.	62
	Diethyl S-(2-oxo 6-chlorobenzoxazolothyl) dithiophosphate	mouse rat	p.o. p.o.	132 120
	Ethyl diphenyl dithiophosphate	mouse mouse	p.o. s.c.	214 163

	Butyl S-benzyl S-ethyl dithiophosphate	mouse	p.o.	120
	Diisopropyl S-(ethylsulfinylmethyl)dithiophosphate	mouse mouse	p.o. s.c.	84.5 118.3
	Octamethyl pyrophosphoramide	rat	p.o.	5.8
	Tetraethyl methylene dithiophosphate	rat	p.o.	96
	Tetraethyl pyrophosphate	mouse rat	p.o. p.o.	3 1.12
	2,3-Di-(diethyl dithiophosphoro) p-dioxane	rat rat	p.o. p.o.	43 ♂ 23 ♀

apr.=approximately

inh.=inhalent

i.p.=intraperitoneal

i.v.=intravenous

p.c.=percutaneous

p.o.=oral

s.c.=sub cutaneous

LD50 in parentheses are an example

TABLE 1

Compounds Containing Phosphorus

Part II From Law Concerning
Screening of Chemical Substances
and Regulation of their Manufacture etc.

Chemical formula	Name	LD 50 mg/kg		
Matalic phosphorus				
Li_3P	Lithium phosphide			
Fe_3P, Fe_2P, FeP, FeP_2	Iron phosphide			
Cu_3P, CuP_2, Cu_3P_2	Copper phosphide			
Sn + P + Cu	Phosphor bronze			
Zn_3P_2, ZnP_2	Zinc phosphide	rat	p.o.	41
GaP	Gallium phosphide			
GaAs + As_2P	Gallium-Arsenic-Phosphorus compound			
Phosphorus Halogenide, nitride, sulfide and oxide				
PBr_2, PBr_3, PBr_5, PBr_7	Phosphorus bromide			
PCl_3	Phosphorus trichloride			
Cl_2-P-P-Cl_2	Diphosphorus tetrachloride			
PCl_5	Phosphorus pentachloride	mouse	inh.	120ppm apr.
PF_5	Phosphorus pentafluoride			
PN, P_4N_6, P_3N_5	Phosphorus nitride			
P_2O_5	Phosphorus pentaoxide			
P_4S_3, P_4S_5, P_4S_7, P_2S_5	Phosphorus sulfide			

phosphoric acid and its derivatives

H_3PO_4	(Ortho)phosphoric acid	rritant effect	man inh. looppm		
Li_3PO_4	Lithium phosphate				
BPO_4	Boron phosphate				
Na_3PO_4	Sodium phosphate	Na_3PO_4	rat	i.p.	326
		Na_2HPO_4	mouse	i.p.	430
		NaH_2PO_4	rat	i.p.	250
$Mg_3(PO_4)_2$	Magnesium phosphate				
$AlPO_4$	Aluminium phosphate				
K_3PO_4	Potassium phosphate				
$Ca_3(PO_4)_2$	Calcium phosphate				
$TiPO_4$, $Ti_3(PO_4)_3$	Titinium phosphate				
$V_3(PO_4)_3$	Vanadium phosphate				
$Cr_3(PO_4)_3$, $CrPO_4$	Chromium phosphate				
$Mn_3(PO_4)_2$, $MnPO_4$	Manganese phosphate				
$Fe_3(PO_4)_2$, $FePO_4$	Iron phosphate				
$Co_3(PO_4)_2$	Cobalt phosphate				

$Ni_3(PO_4)_2$	Nickel phosphate				
$Cu_2(PO_4)_3$	Copper phosphate				
$Zn_3(PO_4)_2$	Zinc phosphate				
$Sr_3(PO_4)_2$	Strontium phosphate				
$(ZrO)_2P_2O_7$, $ZrO(PO_3)_2$, $ZrO(H_2PO_4)_2$	Zirconium phosphate				
$RhPO_4$	Rhodium phosphate				
$Sn_3(PO_4)_2$, $Sn_2P_2)_7$, SnP_2O_7, $Sn_2O(PO_4)_2$	Tin phosphate				
$Ba_3(PO_4)_2$	Barium phosphate				
$La_2(HPO_4)_3$	Lanthanum phosphate				
$CePO_4$, $Ce_3(PO_4)_4$	Cerium phosphate				
$NdPO_4$	Neodymium phosphate				
$Eu_3(PO_4)_2$, $EuPO_4$	Europium phosphate				
Tl_3PO_4, $Tl_6P_4O_{19}$ $12H_2O$	Thallium phosphate				
$Pb_3(PO_4)_2$, $Pb_2P_2O_7$, $Pb(PO_3)_2$	Lead phosphate	Lead orthophosphate LD	guinea pig	i.p.	260

phosphorus acid and phosphites

H_2PHO_3	Phosphorous acid			
Na_2HPO_3	Sodium phosphite			
K_2PHO_3	Potassium phosphite			
$GePHO_3$	Germanium phosphite			

hypophosphorus and hypophosphites

HPH_2O_2	Hypophosphorous acid			
$NaPH_2O_2$	Sodium hypophosphite	rat	i.p.	1584
$Ca(PH_2O_2)_2$	Calcium hypophosphite			

phosphoric complex salts

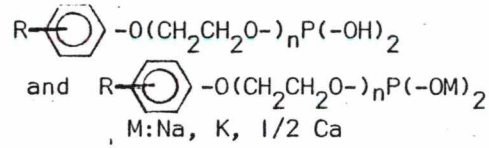
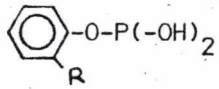
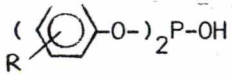
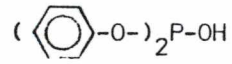
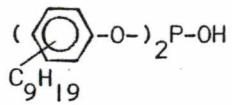
$BF_3\ H_3PO_4$	Boron trifluoride-Phosphoric acid complex
$3Ca_3(PO_4)_2\ CaX_2$ X=halogen	Calcium halophosphate
$[Co(NH_3)_6][PO_4]$	Hexamminecobalt (III) phosphate complex

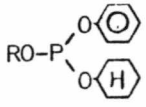
combined acid and its salt	
	Silicon phosphovanadate
	Yttrium phosphovanadate
	Europium phosphovanadate
$H_4[P_2Mo_{12}O_{41}]\cdot nH_2O$ or $H_3[PO_4Mo_{12}O_{36}]$	Phosphorus molybdic acid
$Na_4[P_2Mo_{12}O_{41}]\cdot nH_2O$, $Na_3[PO_4Mo_{12}O_{36}]$ $10H_2O$ etc	Sodium phosphomolybdate
$Zn_2[P_2Mo_{12}O_{41}]\cdot nH_2O$	Zinc phosphomolybdate
$(NH_4)_3[PMo_{12}O_{40}]$, $3(NH_4)_2O\ P_2O_5\cdot 18MoO_3$ etc	Ammonium phosphomolybdate
	Phosphorus wolframic acid
$Na_3[PO_4W_{12}O_{36}]\cdot 15H_2O$ etc	Sodium phosphorus wolframate (complex)
$(NH_4)_3[PO_4W_{12}O_{36}]\cdot 4H_2O$ etc	Ammonium phosphorus wolframate
	Molybdovanadophosphoric acid

other phosphoric compounds

$NaSPO_3$	Sodium metaphosphate sulfide
NaH_2PO_5	Sodium peroxyphosphate
NH_4PF_6	Ammonium hexafluorophosphate

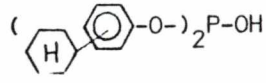
Chemical structure	Name			
$P(-C_4H_9)_3$	Tributylphosphine	rat	p.o.	750
$P(-C_6H_{11})_3$	Tricyclohexylphosphine			
$P(-C_6H_5)_3$	Triphenylphosphine	rat	p.o.	800
$C_6H_5-P(-Cl)_2$	Phenyldichlorophosphine			
$ClC_2H_4O-\underset{OH}{P}-Cl$	Monochloroethylchloro phosphite			
$RX(\text{or } RX_2)COO-P(-OH)_2$ X=Br or Cl	Mono-(or di-)halogenated(Br or Cl) carboxy phosphite			
$(RO-)_2P-OH$	Dialkyl($C_{1\sim30}$) phosphite 、Diethyl phosphite	rabbit	p.c.	2020 ,
$(CH_2=CHCH_2O-)_2P-OH$	Diallyl phosphite	rat	p.o.	178
$(XRO-)_2P-OH$ X=Br or Cl	Bis-bromo(or chloro)alkyl($C_{2,3}$) phosphite			
$RO(CH_2CH_2O-)_nP(-OH)_2$ and $RO(CH_2CH_2O-)_nP(-OM)_2$ R:alkyl or alkenyl M:Na, K, 1/2 Ca	Alkyl(or alkenyl)($C_{9\sim24}$)polyoxyethylene phosphite and its salts(Na, K, Ca)			

 M:Na, K, 1/2 Ca	Alkyl($C_{6\sim14}$)phenylpolyoxyethylene phosphite and its salts(Na, K, Ca)		
$RO\text{-}P(\text{-}OH)_2$ and $RO\text{-}P(\text{-}OM)_2$ R:alkyl or alkenyl M:Na, K, 1/2Ca	Alkyl or alkenyl($C_{8\sim24}$) phosphite and its salts(Na, K, Ca)		
$[(C_{12}H_{25}O\text{-})_2P\text{-}O]_2$ Ba	Barium bis(didodecyl phosphite)		
$[(C_{12}H_{25}O\text{-})_2P\text{-}O]_2$ Ca	Calcium bis(didodecyl phosphite)		
$(ClCH_2CH_2O\text{-})_2P\text{-}Cl$	Bis(2-chloroethyl) phosphoro chloride		
	2-Alkyl($C_{2,6,8}$)phenyl phosphite		
$RO\text{-}P(\text{-}OH)_2$ or $(RO\text{-})_2P\text{-}OH$ R:phenyl, alkyl or alkoxyalkyl	Mono- or di-phenyl mono- or di-alkyl(or alkoxyalkyl, $C_{8\sim13}$) phosphite		
	Di[alkyl($C_{2\sim7}$)phenyl] phosphite		
	Diphenyl phosphite	rat	p.o. 600
	Bis(nonylphenyl) phosphite		



R:alkyl or alkylphenyl

Alkyl($C_{8\sim12}$)[or alky($C_{8\sim12}$)phenyl] cyclohexylphenyl phosphite



Bis(cyclohexylphenyl) phosphite

$P(-OCH_3)_3$ Trimethyl phosphite rat p.o. 2000

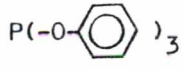
$P(-OC_2H_5)_3$ Triethyl phosphite

$P(-OCH_2CH{=}CH_2)_3$ Trially phosphite rat p.o. 178

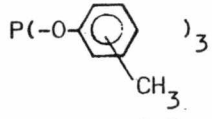
$P(-O\text{-}n\text{-}C_4H_9)_3$ Tri-n-butyl phosphite rat p.o. 3000

$P(-OC_3H_6OC_3H_6OH)_3$ Tris(dipropylene glycol) phosphite

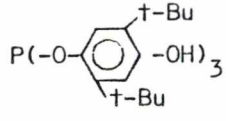
$P(-OCH_2CH_2Cl)_3$ Tris(β-chioroethyl) phosphite mouse i.p. 25 apr.



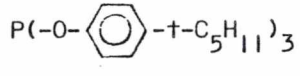
Triphenyl phosphite rat p.o. 1600
rat i.p. 250



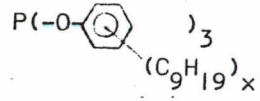
Tricresyl phosphite (Tri-o-cresyl phosphite cat s.c. 100)



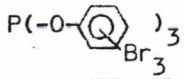
Tris(2,5-di-t-butyl-4-hydroxyphenyl) phosphite



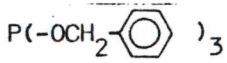
Tris(p-t-amylphenyl) phosphite



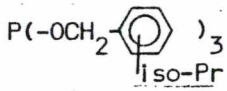
Tris(mono- or di-nonylphenyl) phosphite



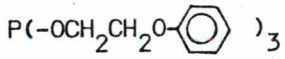
Tris(tribromophenyl) phosphite



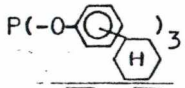
Trisbenzyl phosphite



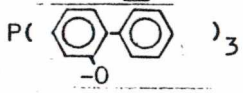
Tris(isopropylbenzyl) phosphite



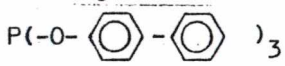
Tris(phenoxyethyl) phosphite



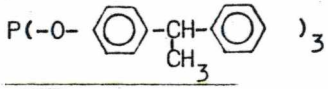
Tris(cyclohexylphenyl) phosphite



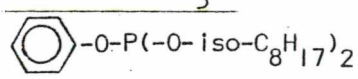
Tris(biphenyl-2-yl) phosphite



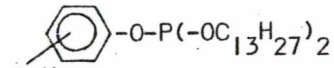
Tris(biphenyl-4-yl) phosphite



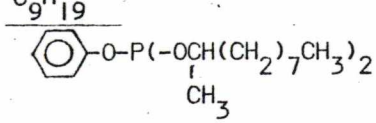
Tris(α-methylbenzylphenyl) phosphite



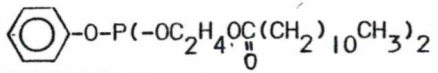
Phenyl diisooctyl phosphite



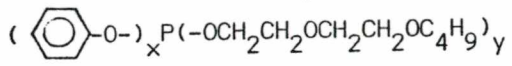
Mono(nonylphenyl) di(tridecyl) phosphite



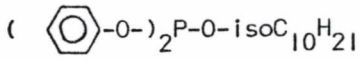
Phenyl diisodecyl phosphite



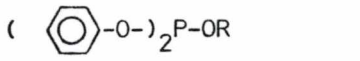
Di(lauroxyethyl) phenyl phosphite



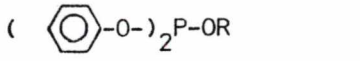
Mono or di[2-(2-butoxyethoxy)]ethyl di or monophenyl phosphite



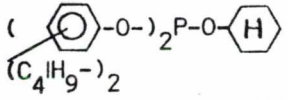
Diphenyl isodecyl phosphite



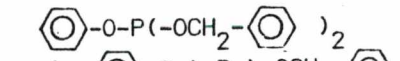
Diphenyl alkyl($C_{12\sim20}$) phosphite



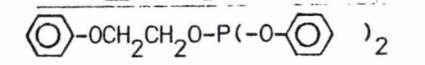
Diphenyl isoalkyl($C_{17\sim25}$) phosphite



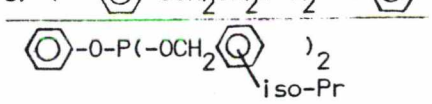
Bis(dibutylphenyl)cyclohexyl phosphite



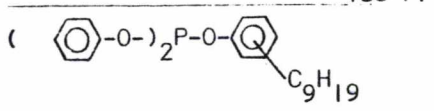
Di(or mono)benzyl mono(or di)phenyl phosphite



Mono(or di)phenoxyethyl di(or mono)phenyl phosphite

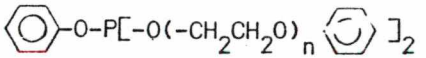


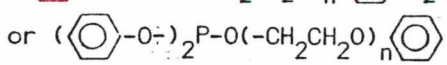
Di(or mono)isopropylbenzyl mono(or di)phenyl phosphite



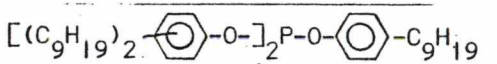
Diphenyl nonylphenyl phosphite

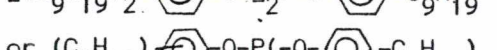
mouse p.o. 1000



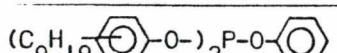
or 

Mono(or di)phenyl di(or mono)[phenoxy poly(oxyethylene)] phosphite

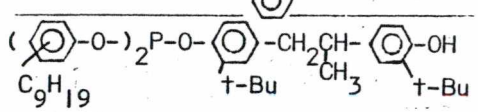


or 

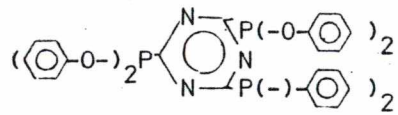
Di or mono(dinonylphenyl) mono or di(p-nonylphenyl) phosphite



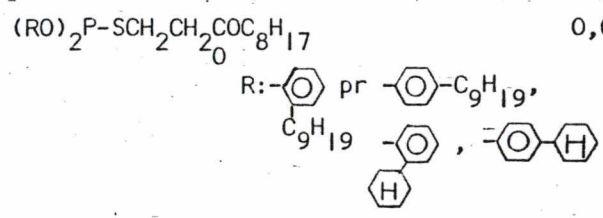
Bis(nonylphenyl)(biphenyl-2-yl) phosphite



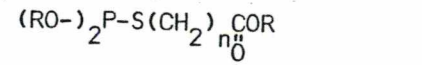
Dinonylphenyl-[4-(2-methyl-2-(3-t-butyl-4-hydroxyphenyl)ethyl)-2-t-butyl]phenyl phosphite

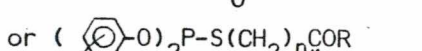


2,4,6-Tri(diphenoxyphosphino)-1,3,5-triazine

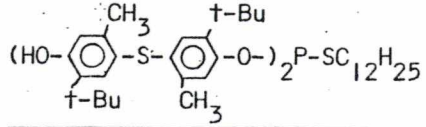


O,O-Bis[o-(or p-)nonyl(or cyclohexyl)phenyl]-S(octoxycarbonylethyl) thiophosphite

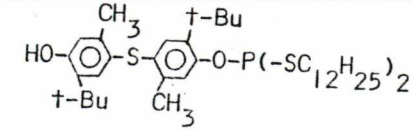


or 

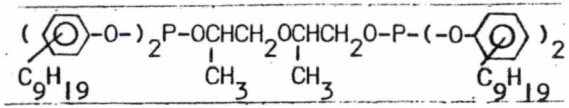
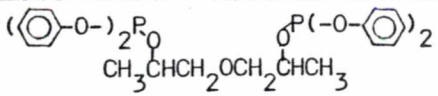
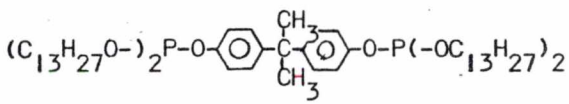
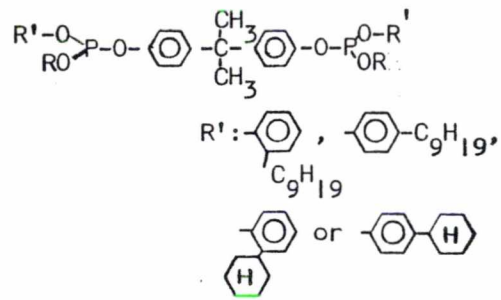
O,O-Bis(alkyl or alkylphenyl)-S-(alkoxycarbonylalkyl) thiophosphite (alkyl:$C_{8\sim18}$)

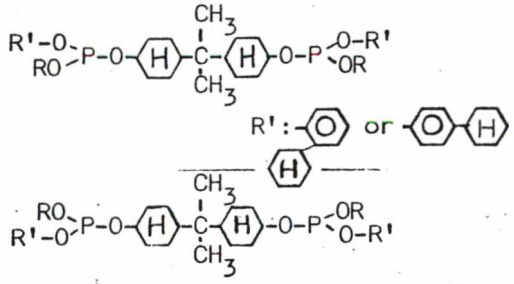


O,O-Bis[2-t-butyl-5-methyl-4-(2-methyl-4-hydroxy-5-t-butyl-phenylthio)phenyl]-S-lauryl thiophosphite

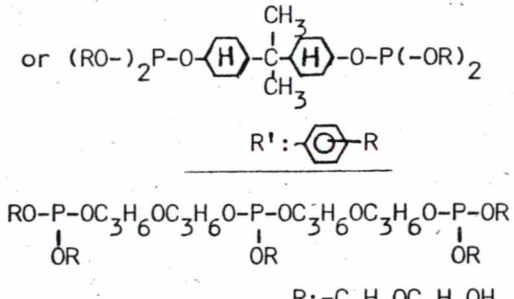


O-[2-t-butyl-5-methyl-4-(2-methyl-5-t-butyl-4-hydroxyphenylthio)phenyl-S,S'-dilauryl dithiophosphite

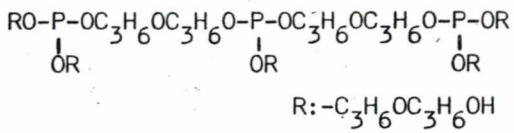
$(C_{12}H_{25}S-)_2P-OC_{12}H_{25}$	Di-S,S'-lauryl-O-lauryl dithiophosphite
$P(-SC_{12}H_{25})_3$	Trilauryl trithiophosphite
$P[-S(CH_2)_{1,2}COOR]_3$	Tri[alkoxy($C_{8\sim18}$)carbonylalkyl($C_{1,2}$)] trithiophosphite
$P[-OCH_2CH_2\underset{\underset{O}{\|}}{P}(-OC_2H_4Cl)_2]_3$	Tris 1-[bis(chloroethyl)phosphonyl]ethyl phosphite
$RX-O-\underset{\underset{OH}{\|}}{P}-O(CH_2)_n O-\underset{\underset{OH}{\|}}{P}-O-XR$ X=Br or Cl	Alkylene(2,3) bis[haloalkyl(Br or Cl,$C_{2,3}$)]hydrogen phosphite
	Tetra(nonylphenyl)diisopropyleneglycol diphosphite
	Tetraphenyldipropyleneglycol diphosphite
	Tetra(tridecyl)-4,4'-isopropylidenediphenyl diphosphite
	Dialkyl($C_{12\sim15}$)bis-[o- or p- nonyl(or cyclohexylphenyl-4,4'-isopropylidenediphenyl diphosphite



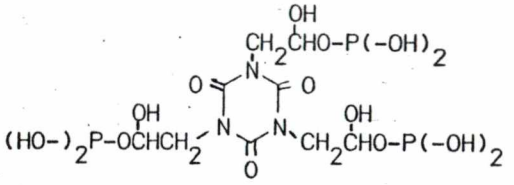
Dialkyl($C_{12\sim15}$(bis(o- or p-cyclohexylphenyl)-4,4' isopropylidenedicyclohexyl diphosphite



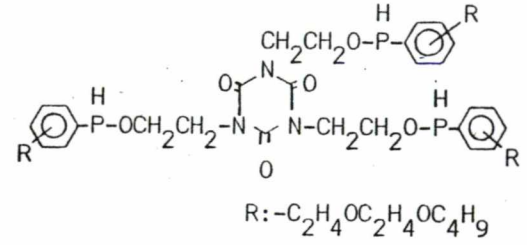
[Dialkyl($C_{8\sim18}$) bis(alkyl($C_{8\sim18}$)phenyl] or tetra-alkyl($C_{8\sim18}$)-4,4'-isopropylidenedicyclohexyl diphosphite



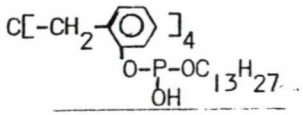
Heptakis(dipropyleneglycol) triphosphite



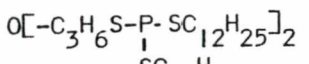
1,3,5-Tris(2-hydroxyethyl)isocyanuric acid phosphite



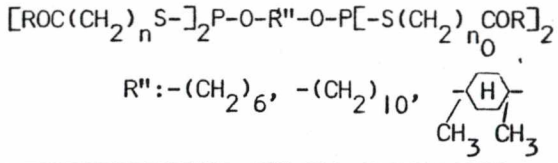
1,3,5-Tris[(butoxyethoxyethyl)phenylphosphinoxy-ethyl] isocyanurate



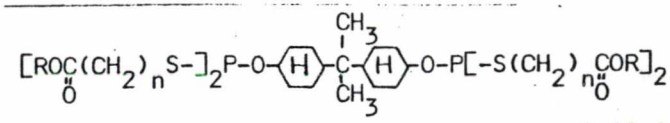
Tetrakis[o-(phenyltridecylphosphite)methyl] methane



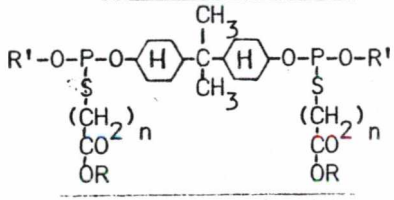
Bis(bisdodecylthiaphosphinothiapropyl) ether



α,ω-Bis[bis(alkoxycarbonylalkylthio)phosphinoxy] hexane (or decane or 1,4-dimethylcyclohexane)



O,O'-(4,4'-Isopropylidenedicyclohexyl) S,S,S',S'-tetrakis[alkoxycarbonylalkyl($C_{8\sim18}$) bis(dithiophosphite)



O,O'-Dialkyl[or bis(alkylphenyl)]-O,O'-(4,4'-isopropylidenedicyclohexyl)-S,S'-bis(alkoxycarbonylalkyl) bisthiophosphite

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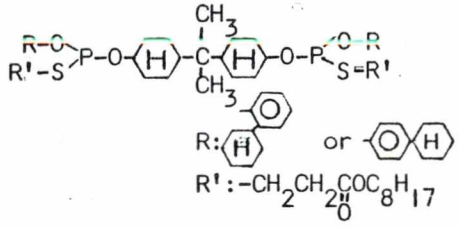
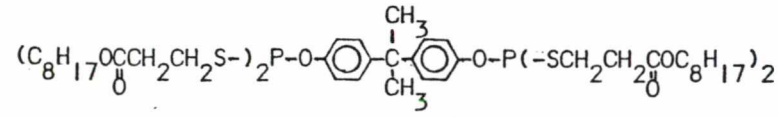
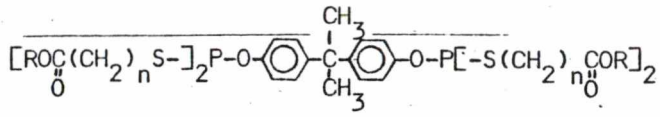


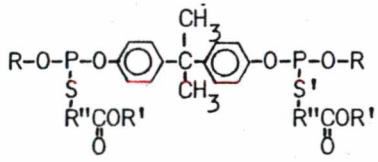
O,O'-Bis(o- or p-cyclohexylphenyl)-O,O'-(4,4'-isopropylidenedicyclohexyl)-S,S'-bis(octoxycarbonylethyl) bis(thiophosphite)



0,0'-(4,4'-Isopropylidenediphenyl)-S,S,S',S'-tetrakis(octoxycarbonylethyl) bis(dithiophosphite)



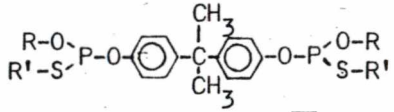
0,0'-(4,4'-Isopropylidenediphenyl)-S,S,S',S'-tetrakis[alkoxy($C_{8\sim18}$)-carbonylalkyl($C_{8\sim18}$)] bis(dithiophosphite)

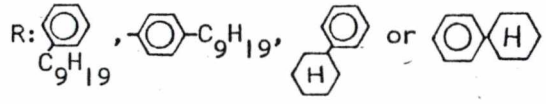


0,0'-Dialkyl($C_{8\sim18}$)[or bis(alkyl($_{8\sim18}$)-phenyl]-0,0'-(4,4'-isopropylidenediphenyl)-S,S'-bis[alkoxy($C_{8\sim18}$)carbonylalkyl($C_{8\sim18}$)] bis(thiophosphite)

R:alkyl or alkylphenyl, R':alkyl

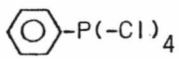
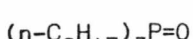
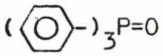
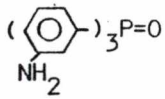
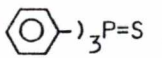
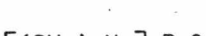
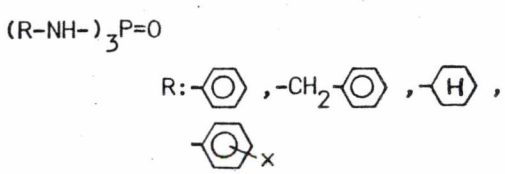
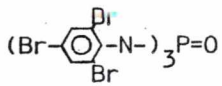
R":alkylene

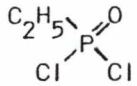




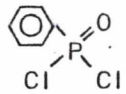
0,0'-Bis[o- or p-nonyl(or cyclohexyl)phenyl]-0,0'-(4,4'-isopropylidenediphenyl)-S,S'-bis[octoxycarbonylmethyl] bis(thiophosphite)

R':-$CH_2COC_8H_{17}$

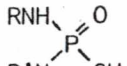
Chemical structure	Name	LD50		mg/kg
	Phenyltetrachlorophosphorus			
	Tri-octylphosphine oxide			
	Triphenylphosphine oxide			
	Tris(3-aminophenyl)phosphine oxide			
	Triphenylphosphine sulfide			
	Hexamethylphosphoric triamide	ckn	p.o.	835
	Triamino(phenylamino, benzylamino, cyclohexylamino, halophenylamino) phosphate			
	N,N',N"-Tri(2,4,6-tribromophenylamino) phosphate			



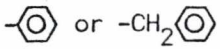
Ethylphosphonyl dichloride

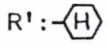


Phenylphosphonyl dichloride

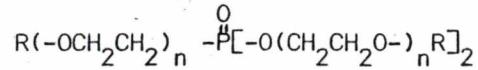


R:alkyl, $-CH_2CH=CH_2$,

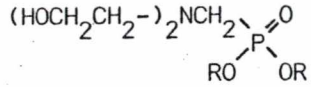


R':  or $-CH_2OH$

N-Alkyl($C_{1\sim4}$)(allyl, phenyl or benzyl)amino N',N'-dicyclohexylamino(or dimethylolamino) phosphate

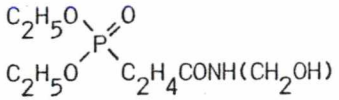


Bis[alkyl($C_{10\sim14}$)polyoxyethylene] alkyl($C_{10\sim14}$)polyoxyethylenephosphonate

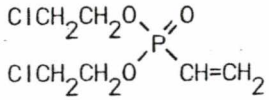


R:alkyl or $-CH_2CH=CH_2$

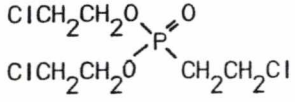
Dialkyl($C_{1\sim3}$ or allyl) N,N-bis(2-hydroxyethyl)aminomethanephosphonate



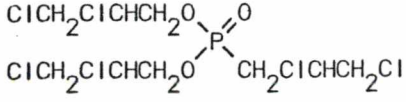
Diethylphosphonopropionic acid N-hydroxymethylamide



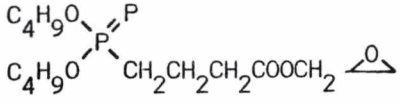
Bis(β-chloroethyl)vinylphosphonate



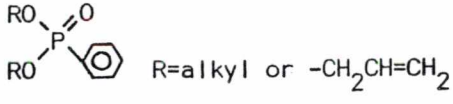
Bis(β-chloroethyl)β-chloroethylphosphonate



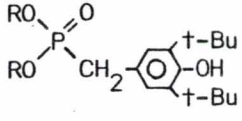
Bis(2,3-dichloropropyl) 2,3-dichloropropyl phosphonate



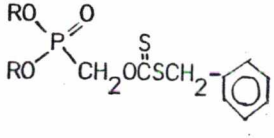
Glycidyl dibutylphosphonobutyrate



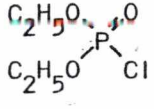
Alkyl($C_{1\sim8}$) or allyl phenylphosphonate



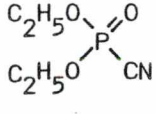
O,O-Bisalkyl($C_{1\sim18}$) 3,5-di-t-butyl-4-hydroxybenzyl phosphonate



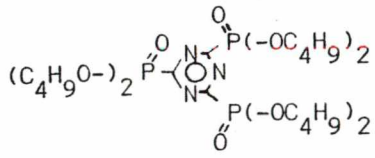
S-Benzyl-O, -(methylphosphonic acid dialkyl) dithiocarbonate



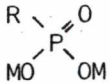
Diethylphosphoryl chloride	rat	p.o.	11 apr.



Diethyl cyanophosphonate	mouse	i.p.	1.4



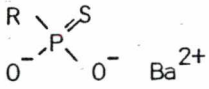
2,4,6-Tri(dibutylphosphono)-1,3,5-triazine



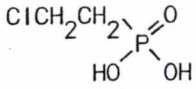
M:H, Na, K, Mg, Al, Zn, Sn, Ca

Alkyl($C_{1\sim8}$) phosphonic acid and its salts

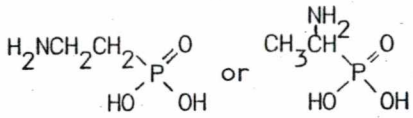
(Phosphonic acid, 2-ethyl-1-hydroxyhexyl mouse i.p. 250 apr.)



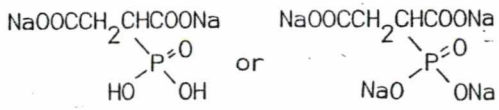
Barium alkyl($C_{30\sim100}$)thiophosphonate



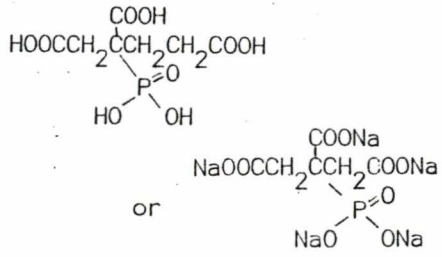
2-Chloroethylphosphonic acid



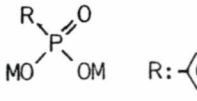
Aminoethanephosphonic acid

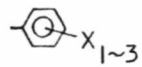


Sodium phosphonosuccinate



2-Phosphonobutane-1,2,4-tricarboxylic acid and its sodium salts

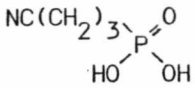


R: or  X:Br or Cl

M:H, Na, K, 1/2Mg, 1/3Al or 1/2Ca

Phenyl(or mono-, di-, tri-bromo or chlorophenyl) phosphonic acid and its salts

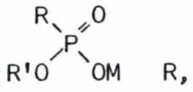
Phosphonic acid, phenyl-	mouse	i.p.	110
Phosphonic acid, (m or p-chlorophenyl)-	mouse	i.p.	500



Nitrylotrismethylenephosphonic acid

Aliphatic phosphonate

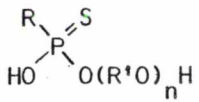
Phosphonic acid, butyl-, dibutyl ester	mouse	i.p.	250 apr.)



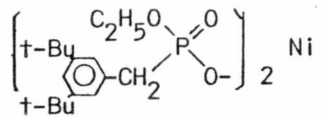
R, R':alkyl or alkenyl

M:H, Na, K, 1/2Ca or $NH(CH_2)_{2,3}OH$

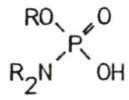
Alkyl(or alkenyl, $C_{8\sim24}$) phosphonic acid alkyl(or alkenyl, $C_{1\sim24}$) ester and its salts



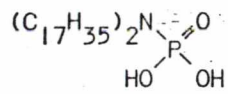
Polyoxyalkylene($C_{2,3}$)alkyl($C_{6\sim30}$) thiophosphonates



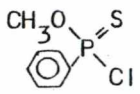
Nickel salt of O- ethyl-3,5-di-t-butylhydroxybenzyl-phosphonate



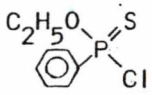
Dialkyl($C_{1\sim8}$, H or $C_{10\sim30}$)amino-O-alkyl($C_{1\sim8}$) phosphate



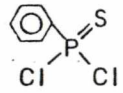
N,N-Distearylamide hydrogen phosphate



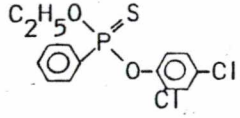
O-Methyl phenylthiophosphonyl chloride



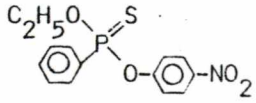
Ethyl phenylchlorothiophosphonate



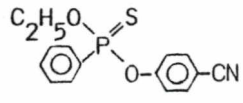
Phenylthiophosphonic acid dichloride



O-Ethyl-O-2,4-dichlorophenyl-phenylthionophosphonate	mouse	p.o.	330 ♂
	mouse	p.o.	390 ♀
	rat	p.o.	385 ♂
	rat	p.o.	420 ♀
	mouse	i.p.	430
	rat	i.p.	840 ♂

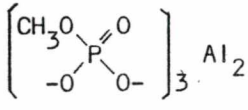


O-Ethyl-O-p-nitrophenyl-phenylthionophosphonate	rat	p.o.	37.5

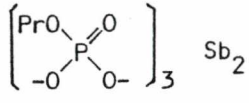


O-Ethyl-O-(4-cyanophenyl) phenylthionophosphonate

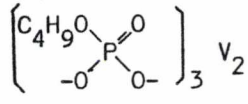
mouse	p.o.	36 ♂
mouse	p.o.	30 ♀
rat	p.o.	89 ♂
rat	p.o.	32 ♀



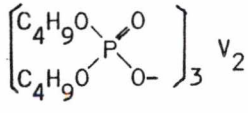
Aluminium monomethylphosphate



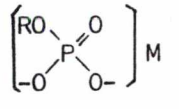
Antimony salt of propyl hydrogen phosphate



Vanadium butylphosphate

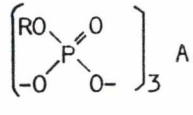


Vanadium dibutylphosphate



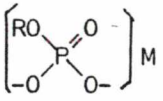
M:Mg or 2/3Al
R:alkyl or alkenyl

Salts(Mg, Al) of alkyl(or alkenyl, $C_{8\sim24}$)phosphate



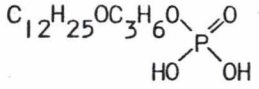
R:alkyl or oleyl

Aluminium alkyl($C_{8,12,16}$) or oleylphosphate

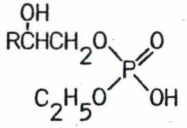


M:Ca, Mg, Ba or 2Na

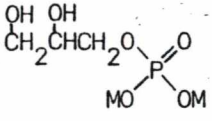
Salts(Ca, Mg, Na, Ba) of alkylphosphate



Dodecyloxypropylphosphate

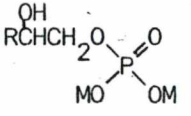


2-Hydroxyalkyl($C_{9\sim11}$) ethylphosphate



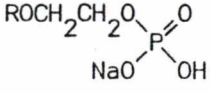
M:H, 1/2Ca, Na

Glycerophosphate and its salts(Ca, Na)

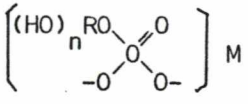


R:alkyl or alkenyl
M:H,Na, K, 1/2Ca

2-Hydroxyalkyl(or alkenyl, $C_{6\sim28}$) phosphate and its salts(Na, K, Ca)

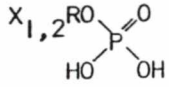


Sodium 2-alkoxy($C_{1\sim6}$)ethylphophate



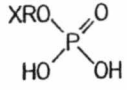
R:alkyl or alkenyl
M:Ca, 2K, 2Na, Mg, 2/3Al, Zn, 1/2Sn

Salts(Ca, K, Na, Mg, Al, Zn, Sn) of polyhydroxyalkyl or alkenyl($C_{1\sim5}$)phosphate



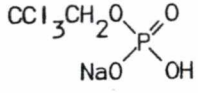
R:alkyl
X:Cl or Br

Mono-(ordi-)halogeno(Cl or Br)alkyl($C_{2,3}$) hydrogen phosphate

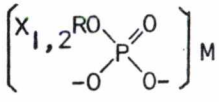


R:alkyl or alkenyl
X:Cl or Br

Bromo- or chloro-alkyl or alkenylphosphate

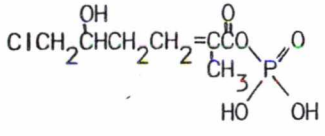


Monosodium 2,2,2-trichloroethylphosphate

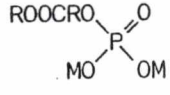


R:alkyl or alkenyl
X:Cl or Br
M:Ca, 2K, 2Na, Mg, 2/3Al
Zn, 1/2Sn, 5/2Sb

Salts(Ca, K, Na, Mg, Al, Zn, Sn, Sb) of mono- or di-chloro- or bromo-alkyl or alkenylphosphate

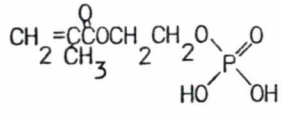


Mono-3-chloro-2-hydroxypropylmethacryloyl phosphate

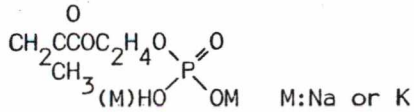


M:H, Na, K, 1/2Ca, NHROH

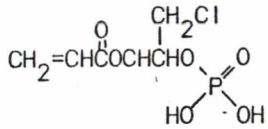
Phosphate of alkyl($C_{1\sim6}$)hydroxyaliphatic carboxylate ($C_{8\sim24}$) and its salts[Na, K, Ca, alkanol($C_{2,3}$)amine]



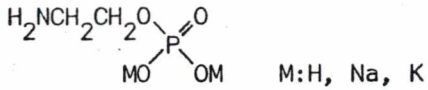
Methacryloxyethylphosphate



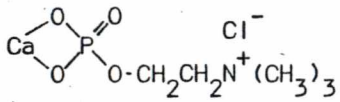
Salts(Na, K) of methacryloyloxyethylphosphate



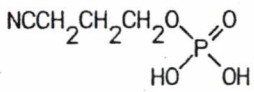
1-Chloromethyl-2-acryloyloxyethylphosphate



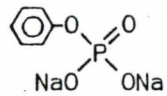
Aminoethylphosphate and its salts(Na, K)



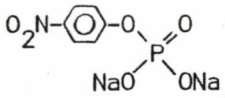
Phosphoryl chloride-cholin calcium



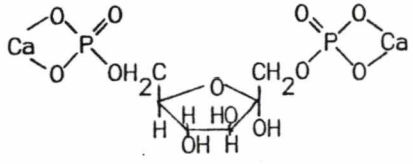
3-Cyanopropylphosphate



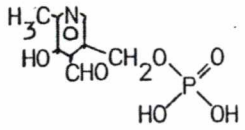
Sodium phenylphosphate



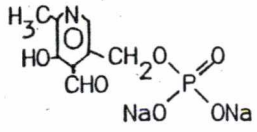
Disodium p-nitrophenylphosphate



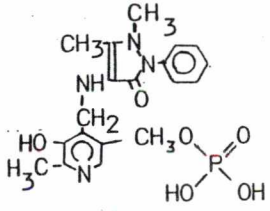
Calcium fructose-1,6-diphosphate



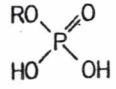
Monopyridoxalphospnate



Sodium pyridoxalphosphate



2-Methyl-3-hydroxy-5-hydroxymethyl-4-(1-phenyl-2,3-dimethyl-5-oxo-3-pyrazolin-4-yl)iminomethyl-pyridine-5-phosphate

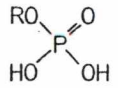


R:$(R'O)_n$-R"

R':alkylene

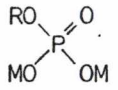
R":polyalcohol

Polyalcohol(glycerin, polyglycerine, sorbitol, trimethylolpropane)polyoxyalkylene phosphate



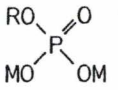
R:$(CH_2CH_2O-)_nR'$
R':alkyl or alkylphenyl

Alkyl(alkylphenyl, $C_{8\sim20}$)polyoxyethylene phosphate



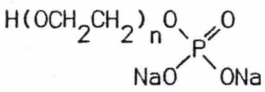
R:$(R'O)_n$-R"
M:Na, K, 1/2Ca
R':alkylene
R":alkyl or alkenyl

Salts(Na, K, Ca) of alkyl(or alkenyl)($C_{1\sim24}$) polyoxyalkylene phosphate

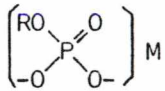


R:$(R'O)_n$-H
M:H,Na, K, 1/2Ca
R':alkylene

Polyoxyalkylene phosphate and its salts(Na, K, Ca) (n=1~150)

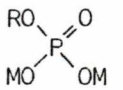


Sodium salt of polyoxyethylenephosphate



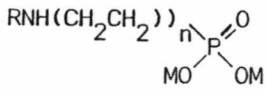
R:$(CH_2CH_2O)_nR'$
M:Mg, Ba, Zn
R':alkyl or alkenyl

Metallic salts(Mg, Ba, Zn) of alkyl(or alkenyl)($C_{6\sim24}$) polyoxyethylene phosphate



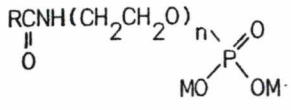
R:$(CH_2CH_2O)_nR'$
M:H, Na, K
R':alkyl or alkenyl

Alkyl(or alkenyl)($C_{8\sim24}$)polyoxyethylene phosphate and its salts(Na, K) (n=2~20)



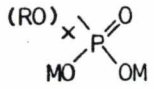
M:H,Na, K, 1/2Ca
R:alkyl or alkenyl

Alkyl(or alkenyl, $C_{8\sim24}$)aminopolyoxyethylene phosphate and its salts(Na, K, Ca)



R:alkyl or alkenyl
M:H, Na, K, 1/2Ca

Alkanoyl(or alkenoyl, $C_{8\sim24}$)aminopolyoxyethylene phosphate and its salts(Na, K, Ca)



R:$(-R'O)_nCH_2CH_2C_nF_{2n+1}$
M:H, Na, K

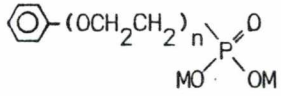
Mono- or di[2-perfluoroalkyl($C_{4\sim16}$)ethylpolyoxyalkylene[($C_{2,3}$)ether] phosphate and its salts(Na, K)

Phosphate and its sodium salt of lanolin(or reduced lanolin) alkylene($C_{2,3}$)oxide adduct

Salts(Na, K, Li, Ca) of lanolin alcohol polyoxyethylene phosphate

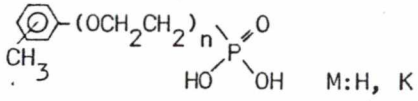
Hydrogen phosphate and its salts(K, Na, Ca) of polyoxyalkylene($C_{2,3}$) of oxidized wax

Phosphate and its salts(Na, K) of alkyl($C_{16\sim18}$) ethylenediamine ethyleneoxide adduct

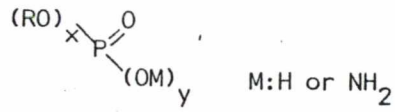


M:H, Na, K, 1/2Ca

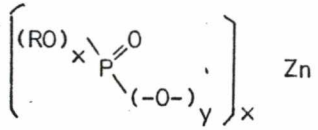
Phenylpolyoxyethylene phosphate and its salts(Na, K, Ca)


M:H, K

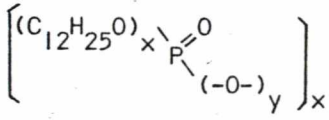
Methylphenoxypolyoxyethylene phosphate and its potassium salt


M:H or NH_2

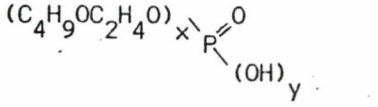
Mono- or di-alkylphosphate and its amine salts


Zn

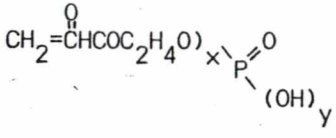
Zinc mono- (or di-)alkylphosphate


Pb

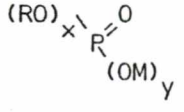
Lead mono- or di-laurylphosphate



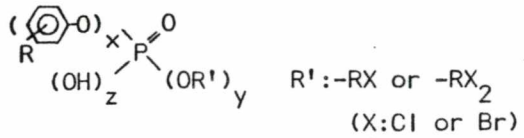
Butoxyethyl hydrogen phosphate



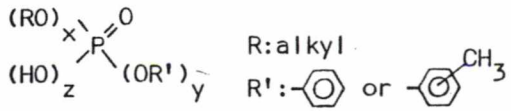
Acryloyloxyethyl hydrogen phosphate


R:polyalcohol aliphatic acid ester
M:Na, K, 1/2Ca

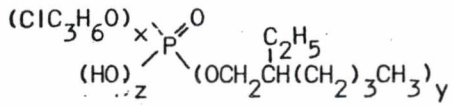
Salts(Na, K, Ca) of polyalcohol(glycerin, polyglycerin, sorbitol, sorbitan, mannitol, mannitan, sucrose, trimethylolpropane, pentaerithritol)aliphatic acid ester phosphate



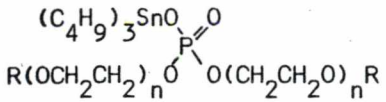
Alkyl($C_{3\sim8}$)phenyl halogeno(mono- or di-chloro or bromo)alkyl($C_{3\sim8}$) mixed phosphate



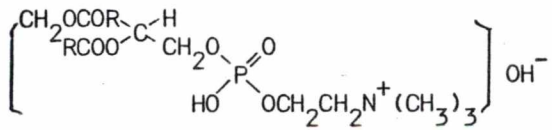
Alkyl($C_{5\sim10}$)aryl(phenyl or methylphenyl) mixed phosphate



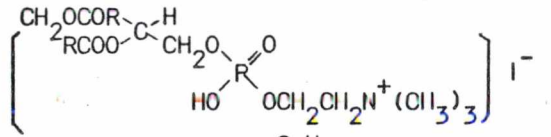
Chloropropyl-2-ethylhexyl mixed phosphate



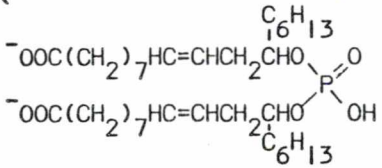
Tributyl tin salts of bis[alkylpolyoxyethylene($C_{2\sim10}$)] phosphate



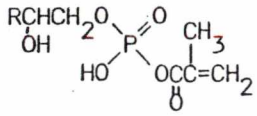
Lecithin (Phosphatidyl cholin)



Lecithin iodide

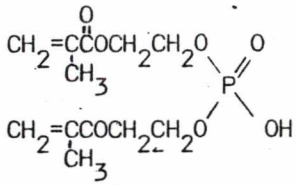


O,O-Bis(1-hexyl-11-carboxy-3-undecenyl) phosphate

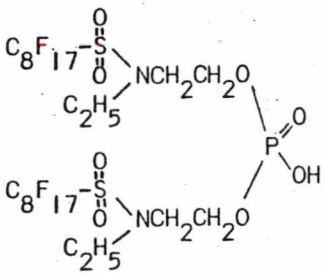


R:H or CH_3

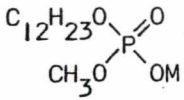
Mono-2-hydroxyalkyl($C_{2,3}$) methacryloyloxy phosphate



Bis(2-methacryloyloxyethyl) phosphate

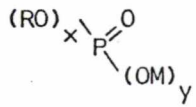


Bis(N-perfluorooctylsulfonyl-N-ethyl-aminoethyl) phosphate



M:H, Na, K

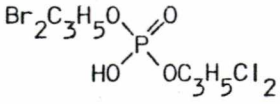
O-Lauryl o-methyl phosphate and its salts(Na, K)



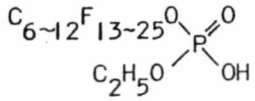
R:alkyl or alkenyl

M:Na, K, 1/2Ca

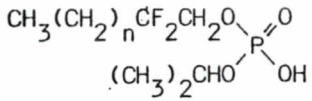
Salts(Na, K, Ca) of mono- or di-alkyl(or alkenyl, $C_{3\sim24}$) phosphate



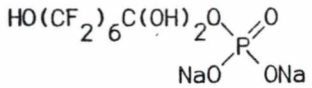
Dibromopropyl dichloropropyl phosphate



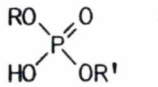
Monoperfluoroalkyl($C_{6\sim12}$)ethyl phosphate



2-perfluoroalkyl($C_{9\sim23}$)-isopropylphosphate



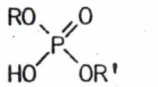
Disodium α,α,ω-trihydroxyperfluoroalkyl(C_7) phosphate



R:alkyl

R':$(-R''O)_nH$

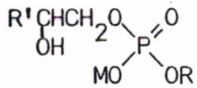
Poly(1~20)oxyalkylene($C_{2\sim7}$)alkyl($C_{2\sim5}$) phosphate



R:$(CH_2CH_2O)_nH$

R':alkyl or alkenyl

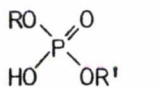
Polyoxyethylene alkyl(or alkenyl, $C_{8\sim24}$) phosphate



R:$(R''O)R'''$

M:H, K, Na

Phosphate and its salts(K, Na) of 2-hydroxyalkyl($C_{6\sim28}$) and alkyl($C_{8\sim28}$)polyoxyalkylene

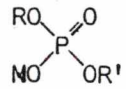


R:$(CH_2CH_2O)H$

R':$-CH_2CH(OH)R''$

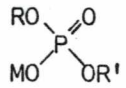
R'':alkyl or alkenyl

Polyoxyethylene 2-hydroxyalkyl(or alkenyl, $C_{6\sim28}$) phosphate



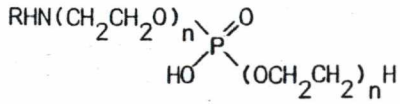
R:$(-R''O)_nH$
R':alkyl ester of hydroxy-aliphatic acid
M:K, Na, 1/2Ca

Phosphate salts(K, Na, Ca) of hydroxyaliphatic acid ($C_{8\sim24}$)alkyl ester and polyoxyalkylene



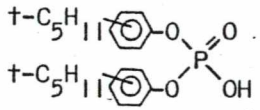
R:$(CH_2CH_2O)_n$-R''
R':alkyl ester of hydroxy-aliphatic acid
M:H, Na, K

Phosphate and its salts(Na, K) of hydroxyaliphatic acid($C_{8\sim24}$)alkyl ester and alkyl(or alkenyl, $C_{6\sim24}$) polyoxyethylene

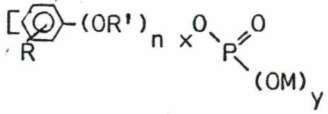


R:alkyl or alkenyl

N-Alkyl(or alkenyl)($C_{8\sim24}$)aminopolyoxyethylene polyoxyethylene phosphate

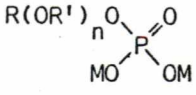


Di(t-amylphenyl)phosphate



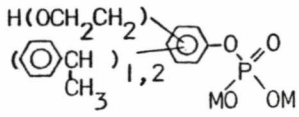
M:H, K, Na, 1/2Ca, 1/2Ba

Mono- or di-alkyl($C_{4\sim14,18}$)phenylpolyoxyalkylene phosphate and its salts(K, Na, Ca, Ba)



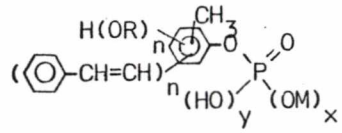
M:H, K, Na, 1/2Ca

Aryl[diphenyl, naphthyl, cumylphenyl or mono-(or bis-, tris-, tetrakis-, pentakis-)benzylphenyl, styrylphenyl-styryldiphenyl]polyoxyalkylene phosphate and its salts(k, Na, Ca)



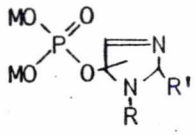
M:H, Na, 1/2Ca

Polyoxyethylenemono-(or bis-)(α-methylbenzyl) phenyl phosphate and its salts(Na, Ca)



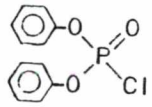
M:Na, K, 1/2Ca

Mono- or di-phosphate salts(Na, K, Ca) of polyoxyalkylene ($C_{2,3}$)(mono-~penta-)styryl-methylphenyl

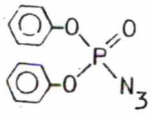


R:polyoxyalkylene
R':alkyl or alkylene
M:K, Na, 1/2Ca

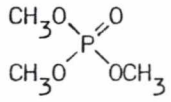
Salts(K, Na, Ca) of 1-polyoxyalkylene-2-alkyl(or alkenyl)-($C_{6\sim28}$)imidazoline phosphate



Diphenylphosphoryl monochloride

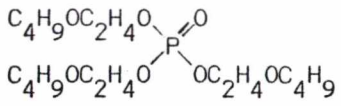


Diphenylphosphoryl azide



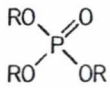
Polymethyl phosphate

Trimethyl phosphate	rat	p.o.	1975	
Trimethyl phosphate	rabbit	p.o.	1256	LD



Tributoxyethyl phosphate

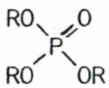
guinea pig	p.o.	3000		



R:alkyl or alkenyl

Alkyl(or alkenyl, $C_{3\sim24}$) phosphate

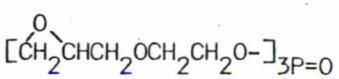
Tributyl phosphate	rat	p.o.	3000	apr.
Triallyl phosphate	mouse	i.v.	70	



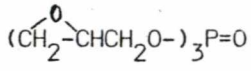
R:alkyl, allylbutoxyethyl, glycero, polyvinyl alcohol

Trialkyl($C_{1\sim20}$, or allylbutoxyethyl, glycero, polyvinyl alcohol) phosphate

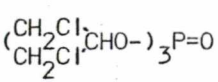
Trimethyl phosphate	mouse	p.o.	1470
Trimethyl phosphate	rat	p.o.	840
Tributyl phosphate	rat	p.o.	3000



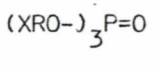
Tris[2-(2',3'-epoxypropyloxy)ethyl] phosphate



Tris(2,3-epoxypropyl) phosphate



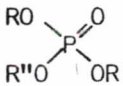
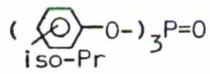
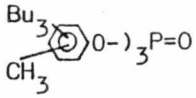
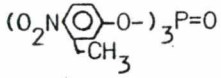
Tris(1,3-dichloro-2-propyl) phosphate

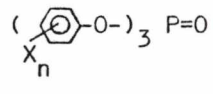


Tris[bromo(or chloro)alkyl(or alkenyl, $C_{6\sim18}$)] phosphate

R:alkyl or alkenyl

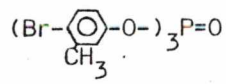
X:Br, Cl

$(ClCH_2CH_2CHBrO-)_3P=O$	Tris(1-bromo-3-chloropropyl) phosphate				
$(ClCH_2CHBrCH_2O-)_3P=O$	Tris(2-bromo-3-chloropropyl) phosphate				
$(BrCH_2CHBrCH_2O-)_3P=O$	Tris(2,3-dibromopropyl) phosphate	rat	p.o.	1010	
$(CH_2=C(CH_3)COCH_2CH(CH_2Cl)O-)_3P=O$	Tris(1-chloromethyl-2-methacryloyloxyethyl) phosphate				
$(RO)_3P=O$ R: phenyl, monomethylphenyl, dimethylphenyl, nonylphenyl	Triphenyl(or monomethylphenyl, dimethylphenyl, nonylphenyl) phosphate				
	Triphenyl phosphate	rat	i.p.	250	
	Tri-O-cresyl phosphate	man	p.o.	1000	apr.
 R,R',R": phenyl, monomethylphenyl, dimethylphenyl, nonylphenyl	Tris(phenyl, monomethylphenyl, dimethylphenyl, nonylphenyl mixed) phosphate				
	Tris(isopropylphenyl) phosphate				
	Tris(methyltributylphenyl) phosphate				
	Tris(3-methyl-4-nitrophenyl) phosphate				

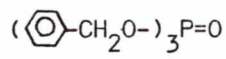


X=Cl, Br, CH_3

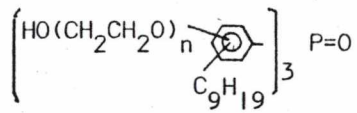
Tris[mono(~tri)bromo(or chloro)phenyl(or methyl-phenyl)] phosphate



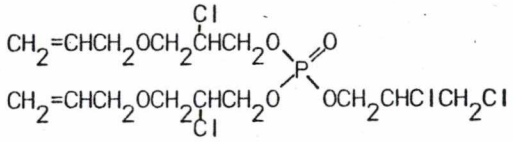
Tris(4-bromo-3-methylphenyl) phosphate



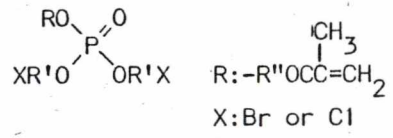
Tribenzyl phosphate



Tris[poly(n=2~20)ethyleneglycolmono(nonyl-phenyl) phosphate

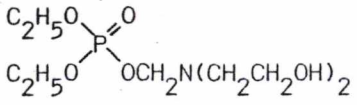


Bis(3-allyloxy-2-chloropropyl) 2,3-dichloro-propyl phosphate

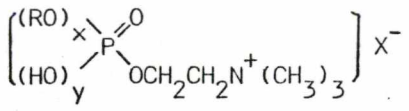


X:Br or Cl

Methacryloxyalkyl($C_{2\sim4}$)bis[halogenated(Br or Cl)alkyl($C_{2\sim4}$)] phosphate

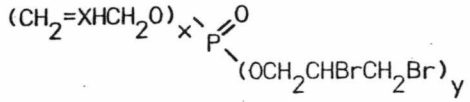


Diethyl N,N-bis(2-hydroxyethyl) aminomethyl phosphate

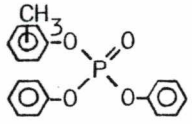


R:alkyl or alkenyl

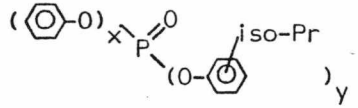
(Mono- or di-)alkyl(or alkenyl, $C_{8\sim24}$) phosphate cholin salts



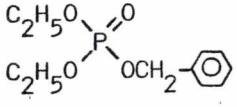
Allyl 2,3-dibromopropyl mixed phosphate
Diallyl 2,3-dibromopropyl phosphate
Bis(2,3-dibromopropyl) allyl phosphate



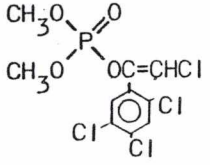
Cresyl diphenyl phosphate



Mono-(or di-)phenyl di-(or mono-)isopropyl-phenyl phosphate

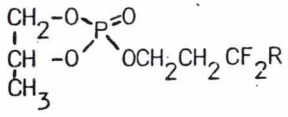


Diethyl benzyl phosphate

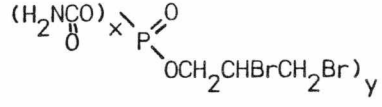


2-Chloro-1-(2,4,5-trichlorophenyl)vinyl dimethyl phosphate

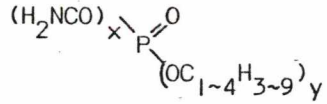
rat	p.o.	5000	apr.



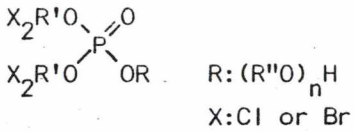
Phosphoric acid ester of 3-perfluoroalkyl($C_{7\sim23}$)-1,2-propanediol



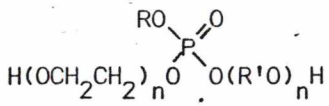
Carbamyl-2,3-dibromopropyl mixed phosphate



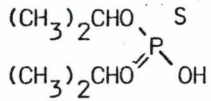
Carbamyl alkyl($C_{1\sim4}$) mixed phosphate



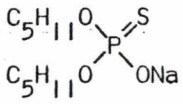
Polyoxyalkylene($C_{2\sim20}$)bis[di(chloro- or bromo-)alkyl] phosphate



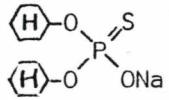
Alkyl(or alkylene)($C_{8\sim24}$)polyoxyalkylene polyoxyethylene phosphate



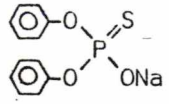
O,O'-Diisopropylthiophosphate



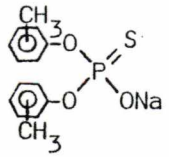
Sodium diamyl(mono)thiophosphate



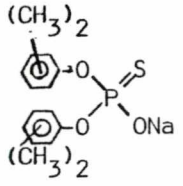
Sodium dicyclohexylmonothiophosphate



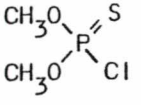
Sodium diphenylmonothiophosphate



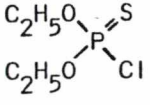
Sodium dicresylmonothiophosphate



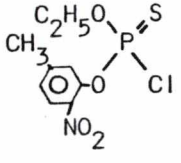
Sodium dixylenylmonothiophosphate



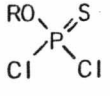
O,O-Dimethylthiophosphoryl chloride



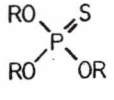
O,O'-Diethylthiophosphoryl chloride



O-Ethyl-O-(2-nitro-5-methylphenyl)thiophosphoryl chloride



Alkyl($C_{1,2}$) dichlorothiophosphate



Trialkyl($C_{4\sim18}$)thiophosphate

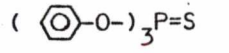
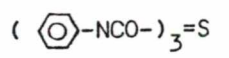
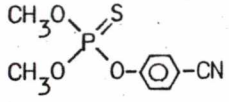
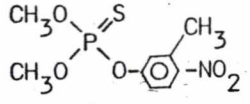
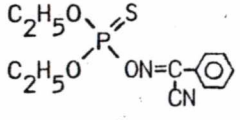
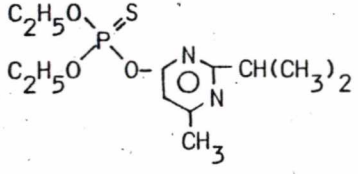
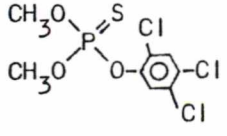
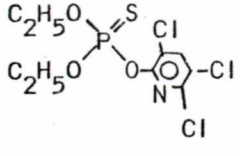
$(C_{17}H_{33}O-)_3P=S$

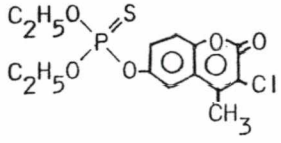
Trioleyl thiophosphate

rat p.o. 84

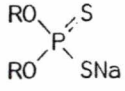
$(CH_2ClCHClCH_2O-)_3P=S$

Tris(2,3-dichloropropyl) thiophosphate

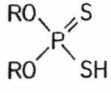
	Triphenylthiophosphate			
	Tris(phenylisocyanato)thiophosphate			
	O,O-Dimethyl-O-(4-cyanophenyl)thiophosphate	mouse	p.o.	995
	O,O-Dimethyl-O-(3-methyl-4-nitrophenyl)thiophosphate	rat rat	p.o. p.c.	250 300
	O,O-Diethyl-O-(α-cyanobenzylideneamino)thiophosphate			
	O,O-Diethyl-O-(2-isopropyl-4-methyl-6-pyrimidinyl)thiophosphate	mouse rat rat	i.p. p.o. p.o.	65 180 ♂ 76 ♀
	O,O-Dimethyl-O-(2,4,5-trichlorophenyl)thiophosphate	rat	p.o.	1740
	O,O-Diethyl-O-(3,5,6-trichloro-2-pyridyl)thiophosphate	rat	p.o.	145



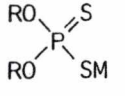
O,O-Diethyl-O-(3-chloro-4-methyl-7-(cumaronyl) thiophosphate — rat — p.o. — 41



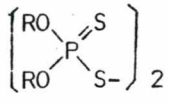
Sodium dialkyl($C_{1\sim3}$) dithiophosphate



Dialkyl dithiophosphate

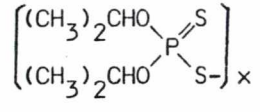


Salts(Na, K, Li) of dialkyl($C_{4\sim10}$) dithiophosphate

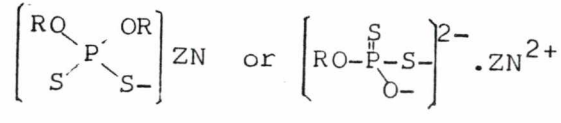


Zinc dialkyl($C_{3\sim6}$) dithiophosphate

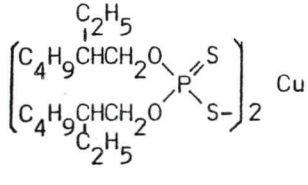
Zinc dialkyl($C_{8\sim24}$) dithiophosphate



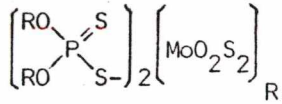
Iron diisopropyl dithiophosphate



Zinc alkyl($C_{3,4}$) dithiophosphate

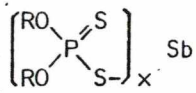


Copper ,O,O'-di(2-ethylhexyl) dithiophosphate

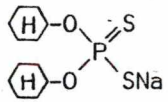


R:alkyl or alkyl-phenyl

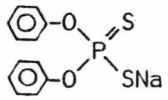
O,O'-dialkyl($C_{3\sim8}$) or dialkylphenyl($C_{4\sim9}$)-dithiophosphate molybdenum oxysulfide



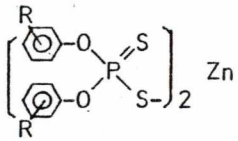
Antimony O,O'-dialkyl($C_{3\sim8}$) dithiophosphate



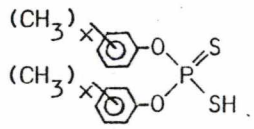
Sodium dicyclohexyldithiophosphate



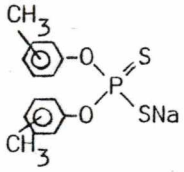
Sodium diphenyldithiophosphate



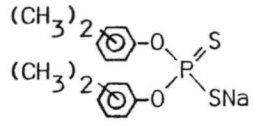
Zinc dialkyl($C_{8\sim18}$)phenyl dithiophosphate



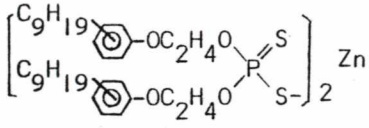
Bis(mono- or di-methylphenyl) dithiophosphate



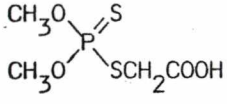
Sodium dicresyldithiophosphate



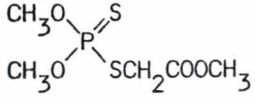
Sodium dixylenyldithiophosphate



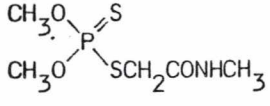
Zinc dinonylphenoxyethyl dithiophosphate



O,O-Dimethyl-dithiophosphorylacetic Acid

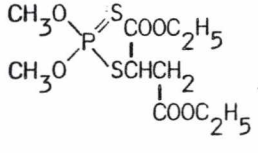


Methyl O,O-dimethyl-dithiophosphorylacetate



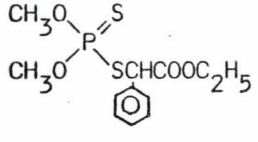
O,O-Dimethyl-S-(N-methylcarbamoylmethyl) dithiophosphate

rat	p.o.	50
rat	p.c.	700
mouse	p.o.	53.3



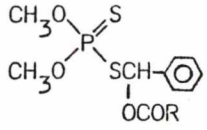
O,O-Dimethyl-S-(1,2-diethoxycarbonylethyl) dithiophosphate

rat	p.o.	1375 ♂
rat	p.o.	1000 ♀



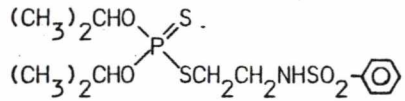
O,O-Dimethyl-S-(1-ethoxycarbonyl-1-phenyl)-methyl dithiophosphate

rat	p.o.	200



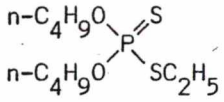
O,O-Dimethyl-S-(1-alkylcarboxy-1-phenyl)methyl dithiophosphate

rat	p.o.	200	)

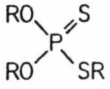


O,O-Diisoprpyl-2-(benzenesulfonamide)ethyl dithiophosphate

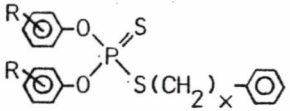
rat	p.o.	770	



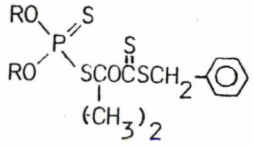
O,O-di-n-butyl-S-ethyl dithiophosphate



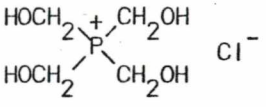
Trialkyl($C_{6\sim20}$) dithiophosphate



O,O-Bis[alkyl($C_{3\sim8}$)phenyl]S-phenylalkyl($C_{1,2}$) dithiophosphate

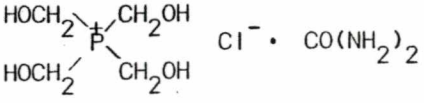


S-Benzyl-O-(isopropyldithiophosphoric acid dialkyl) dithiocarbonate

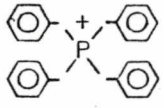


Tetrakis-hydroxymethylphosphonium chloride

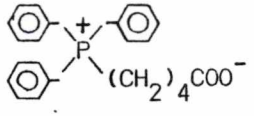
mouse	i.p.	125	apr.



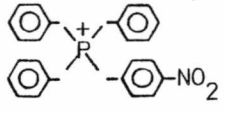
Tetrakis(hydroxymethyl)phosphonium chloride·urea complex



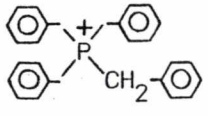
Tetraphenylphosphonium



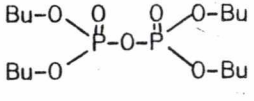
4-Carboxybutyl-triphenylphosphonium salt



p-Nitrophenyl-triphenylphosphonium

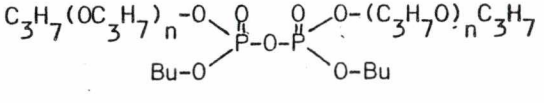


Benzyltriphenylphosphonium

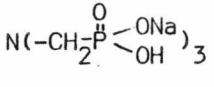


Butyl pyrophosphate

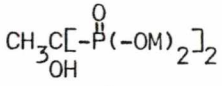
rat	p.o.	50	apr.



Bis(polyoxypropylene)dibutyl pyrophosphate

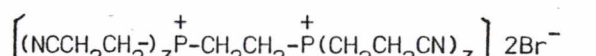


Sodium nitrylo-trismethane-triphosphonate

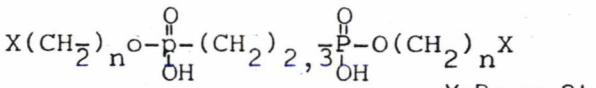


M:H, Na

1-Hydroxyethylidene-1,1-diphosphonic acid and its sodium salt

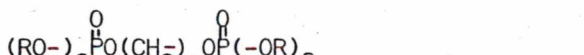


Ethylene-bis(tri-β-cyanoethyl)phosphonium bromide

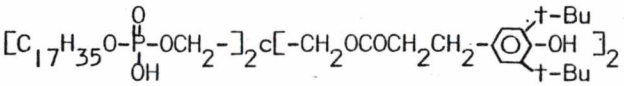


X:Br or Cl

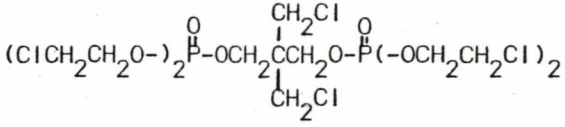
Alkylene($C_{2,3}$)bishalo(Br or Cl)alkyl($C_{2,3}$)phosphonate



Alkylene($C_{2\sim5}$)bis[dialkyl($C_{2\sim4}$)phosphate]



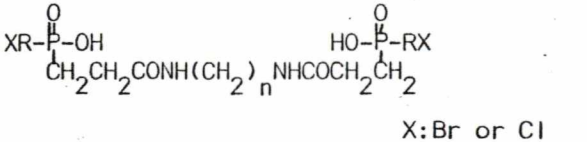
Bis(stearoxyphosphoroxymethyl)-bis[β-(3,5-di-t-butyl-4-hydroxyphenyl) propionyloxymethyl] methane



Tetrakis(chloroethyl) dichloroneopentylglycol diphosphate

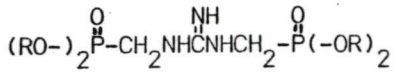
X:Br or Cl

Alkylene($C_{2\sim4}$) bis[halo(Br or Cl)alkyl($C_{2,3}$) phosphate]



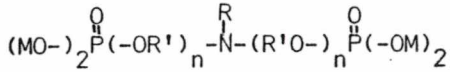
X:Br or Cl

Alkylene($C_{2,3}$) bis[halo(Br or Cl)alkyl($C_{2,3}$)phosphono-propioneamide



R:alkyl or haloalkyl

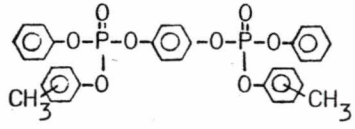
N,N'-Bisdialkyl($C_{1\sim4}$) or haloalkyl($C_{2,3}$)phosphono-methyl guanidine methylol compounds



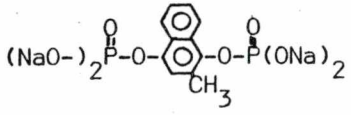
R:alkyl or alkenyl

M:H, Na, K, 1/2Ca

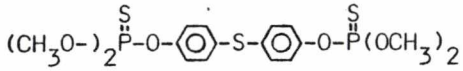
Salts(Na, K, Ca) of N-alkyl(or alkenyl)($C_{6\sim28}$)-N,N-di[polyoxyalkylene monophosphate]



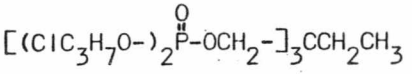
Phenylene bis(phenyl cresyl phosphate)



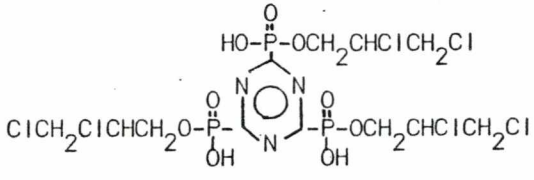
Tetrasodium 2-methyl 1,4-naphthohydroquinone-diphosphate



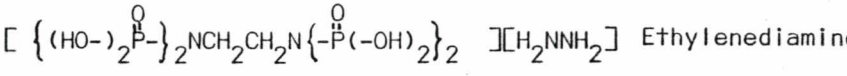
O,O,O',O'-Tetramethyl-o,o'-thiodi-p-phenylenethio-phosphate



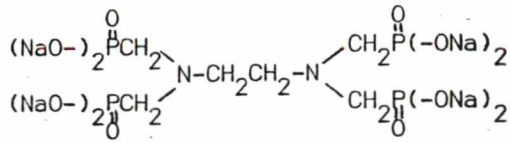
1,1,1-Tris[di(chloropropyloxy)phosphynyloxy-methyl] propane



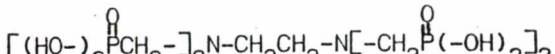
2,4,6-Tri(2,3-dichloropropylphosphono)-1,3,5-triazine



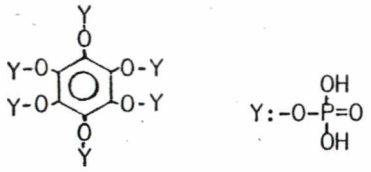
Ethylenediamine tetrakisphosphonic acid hydrazine complex



1,2-Bis(N,N-bisphosphonomethyl)aminoethane sodium salt

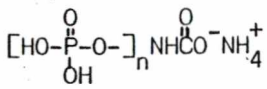


N,N,N',N'-Tetrakis(phosphonomethyl)ethylenediamine

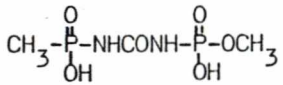


Phytic acid

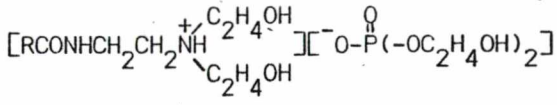
(Phytic acid, hexa copper salt mouse i.p. 7.75 apr.)
(Phytic acid, hexa zinc salt mouse i.p. 125 apr.)



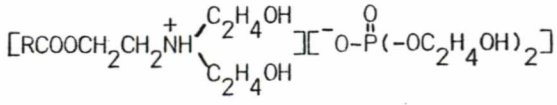
Ammonium carbamyl polyphosphate



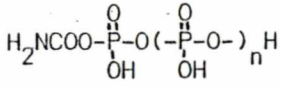
Monomethyl phosphate urea condensate



N-Alkyloyl(or alkenoyl)aminoethyl-N,N-di-β-hydroxy-ethylamine-di-β-hydroxyethyl phosphate ($C_{7\sim23}$)



N-Alkyloyloxy(or alkenoyloxy)ethyl-N-di-β-hydroxy-ethylamine-di-β-hydroxyethyl phosphate ($C_{7\sim23}$)

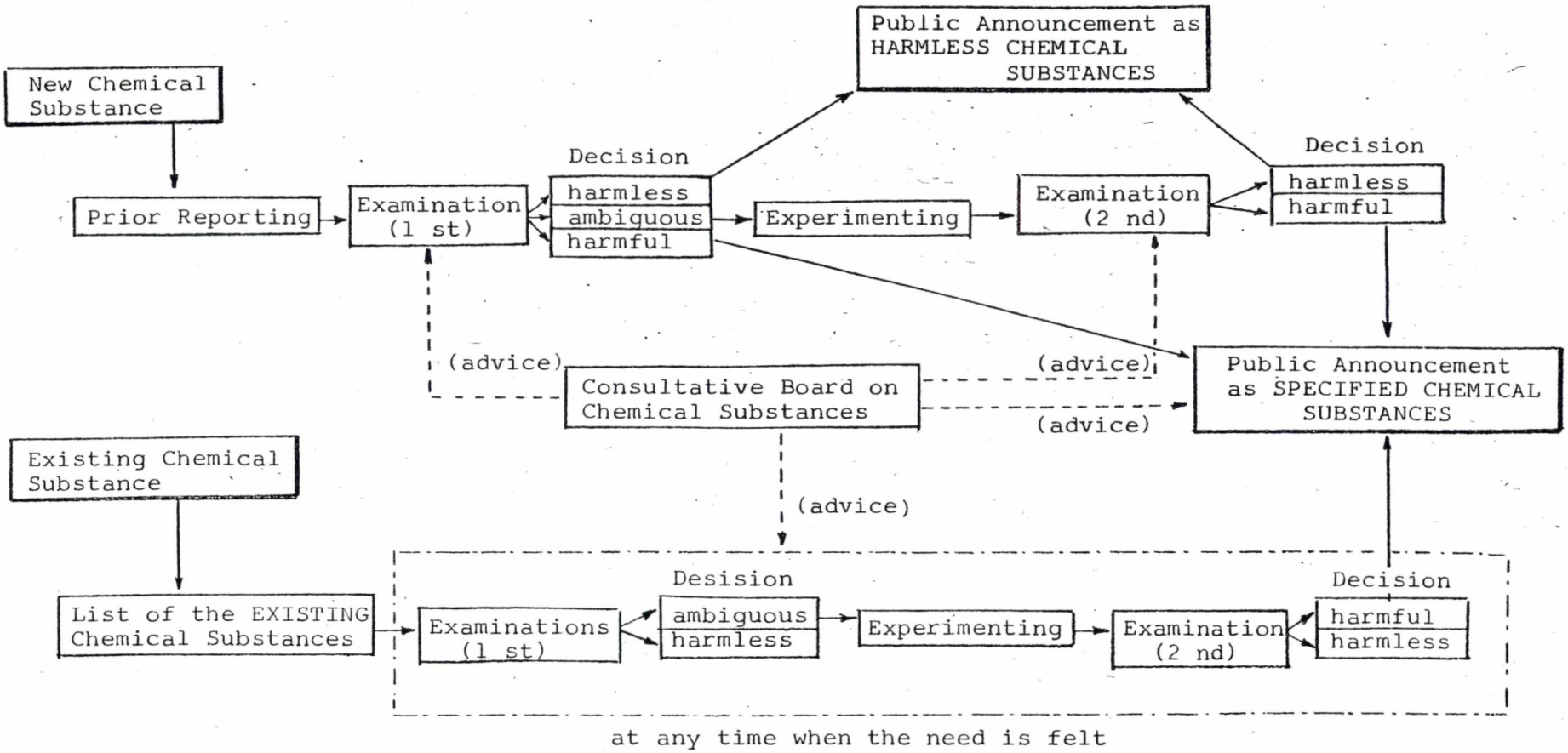


Polyphosphoric acid carbamate

TABLE 2

Control System Contained in

"The Law concerning the Screening of Chemical Substances and Regulation of Their Manufacture, etc."



CONFERENCE OF THE COMMITTEE ON DISARMAMENT

CCD/473
26 August 1975

Original: ENGLISH

CANADA

Working paper on use of measurements of lethality for definition of agents of chemical warfare

SUMMARY

To arrive at a Treaty limiting or prohibiting chemical weapons it may be necessary to define what chemical agents shall fall within the terms of the Treaty, in which case it will also be necessary to agree to a measure of lethality. The specific problems associated with determination of lethality of chemical warfare agents are discussed and the general concept of the LD_{50} as a measure of lethality is explained.

It is recommended that separate standards of lethality should be adopted for three groups of agents, according to their routes of entry into the human body, i.e., inhaled gases or vapours, percutaneously lethal materials, and supertoxic solids. It is also recommended that a reference toxic material be adopted by agreement for each of these three groups of agents; and that the reference toxic material should be a readily available substance chosen to have a lethality equal or slightly less than what is agreed to be the least lethal of chemical agents to be restricted or prohibited in each class.

A specific proposal based on the above general principles is submitted for discussion.

DEFENCE RESEARCH ESTABLISHMENT SUFFIELD
RALSTON ALBERTA

MEASUREMENT OF LETHALITY OF TOXIC MATERIALS:
GENERAL DESCRIPTION OF THE LD_{50}

The lethality of a toxic material is usally determined by administering the material to several groups of uniform animals of a single species. The groups usually contain from 5 to 30 individuals, the number depending on the degree of accuracy required, and on the availability of suitable animals. An accurate measurement of LD_{50} requires the use of from 30 to 100 animals; tests using groups of animals smaller than 5 individuals yield only approximate results. Within each group, the animals are equally exposed to the same toxic material: in the case of injected toxic substances, each animal receives an amount proportional to his body weight: in the case of inhaled gases, each animal is exposed to the same concentration of the gas diluted in air for the same length of time. At a selected time after the end of the exposure (from a few hours to several days, depending on the nature of the effects of the poison,) the number of dead animals in the group is counted.

Each of the several groups of animals is given a different dosage level, beginning with a dosage which kills few or none of the animals in the group, and increasing for each group until a dosage is reached which kills all or nearly all the animals in the group. The stepwise increases in dosage are chosen to be sufficiently small to result in two or three of the groups having killing ratios between 20% and 80%.

A set of data obtained in this way is then subjected to a mathematical process which estimates the dose which would be expected to kill 50% of a large population of similar animals. The resulting figure is the dose for 50% kill or LD_{50} and is usually expressed as milligrams of toxic material per kilogram of body weight.

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LD_{50} values for a given toxic material vary considerably, depending on a number of factors, some of which are:-

Concentration of the dosage;
Rate of administration;
Route of application;
Animal (species
(age
(sex
(genetic strain
Time of determination of death

Estimates of lethality for man are usually based on LD_{50} figures from more than one species of mammals extrapolated to a body weight of 70 Kg. When results with different species are in wide disagreement, results obtained with primate species are given disproportionate weight in making the human estimate.

MEASUREMENT OF LETHALITY OF INHALED TOXIC MATERIALS

When the toxic material is a vapour or aerosol which is inhaled into the lungs, practical difficulties arise in determining the amount of toxic material actually inhaled by each individual animal exposed. This determination would be required in order to calculate the LD_{50} in mg. toxic material inhaled per Kilogram of body weight.

These difficulties are normally avoided by using the LCt_{50} as the measure of toxicity. The concentration of the toxic material in the air (in mgm. per cubic metre) is multiplied by the time of exposure (in minutes). The resulting product or Ct, is a measure of the dosage breathed by each animal which allows for variations in size. The amount of air an animal breathes per minute is approximated proportional to body weight; and therefore Ct values are proportional to inhaled dosage per Kilogram.

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$$LD_{50} \text{ (inhaled)} = LCt_{50} \times \frac{\text{liters of air inhaled per minute}}{\text{Kilograms body weight}}$$

Either LD_{50} (inhaled) or LCt_{50} can be used as indices of vapour toxicity, however, the LCt_{50} has obvious practical and theoretical advantages over the LD_{50} (inhaled) for comparison of lethality of inhaled materials.

MEASUREMENT OF LETHALITY OF TOXIC MATERIAL ABSORBED THROUGH THE SKIN

For toxic materials (usually liquids of low volatility) which cause death when absorbed through the skin, the LD_{50} (percutaneous) may be estimated by applying measured amounts of liquid droplets to the bare shaved skin of suitable animals, while at the same time preventing the inhalation of vapours. For extremely toxic materials, difficulties in measuring and applying the very small amounts of liquid may be encountered; in these cases, the toxic material may be suitably diluted in a non-toxic volatile solvent. The calculation of the LD_{50} is the same as that previously described, and is expressed proportionally to the body weight, i.e. mg. per Kgm.

POSSIBLE APPROACHES TO STANDARDS OF LETHALITY FOR TREATY PURPOSES

A standard of lethality which would be suitable for international agreement should as far as possible define materials which would be attractive as chemical weapons, but exclude a number of materials in common use which, although lethal at low doses, are unattractive as weapons and have important economic and utilitarian values (or the use of the latter materials as CW agents could be banned, but their manufacture for civil purposes might be permitted).

Toxic materials which would be effective as weapons may be classified in three categories as follows:-

I. Vapour Group

This group of possible CW agents are toxic materials which are volatile liquids, which can be loaded into munitions as liquids but which readily vaporize on release, either because of the heat of explosion or by evaporation in air, releasing large clouds of highly concentrated toxic vapour. Examples of agents of this type are Phosgene, Hydrogen Cyanide and non-persistent nerve gases. They produce their effects by inhalation over short periods of time (seconds to minutes), either by effects on the lung itself (e.g. phosgene), or through absorption through the lungs into the blood stream to cause subsequent systemic poisoning (e.g. hydrogen cyanide, non-persistent nerve gas).

II. Percutaneous Group

This group of dangerous materials are toxic substances which are absorbed through the intact skin. They are generally liquids of low volatility, which on release remain as slowly evaporating droplets. The vapours are also toxic (by inhalation), but present at low concentrations. These agents may attack the skin itself (e.g. mustard), or may be absorbed through the skin into the blood stream (e.g. persistent nerve gas), thus causing general systemic poisoning, or may be absorbed by inhalation of low concentrations of vapour over comparatively long periods of time (minutes to hours).

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III. Supertoxic Solids

Solid toxic materials are generally not dangerous as possible agents of warfare, because they are not readily absorbed through the skin, and are not sufficiently volatile to form inhalable vapour clouds, or sufficiently heat resistant to be disseminated as toxic smoke from pyrotechnic devices. However, development of munitions for producing large clouds of inhalable aerosol of solid materials would allow these substances to become available as weapons. Solid materials would have to be considerably more toxic than persistent nerve gases to offer any military advantage. Examples of such supertoxic solid materials are found among naturally-occurring toxins; examples are snake venom, ricin, staphylococcus enterotoxin, botulinus toxin.

The approximate lethal levels of toxic materials, including agents of chemical warfare, are indicated in Table I.

In considering possible criteria for materials to be defined by treaty as potential weapons, it would appear to be impractical to use only the injected LD_{50}s as such a criterion because:-

(a) Injected LD_{50}s only very approximately reflect the toxicity of materials by inhalation or percutaneous absorption.

(b) A limiting LD_{50} high enough to include phosgene and hydrogen cyanide (e.g. about 1 mg/Kg would also include a large number of toxic solids which need not be considered as likely weapons.

(c) LD_{50} figures by any route vary widely depending on test conditions, particularly on species and sex of animals used. In order to specify a limiting injected LD_{50}, it would probably be necessary to specify test conditions quite exactly, and these test conditions would be difficult to standardize, particularly as to the specifications of the animals to be used.

Because of the difficulties enumerated above, it would seem more practical to set up three standards of lethality, one for inhaled gases and vapours, a second for percutaneously toxic substances, and a third for supertoxic solids. If these levels were chosen to just include the least toxic of present chemical agents of chemical warfare, the degree of overlap with toxic materials necessary for use in industry, agriculture, and medicine, would be minimized.

The difficulties of standardizing animal test conditions are encountered with any toxic material. However, it may be argued that accurate LD_{50} figures are unnecessary for treaty purposes, since it is only necessary to decide whether a given material is more or less lethal than a set limit. Considerable savings in test costs could be realized and less uncertainty would exist if certain easily available chemicals were named as agreed standards of lethality.

Based on the foregoing considerations, the following scheme is proposed as a basis for discussion:

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Proposed Criteria of Lethality

Materials fulfilling any of the following criteria of lethality would be considered as potential agents of chemical warfare to be subject to a general prohibition (or, more particularly, to be considered as agents sufficiently lethal and militarily useful to be made subject of a ban on their manufacture):

1. Vapour-forming materials having lethality equal to or greater than that of reference substance (suggested standard: Phosgene) when administered by inhalation to animals of any of the common laboratory species (mouse, rat, rabbit, guinea pig, cat or dog).
2. Percutaneously toxic materials having lethality equal to or greater than that of the reference substance (suggested standard: Nicotine (alkaloidal base), when administered percutaneously to any of the common laboratory species (mouse, rat, rabbit, guinea pig, cat, dog or swine).
3. Materials having lethality equal to or greater than that of ~~of~~ the reference substance (suggested standard: Neostigmine) when administered by subcutaneous injection to any of the common laboratory species (mouse, rat, rabbit, guinea pig, cat or dog).

The reasons for proposing these particular substances as reference materials are (a) that they are materials readily available commercially in many countries, (b) that they have levels of toxicity such as to minimize inclusion in a prohibition of less toxic materials which have legitimate uses (see Table I). It may be possible to establish a ban on manufacture, without interference in commercial uses, on all those agents having a lethality greater than these standards.

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GENERAL DESCRIPTION OF TESTING PROCEDURES FOR PROPOSED CRITERIA OF LETHALITY

The principle of comparative testing would be to subject one small group of uniform animals (mammals) to a dosage of the reference substance, by the appropriate route (inhalation, percutaneous or injected subcutaneously), and to subject a second group to an equal dosage of the chemical to be tested. The dosage used would be one known to be close to the LD_{50} for the reference substance. In most cases, all the animals in the group receiving the test chemical would either live or die, and a clear-cut decision on the lethality of the chemical could be made. In the minority of cases, some of the animals in the test group would survive and some die; this would indicate that the material was of approximately equal lethality to the reference substance, and would be considered as a possible chemical warfare agent. These borderline cases would be of minor importance, since they would not offer attractive alternatives to recognized agents of chemical warfare.

The advantages of this proposal over more accurate methods for determining LD_{50} values are that it is a much simpler and more economical test which need not be tied to any particular species or strain of animal, or to any agreed mathematical calculation.

LIMITATIONS OF THE PROPOSAL

The most important limitation on the above proposal, or on others which adopt a sole criterion of lethality, is that they would not include materials which are less lethal, but which could still have military utility against forces or civilians poorly protected. (For this reason, it may be

necessary to allow a category of chemical agents of lesser lethality the use of which as agents of weapons of war would be prohibited, but whose manufacture for legitimate civil uses would be permitted).

This shortcoming could be avoided if the treaty also prohibited materials which caused disability lasting more than a few days. However, the means of verifying this property of chemicals would be much more difficult than simple lethality, and at the present time non-lethal but permanently disabling chemical weapons are only a possibility.

The treatment of chemical weapons which cause temporary disability (incapacitating agents and irritant agents) is outside the scope of this paper; however, similar principles might be applicable in defining levels of incapacitating potency as have been proposed above for defining lethality, i.e., use of known incapacitating or irritant compounds as standards of comparison for tests with experimental animals or human subjects.

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TABLE I

APPROXIMATE LETHAL DOSAGES OF CW AGENTS AND OTHER TOXIC MATERIALS

GROUP I - Toxic Vapours and Gases

Name of Lethal Material	Approximate Lethal Dose Inhaled: LCt_{50} mg min/m^3	LD_{50} mg/Kg.
Carbon Monoxide	150,000	21
Ammonia	70,000	10
Sulfur Dioxide	40,000	5.6
Chlorine	36,000	5.1
Hydrogen sulfide	22,000	3.1
Hydrogen cyanide	5,500	0.790
Proposed reference substance → Phosgene	3,000	0.43
Ozone	2,000	0.28
Non-Persistent nerve gas	100	0.014

GROUP II - Percutaneously Toxic Liquids

Name of Lethal Material	Approximate Lethal Doses Percutaneous: Percutaneous mg/Kg.	Inhaled Vapour LCt_{50} mg min/m^3	Injected mg/Kg.
Parathion	500		5
Diisopropyl fluorophosphate	100	5,000	4
Allyl alcohol	50	140,000	-
Proposed reference substance → Nicotine (base)			
Mustard Gas	20(?)	2,000	10
Paraoxon	10		-
Persistent nerve gas	0.2	50	0.02

...11

TABLE I

APPROXIMATE LETHAL DOSAGES OF CW AGENTS AND OTHER TOXIC MATERIALS

GROUP I - Toxic Vapours and Gases

Name of Lethal Material	Approximate Lethal Dose Inhaled: LCt_{50} mg min/m^3	LD_{50} mg/Kg.
Carbon Monoxide	150,000	21
Ammonia	70,000	10
Sulfur Dioxide	30,000	5.6
Chlorine	36,000	5.1
Hydrogen sulfide	22,000	3.1
Hydrogen cyanide	5,500	0.790
Phosgene	3,000	0.43
Ozone	2,000	0.28
Non-Persistent nerve gas	100	0.014

GROUP II - Percutaneously Toxic Liquids

Name of Lethal Material	Approximate Lethal Doses Percutaneous: Percutaneous mg/Kg.	Inhaled Vapour LCt_{50} mg min/m^3	Injected mg/Kg.
Parathion	500		5
Diisopropyl fluorophosphate	100	5,000	4
Allyl alcohol	50	140,000	-
Nicotine (base)			
Mustard Gas	20(?)	2,000	10
Paraoxon	10		-
Persistent nerve gas	0.2	50	0.02

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TABLE I (continued)

GROUP III - Supertoxic Solids Name of Lethal Material	Approximate Lethal Dose Injected mg/Kg. (subcutaneous)
Strychnine	1.0
Physostigmine	0.5
Curarine	0.5
Proposed → reference substance Neostigmine	0.4
Digitoxin	0.3
Carbachol	0.3
Snake Venoms	0.5 → 50
Ricin	0.02
Carbamates	0.01
Bacterial Toxins	
- staphylococcus	0.00001
- tetanus	0.00000003
- botulin	0.00000002

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