paper comes to the conclusion that by using satellite-
i it is technically possible to detect field tests with a
$^{-1}$ mg/m^2 and a probability of 0.3 and 0.75 in winter
pectively; when the analysed layer is 100 metres thick,
vity is 10^{-3} mg/m^3.

t stage of development of science and technology, a
detector such as the cadmium-mercury-tellurium
ribed in working paper CCD/371 is not the most sensi-
bly greater sensitivity is attainable with monolithic
on impure crystals at ultra-low temperatures (a condi-
nable in outer space) coupled with an advanced system
essing.

o achieve a high detection sensitivity involve the use
and resonance combination scattering (Shorygin)
best results are obtained with modulated lasers, which
to operate in "windows" of atmospheric transparency.
access to a very high limit of sensitivity (five or more
han that of ordinary combination scattering).

ethods of identifying chemical structures and statisti-
data analysis which are not covered in working paper
it possible to expand considerably the potentialities of
monitoring methods in terms of increasing sensitivity
ss in the identification of structures. Characteristics of
of chemical agents can be identified by mathematical

an be identified from infrared spectra and spectra of the
attering of light. In this case the spectral characteris-
stances analysed should be fed into computer memories
rocessing the results.

est attaches to the use of satellites in geostationary orbit
case noise can be averaged over time, thus providing an
of eliminating noise disturbances generated by atmos-
ions. By this method, the sensitivity of the system can be
ortionally to the square root of the number of scans.

l solutions described above can be applied through the
ined system in which one satellite is positioned in geo-
it while others revolve in low circular orbits at an alti-
50 km.

rom the foregoing that, by improving technical means
detection of chemical agents and using a system of certi-
llites, it will be possible to increase the effectiveness of the
lerably, to record with a high degree of reliability the
ie atmosphere of very low concentrations of chemical
nsequently to detect the production of chemical weapons
of such weapons. Therefore the application of remote
ig use of artificial earth satellites is quite sufficient for
toring of compliance with many of the provisions of a
tion on the prohibition of chemical weapons.

Indirect methods of monitoring

Indirect methods can be particularly effective for purposes of extraterritorial monitoring when based on analytical processing of a wide range of information accessible to the general public and covering the development, production and stockpiling of chemical agents. In addition, use may be made of the national information centres already in existence in various countries which analyse for commercial purposes the activities of various foreign research centres, factories, firms and departments and the progress made by individual scientists and specialists employed there. Since such national systems for selecting and evaluating information in all fields of science and technology exist in the majority of large and technically developed States, it is virtually impossible that any of them should be able to outstrip the others for a long period and on a large scale in any branch of fundamental military technology, including chemical weapons.

Individual questions connected with the use of statistical analysis in production have already been discussed in, for instance, the working papers submitted by the United States of America (CCD/283)[4] and Japan (CCD/344 and to some extent CCD/430[5]).

* * *

Thus the sum total of remote and indirect methods of monitoring afford adequate scope for extraterritorial monitoring by national means. By combining those methods with the specific methods of intraterritorial national monitoring (laboratory, conservative and other methods), a comprehensive and effective solution can be found for the entire problem of monitoring compliance with an agreement on the prohibition of chemical weapons.

Soviet Working Paper Submitted to the Conference of the Committee on Disarmament: Verification of the Destruction of Declared Stocks of Chemical Weapons, August 3, 1977[1]

Working paper CCD/497 of 29 June 1976, submitted by the United States, considered problems of monitoring the destruction of declared stocks of chemical weapons. The paper notes, in particular, that "the basic purpose of on-site monitoring would be to confirm information provided as to the type and quantity of agent destroyed".[2]

The main purpose of monitoring the destruction of declared stocks of chemical weapons should be to establish (a) the fact of the destruction of an agent of a certain type, (b) the quantity of the agent destroyed and (c) the quality of this agent, and to produce appropriately documented results of the verification.

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[4] Ibid., 1970, pp. 91–93.
[5] Ibid., 1974, pp. 306–325.
[1] CCD/539.
[2] *Documents on Disarmament, 1976*, pp. 369–372.

The present paper describes one of the methods of attaining this objective.

Taking as a basis the principle of national control over the destruction of chemical agents, it is necessary to bear in mind that:

(a) chemical agents are destroyed by incineration or detoxification;

(b) the planning of the destruction of chemical agents, as well as their removal from containers or warheads and collection in special receptacles, are regarded as preparatory operations which are undertaken without the participation of controllers;

(c) chemical agents are transported to the place of destruction in special receptacles.

* * *

The quantity of chemical agents brought for destruction is determined by weighing them or by measuring their volume. Where the volume is measured, the weight of liquid substance is calculated by the following formula:

where:
V=the volume, in $\underline{Q=V\cdot\rho}$ m^3,
ρ=the density of the substance, in g/cm^3 or t/m^3, and
Q=the quantity of the substance brought for destruction.

The density of the chemical agent is determined in the laboratory. For measuring the density, use may be made of known densitometers (float-type, pycnometric, piezometric and radioactive) which are likely to prove most suitable for work with these substances.

The quantity of solid chemical agent can be measured in a similar manner, with minor differences only in the measurement of density or bulk weight.

On completion of the process of the destruction of the chemical agent, the quantity of the agent remaining in the receptacle—Q_{rem}—is measured.

The quality of the chemical agent brought for destruction is determined by the content, in per cent, of the basic substance in the agent—q(%). The method of measuring this can be illustrated by the examples of quality testing for sarin and yperite.

For quality testing for sarin, for example, it is possible to use the technique based on its ability to hydrolyze in an alkaline medium. The control is effected by monitoring the consumption of alkali, and the sarin content is calculated by the following formula:

$$q\%=\frac{7.005\,(a\cdot K_{NaOH}-b\cdot K_{HCl})\cdot 100}{A}$$

where:
a=the quantity 0,1 N of NaOH solution consumed for titration, in ml,
b=the quantity 0,1 N of HCl solution consumed for reverse titration, in ml, and
A=dose by weight, in mg.

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$$005\,(a\cdot K_{NaOH}-b\cdot K_{HCl})\cdot 100 \over A$$

N of NaOH solution consumed for titration,

N of HCl solution consumed for reverse
nd
n mg.

Another possible technique is based on the reaction of sarin with hydrogen peroxide in an alkaline medium, with iodometric monitoring of the consumption of hydrogen peroxide.

The sarin content is calculated by the following formula:

$$q\%=\frac{3.502\,(a-b)\cdot K_{Na_2S_2O_3}\cdot 5.100}{A}$$

where:

a=the quantity 0,1 N of $Na_2S_2O_3$ solution consumed for titration of the control sample, in ml,
b=the quantity 0,1 N of $Na_2S_2O_3$ solution consumed for titration of the substance tested, in ml.

In quality testing for yperite, it is possible to make use of its reaction with an aqueous solution of chloramine T. The control is effected by monitoring the consumption of chloramine by the iodometric method. The yperite content is determined by calibration curves, obtained by titration of standard yperite solutions.

In terms of the main substance, the true quantity of the agent destroyed in one cycle is as follows:

$$Q_{tr}=(Q-Q_{rem})\,\frac{q}{100};\ (m).$$

It is impossible to rule out the possibility that the chemical agent brought for destruction may be non-homogeneous in quality. In this case, when the substance is removed from the receptacle for destruction, it is necessary to analyse at least three samples—one at the beginning of the destruction process, one in the middle and one at the end.

The samples can be taken either directly from the receptacle with a sampler from different layers of the chemical agent, or from the flow by "the flow method" technique when the substance is being fed to the destruction facility.

Each sample is used for determining the content of the basic substance and the density. From the values for the content of the basic substance and for the density, it is possible to calculate their mean values $\overline{q}$ and $\overline{\rho}$ as follows:

$$\overline{q}=\frac{q_1+q_2+q_n}{n}$$

where q_1, q_2, and q_n are the content, in per cent, of the basic substance in the first, second and n-th samples; and n is the number of samples taken.

In this case the quantity of the chemical agent destroyed, in terms of the basic substance, would be:

$$Q_{tr}=(Q-Q_{rem})\,\frac{q}{100};\ (m).$$

Quantitative data on the destruction of declared stocks of chemical weapons should be recorded in a ledger. The ledger might have, for example, the following entries:

Date	Type of chemical agent to be destroyed	Quantity of chemical agent on arrival (tons) Q	Quantity of chemical agent remaining (tons) Q_{rem}	Mean value of the content of the basic substance $\bar{q}$ (%)	Quantity of basic substance destroyed (tons) Q_{tr}	Remarks
1	2	3	4	5	6	7
Total (tons)						

The final stage of laboratory chemical analysis shall be the analysis of the extent of decomposition of the chemical agents destroyed.

From the ledgers recording the quantities of substances destroyed at each facility, it is possible to determine whether the quantity of the stocks of chemical weapons actually destroyed corresponds to the declared stocks.

It would seem that stocks of chemical weapons declared for destruction should be expressed in terms of the quantity by weight of the basic substance. This will make it possible to exclude from the destruction records non-toxic elements present in the composition of chemical agents destroyed.

Conclusion:

Effective monitoring of the destruction of declared stocks of chemical weapons is feasible provided that preparatory work and chemical analyses are undertaken, and that statistical records are kept—in terms of the basic substance—of the quantity and quality of chemical agents destroyed.

International Security Assistance Act of 1977: Nuclear Enrichment and Reprocessing Transfers [Extract], August 4, 1977[1]

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22 USC 2429. Sec. 12. Chapter 3 of part III of the Foreign Assistance Act of 1961 is amended by striking out section 669 and inserting in lieu thereof the following new sections:

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[1] P.L. 95–92, 95th Cong.; 91 Stat. 620–621. For ACDA testimony on this act, see *ante*, pp. 240–245; the President's statement upon signing the act is reprinted *post*, pp. 483–484.