

should be defined so as to separate will be impossible to do so. However, 0.50 mg/kg (mouse; subcutaneous) suggested in CCD/301, or a value close solution to the problem of selecting

ts from different laboratories to be filed experimental procedures must conditions which would have to be. If general agreement were reached specific toxicity threshold, the precise solution would be worked out by experts

standardized, there will be a certain requirements. It is to be expected that samples of chemical will still obtain. This is because it is difficult to involved in making toxicity tests

es, a range of 20 per cent on either ly considered good. Studies on the es have demonstrated that a broader . The ratio of the highest to lowest and 3 for oral toxicity values and oral toxicity values, the range may e LD₅₀ value reported is the average

s could pose a problem in applying es. Normally only one or two inde- and it is quite possible that these e average value that would be ob- independent determinations. For a ory might report the compound to e a different laboratory might con-

ted by assuming that the toxicity n LD₅₀ of .050 mg/kg (mouse; sub- that a standardized experimental a compound with an average LD₅₀ low the limit, the possible results approximately from 0.18 mg/kg to s greater than 0.50 mg/kg, it might uld not be prohibited. Analogously, an average LD₅₀ value of 0.80 mg/kg, 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.

United States Working Paper Submitted to the Conference of the Committee on Disarmament: Chemical Agent Destruction, July 16, 1974¹

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.² 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

¹ CCD/436, July 16, 1974.

² *Documents on Disarmament*, 1972, pp. 352-361.

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 [gas] 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

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sump where they were decontaminated with a standard military de-
contaminant that reacts rapidly with mustard and achieves complete
decontamination in about five minutes. These liquids were subse-
quently 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 efficiency the dis-
posal 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 in-
organic 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 precip-
itator 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 4,000 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 con-

tainers 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 (10 ml) sample the type and verification the

(c) *Step 4:* provide the be destroyed. In t ferred from th tap valve coul mustard is inj step, a sample and its concen with data fror diluted (part di

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(d) *Steps 5: contamination disposal, these opportunities*

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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.

United States Working Paper Submitted to the Conference of the Committee on Disarmament: Diversion of Commercial Chemicals for Weapons, July 16, 1974¹

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).² At that time we noted that there were certain problems and disadvantages to be overcome, particularly in regard to identifying deliberate attempts at deception.

¹ CCD/437, July 16, 1974.

² *Documents on Disarmament*, 1970, pp. 455-459.