CONFERENCE ON DISARMAMENT

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SOME QUANTITATIVE ASPECTS OF A CHEMICAL WEAPONS CONVENTION

I. INTRODUCTION

1. As the CD moves into more detailed examination of the various provisions of a Chemical Weapons Convention, the ad hoc Committee and its Working Groups have arrived at the stage of discussing such practical measures as the "number of random inspections" or "significant quantities below which control and verification could be exempted". There are also many other quantitative parameters that are being taken up.

2. It is important to realize that

(a) these figures may differ between the various chemical facilities and as for different chemical agents, but at the same time, that

(b) they are governed by the same mathematical principles and thus quantitative consistency should be maintained, while

(c) these figures, when accumulated, will determine the resource requirements for the inspectorate and the technical secretariat.

3. Japan has pointed to the importance of such technical consistencies, as well as the need to identify the governing mathematical principles in its plenary statement of 3 April 1986. It is also extremely important that the international régime of verification and control be defined within a reasonable scale, so as not to exceed the practically available resources both in personnel and financial terms. A great deal will depend on the number of chemical agents and facilities to be subject to the different régimes of verification and control, as well as the required amount of paper work including reports and records, as these may be shared between international and national régimes of control if such a dual system were to be adopted.

4. There is a great deal of information that can be derived from the IAEA safeguards experience, in that it is also a verification régime based on material accountancy. The analogy ceases there, however, because the number of chemical elements involved is maximum of three (uranium, plutonium and thorium) in the case of nuclear safeguards, while a CW convention will have to deal with a very large number of complex chemical compounds. (The amount of material and the number of facilities involved may be orders of magnitude different in the case of a CW convention). This speaks all the more for the need of clear and consistent logic in the quantitative handling of the various aspects of CW control.

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II. STATISTICAL SAMPLING AND CW TREATY VERIFICATION

Where continuous monitoring is impractical, one may attain the best results through a statistical sampling technique. Such statistical samples are composed of systematic and random components. For example, visits every other day is systematic in that one can predict when. (Systematic components are sometimes referred to as "bias" in mathematics). The random component is unpredictable save their total number, and can be defined, for example, on the basis of computer-generated random numbers.

Destruction of stocks

1. Verification of the initial inventory (declared store) is done by

(a) counting the number of containers or shells, and

(b) establishing the average content of such containers or shells by means of

- chemical analysis (representative samples) and
- weight measurement.

Since not all containers or shells can be examined, "random sampling" leading most likely to a "normal distribution" curve should be employed to determine the chemical contents and weight.

2. Verification of no unauthorized removal from the inventory - periodic inventory takings (involving random sampling again) or continuous monitoring of the perimeter (containment) - is a necessary element.

So are the quantitative verification of authorized removals from the inventory to the destruction facility and the establishment of a running inventory at the destruction facility.

3. Material balance at the destruction facility will be established through

feed measurement: weight, chemical composition, etc.,

waste (product) measurement: weight, flow rate, pressure, temperature and content.

For any given time (day), the material balance of the feed and output have to match. Otherwise diversion may have taken place, meaning some CW may remain while reported as having been destroyed.

This verification can be done either by constant on-site observation or random verification of samples (which the destruction facility will need to take for its own operational control). In view of the fact that STLCs with very low threshold quantities will be handled daily, daily presence of inspectors will probably be required.

If there are means of using tamper-proof continuous automatic monitoring devices, there is a possibility of reducing some human presence. (See papers CD/271, CD/619 etc.).

Production facilities

4. Production facilities for protective purposes

For a dedicated facility of limited annual output, something analogous to the quality control system of the plant operation should give sufficient confidence regarding the quality of the substance and the amount of production. (The normal technique is random sampling).

However, when dealing with an integral part of a large chemical complex, the process of confirming the quality and production volume will be more difficult, with a larger number of sampling points, and possible computer simulations which may or may not be a part of the plant's operational routine.

5. Non-production or "no diversion" from permitted activities

Large-scale production lines require a large number of sampling points and very sophisticated instruments to assure the representativeness of samples. To follow all such activities will require very large resources (qualified inspectors, independent measuring instruments etc.). It makes more sense to rely on the plant's own record and report system, and to have access to the plant for a limited period (but on the dates the inspectorate can decide on their own, based on random sampling either of operating days or among the necessarily many production plants).

6. Random sampling allows one to have knowledge about the whole, from a surprisingly small number of (random) samples. An example is a few hundred people polled over the telephone to give good and reliable indication of nation-wide public opinion, if the subjects are carefully chosen with sufficient stratification and randomness. Such statistics should be accompanied by "confidence" statements, so that one comes to the conclusion that "with 20 visits to the plant during a year, there is 95 per cent confidence that production of no more than X kgs of a prohibited substance could have taken place".

The number of visits and the level of confidence can be determined according to the level of toxicity or the threshold volume of military significance. If very large volumes and low toxicity are involved, verification statistics can be handled very easily. In the case of low priority items, it is possible and in fact will be more efficient to forget the statistics and limit verification to occasional "spot check visits" for the sake of a deterrence effect.

Challenge inspection

7. When such statistical verification produces an anomaly which requires additional inspection to clarify the situation, the Technical Secretariat could recommend ad hoc inspections. This is one form of "challenge inspection" which, in principle, may not be refused.

When there is suspicion of undeclared and unreported activities outside the coverage of routine (statistical) inspection, challenge on such cases has to be handled in a very different manner, and according to more politically oriented criteria.

III. THRESHOLD LEVEL FOR DATA REPORTING

A militarily significant quantity

1. For a chemical agent to be considered within the context of a CW convention, it will be necessary to assign a minimum quantity below which the agent will have no military significance. This is a practical consideration necessary in order to avoid undue complication.

(a) If the agent in question is a chemical weapon as defined in the Convention, this quantity (Q) will theoretically be determined by considering the probable mode of its deployment as well as the specific scenarios for its use. Considerable elements of human judgement will enter into the process of the determination of Q for different categories of chemical weapons.

(b) If the chemical in question is unrelated to any known CW, Q in this case will be infinity.

(c) If the chemical is used on a large scale in civilian industry, but may be converted into a CW, then Q for this substance will be determined by taking into account such factors representing the time and means required for conversion, and the required work at the facility.

In any event, Q is an amount (kgs or tons) linked to the individual chemical agent.

Threshold level

2. For the effective implementation of a CW convention, there will be a need to set threshold levels for verification and control. For example, some agreed threshold level will have to be established for the verification of declared CW stocks or for its destruction, in order to establish a confidence level for statistical sampling or of setting allowable margins of error in measurement.

By definition, and for practical purposes, this threshold level (L) will need to be expressed in terms of individual facilities and for a given period of time. In other words, while Q was so many kgs or tons as a more or less time independent quantity, L will be stated in units such as kgs/week per facility. This means conversion of the notion from a "maximum allowable" in absolute terms, to one of control parameters in a system.

Something other than pure scientific logic is usually required in the process of deriving L from Q and here again good common sense and judgement by those very knowledgeable about the subject will be required.

3. The relationship between Q and L may be stated as follows:

(a) Q is an amount below which there is no need to worry about the chemical in question. If sub-Q amounts of a chemical are being stored or produced, they are for all intents and purposes not a factor to reckon with as far as the CW Convention is concerned.

(b) Q itself cannot be taken as L when there is more than one production facility. If there are N number of sub-Q facilities which are all exempted from controls, the total exemption NxQ will obviously exceed Q, and thus will have military significance. This means that some fraction of Q will be an appropriate level as the threshold quantity. Q should be defined either as a "national limit" or "facility limit" as the case may be. Similarly, if statistical uncertainty and measurement error were to accumulate over many years, they will eventually exceed Q no matter how often inspections take place. This is another reason for defining the threshold level in relation with the time factor.

(c) In this connection, adopting one year as the time factor seems to be a practical suggestion based on the assumption that continuing clandestine production in N number of facilities for one full year would be a very cumbersome and unrewarding operation. If some facilities are to be visited by inspectors once a year for a check of the production records, one year may be justified on such grounds.

(d) However, one should be very careful before adopting a certain parameter which would determine necessary inspection resources. The quantitative aspect of verification and control has to be approached with utmost caution, otherwise one may end up with a logically consistent but inoperable scheme.

4. There are a number of considerations which have to enter into the determination of L, especially in the case of non-CW chemicals.

(a) If the main concern is the production capacity, then rather than X tons/year, it is better to use X kgs/day, which, with an appropriate plant load factor, becomes X tons produced during a year's time. This conversion from annual production capacity to production levels makes the work of day-to-day control much easier.

(b) As explained above, L is likely to be some fraction of Q. Though below L, the chemical is as good as non-existent for the purpose of the CW convention, excessive activities involving a large number of just sub-L productions or storages should be regarded with some suspicion. There will be a need to go beyond data reporting and occasional spot check visits. The mechanism of challenge inspection can be applied to such "legally consistent but substantively clandestine activities".

(c) On the other hand, the nature of the chemical industry is such that it is conceivable that there will be plants whose annual throughputs would be tens of hundreds of times L. In these cases, accumulation of normal measurement errors can easily exceed L tons/year. In such a case, reporting of the total output as well as some technical indication of the level of quality control may be all that is feasible as a means to establish confidence to assure the absence of unauthorized activities.

5. In all the cases hitherto discussed, the threshold level for data reporting is derived with a considerable amount of judgement factors. It is natural that within such judgements should be included those such as:

proprietory considerations of industrial production data,

restriction on access of inspectors in the plant premises, if only from a safety point of view, available resources at the international (national) control organ(s) for handling reports and for the dispatch of qualified inspectors.

6. It may be worth noting that the problems of setting a threshold level of control, of reporting and recording have been extensively dealt with in regard to nuclear materials control within the IAEA safeguards. Although figures such as 25 kgs for enriched uranium and 8 kgs for plutonium, have been used as a practical solution, representing one explosive device each, and somehow a standard was established to exercise control on the basis of a unit of such "significant quantity" per facility per year as a working hypothesis in most cases, a completely consistent justification for these practices may need further elaboration.

IV. CONSISTENCY OF MEASUREMENT IN CW DECLARATION AND ELIMINATION

1. Chemical weapons (CW) to be destroyed will initially be identified by "declarations". These declarations will specify:

the location,

physical state of the CW (whether in shells or containers, whether liquid, vapor under given temperature and pressure, etc.),

the amount (weight, volume and number of containers, etc.), and

chemical composition and known impurity.

Even if it were to take some time for the CW stocks to be gathered at sites suitable for declaration, such process should be carried out in as short a time period as is possible, so that the starting point for CW elimination may be quickly established.

2. The declared stock will need to be verified, and for this purpose, measurement of weight (per individual shell or container, as the case may be) may either be done for the total number of units individually or through statistical sampling. Analysis of chemical composition is, by definition, on a sampling basis. The theory of statistical sampling will determine, based on an assumed distribution of variances, the relationship between the number of random samples and the level of confidence. Measurement errors for weighing and analysis will have to be clearly established so that it will be possible to have a good grasp of the extent of accuracy with which the stock is verified.

3. The schedule of destruction for CW stocks will specify:

the location of destruction facility,

the method of destruction (incineration, chemical decomposition, etc.), and

daily (hourly, weekly) rate of such destruction, as well as the annual schedule of operation.

This means that at the declared location, removals of CWs other than scheduled (for destruction, protective purposes, etc.) will be unauthorized acts and will come under strict control. This could be verified by either periodic re-establishment of inventory, or through continuous surveillance of the perimeter to confirm that no unauthorized removals have been made.

It is important to realize that verification at this stage (either re-establishment of inventory or measurement of CWs being removed) has to be on the level of accuracy and confidence compatible and consistent with the level originally employed to verify the initial declaration.

4. Throughout the destruction process, verification would very likely involve establishment of a material balance either on a comprehensive basis for the batch or with emphasis on some predominant chemical element. If the process involved is incineration of CWs contained in a shell, measurement of material (in weight) and the subsequent analysis of discharged waste may be either on a continuous basis or according to some statistical sampling.

Since the level of accuracy in measurement at the destruction stage will reflect the "state of art", it is likely that the level of measurement accuracy and thus the confidence required at earlier stages (stock and removal verification) may not meaningfully exceed this level. It will be useful to consider the problem of such consistency by creating some representative numerical model from initial declaration through the various stages of destruction.