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DISARMAMENT COMMISSION

Supplement for 1972

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Report of the Conference of the Committee on Disarmament (29 February 1972–7 September 1972)

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ANNEXES

INTRODUCTION

1. The Conference of the Committee on Disarmament submits to the General Assembly of the United Nations and to the Disarmament Commission a progress report on the Committee's deliberations on all questions before it for the period from 29 February 1972 to 7 September 1972, together with the pertinent documents and records.

2. This report includes accounts of the Committee's work during 1972 on further effective measures relating to the cessation of the nuclear arms race at an early date and to nuclear disarmament, non-nuclear measures including the question of the prohibition of chemical weapons, other collateral measures, and general and complete disarmament under strict and effective international control.

I. ORGANIZATION OF THE CONFERENCE

A. *Procedural arrangements*

3. The Conference reconvened on 29 February 1972.

4. Two sessions were held, the first from 29 February to 27 April 1972, and the second from 20 June to 7 September 1972. During this period the Committee held 40 formal plenary meetings during which members set forth their Government's views and recom-

* Originally circulated as document A/8818-DC/235.

mendations for progress on the questions before the Committee. The Committee also held six informal meetings without records.

5. In addition to the plenary meetings described above, members of the Committee met frequently for informal multilateral consultations on disarmament questions of common interest.

6. The representatives of the Union of Soviet Socialist Republics and the United States of America, in their capacity as Co-Chairmen of the Committee, also held meetings to discuss procedural and substantive questions before the Committee.

B. *Participants in the Conference*

7. Representatives of the following States continued their participation in the work of the Committee: Argentina, Brazil, Bulgaria, Burma, Canada, Czechoslovakia, Egypt, Ethiopia, Hungary, India, Italy, Japan, Mexico, Mongolia, Morocco, Netherlands, Nigeria, Pakistan, Poland, Romania, Sweden, Union of Soviet Socialist Republics, United Kingdom of Great Britain and Northern Ireland, United States of America and Yugoslavia.

II. WORK OF THE COMMITTEE DURING 1972

8. In a letter dated 18 February 1972 (CCD/357), the Secretary-General of the United Nations transmitted to the Conference of the Committee on Disarmament the following resolutions adopted at the twenty-sixth session of the General Assembly: resolution 2825 B (XXVI) on general and complete disarmament, resolution 2827 A (XXVI) on the question of chemical and bacteriological (biological) weapons, resolution 2828 C (XXVI) on the urgent need for suspension of nuclear and thermonuclear tests, resolution 2831 (XXVI) on the economic and social consequences of the armaments race and its extremely harmful effects on world peace and security, and also the following resolutions which deal with disarmament matters: resolutions 2825 A (XXVI) and 2825 C (XXVI), entitled "General and complete disarmament", resolution 2826 (XXVI), entitled "Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction", resolution 2827 B (XXVI) entitled "Question of chemical and bacteriological (biological) weapons", resolution 2828 A (XXVI) and 2828 B (XXVI) entitled "Urgent need for suspension of nuclear and thermonuclear tests", resolution 2829 (XXVI), entitled "Establishment, within the framework of the International Atomic Energy Agency, of an international service for nuclear explosions for peaceful purposes under appropriate international control", resolution 2830 (XXVI) entitled "Status of the implementation of General Assembly resolution 2666 (XXV) concerning the signature and ratification of Additional Protocol II of the Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco)", resolution 2832 (XXVI), entitled "Declaration of the Indian Ocean as a zone of peace", and resolution 2833 (XXVI), entitled "World Disarmament Conference". Members of the Committee were assisted in their examination and analysis of possible disarmament measures by numerous messages, working papers, and other documents that were submitted to the Conference (see below annexes A and B). and by the statements in plenary by Committee members.

9. At the opening plenary meeting of the 1972 session, the Secretary-General of the United Nations addressed the Conference. The Secretary-General paid tribute to the accomplishments of the Conference of the Committee on Disarmament over its 10 years of existence and called it "the most effective and productive organ for multilateral arms control and disarmament negotiations available to the international community" (see CCD/PV. 545). He emphasized the need for a comprehensive test ban as the single most important measure to halt the nuclear arms race, and expressed his belief that all the technical and scientific aspects of the problem had been so fully explored that only a political decision was now necessary to achieve final agreement. He expressed views on the prohibition of the development, production and stockpiling of chemical weapons, emphasized the significance of the question of general and complete disarmament and stated that in his opinion it would be most fitting that a world disarmament conference be held at some early date. He also referred to the progress that has been made in working out safeguards agreements as required by article III of the Treaty on the Non-Proliferation of Nuclear Weapons,[1] and urged that the speedy and successful conclusion of negotiations on the agreements be facilitated. He called for the participation of all the permanent members of the Security Council in disarmament negotiations. The Secretary-General also expressed assurance that the Committee would put forward its utmost efforts to deal with the full range of problems referred to it by the General Assembly.

10. The Committee continued work in accordance with its provisional agenda on the following measures in the field of disarmament:

(*a*) Further effective measures relating to the cessation of the nuclear arms race at an early date and to nuclear disarmament;

(*b*) Non-nuclear measures;

(*c*) Other collateral measures;

(*d*) General and complete disarmament under strict and effective international control.

11. Many members of the Committee addressed themselves to the question of a world disarmament conference.

12. The question of the Committee's organization and procedures was also discussed.

A. *Further effective measures relating to the cessation of the nuclear arms race at an early date and to nuclear disarmament*

13. Members of the Committee continued their work on questions relating to the cessation of the nuclear arms race and many delegations expressed in their statements in plenary meetings the view that nuclear disarmament must be given highest priority. They urged the adoption of effective measures for the reduction and cessation of the arms race.

14. A number of delegations made reference to the signing of the two major agreements worked out through the Strategic Arms Limitation Talks (SALT) between the USSR and the United States—the Treaty on the Limitation of Anti-Ballistic Missile Systems and the Interim Agreement on Certain Measures with Respect to the Limitation of Strategic Offensive Systems. While

[1] General Assembly resolution 2373 (XXII), annex.

citing the need for further measures, particularly of nuclear disarmament, several members of the Committee indicated that they viewed those agreements as significant and promising accomplishments in the effort to restrain and turn back the nuclear arms race. Some delegations emphasized the need for further measures of a qualitative as well as a quantitative nature.

15. The delegations of Czechoslovakia (see CCD/PV.550), Poland (see CCD/PV.551), Mexico (see CCD/PV.565), the Netherlands (see CCD/PV.572), Pakistan (see CCD/PV.576), the Soviet Union (see CCD/PV.577), Canada (see CCD/PV.581) and the United States (see CCD/PV.584) expressed views on the need to ensure a fuller measure of participation in disarmament agreements, particularly in the field of nuclear disarmament, concluded over the last few years.

16. The delegation of the Soviet Union expressed views on the problem of ensuring the full effectiveness and universality of the agreements in the field of disarmament and particularly of those relating to nuclear disarmament (see CCD/PV.577).

17. The delegations of Czechoslovakia (see CCD/PV.550), Poland (see CCD/PV.551), Mexico (see CCD/PV.565), Pakistan (see CCD/PV.576) and the Soviet Union (see CCD/PV.577) stressed the importance of full implementation of and adherence to the Treaty on the Non-Proliferation of Nuclear Weapons by all States. Some of those delegations called for the prompt conclusion of safeguards agreements required under the Treaty.

18. The delegation of Romania advocated a concrete programme in the field of nuclear disarmament (see CCD/PV.550, 559 and 574).

Question of a comprehensive test ban

19. Having in mind the recommendations of the twenty-sixth session of the General Assembly, the Committee continued its deliberations on the question of a comprehensive test ban. Many delegations stressed the great importance of the early achievment of a comprehensive prohibition of the testing of nuclear weapons.

20. The delegation of the Soviet Union stated that the aim pursued by the USSR was to ensure the cessation of all nuclear weapon tests, everywhere and by everyone (see CCD/PV.545, 561 and 577).

21. The delegation of the United States reaffirmed the policy commitment of the United States to work towards a cessation of nuclear weapons testing pursuant to an adequately verified treaty (see CCD/PV.545).

22. The United Kingdom representative said it was his wish to make progress towards the conclusion of the comprehensive test ban. With a real effort and goodwill on all sides it should be possible to make that further step which would be welcomed throughout the world (see CCD/PV.559).

23. The delegation of India (see CCD/PV.552), Japan (see CCD/PV.547 and 562), Canada (see CCD/PV.562 and 571), Mexico (see CCD/PV.565), and Morocco (see CCD/PV.574) expressed the view that all nuclear weapon States should adhere to the Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water signed in 1963.[2] The representative of Mexico expressed the view that the achievement of that aim would be easier if underground nuclear weapons tests were discontinued (see CCD/PV.565 and 580).

24. The delegation of Yugoslavia expressed the view that an early solution of the prohibition of all nuclear tests could be successfully approached only in the wider context of nuclear disarmament, respecting the vital interests of all partners (see CCD/PV.548).

25. The representative of Sweden urged that action be taken during the session on a comprehensive test ban, and said that if this were done the renewed series of SALT could lead to a definite halt of the nuclear arms race (see CCD/PV.549 and 572).

26. The representative of India stated that a comprehensive ban had two aspects: (*a*) all nuclear weapon tests in all environments should be prohibited and (*b*) all nuclear weapon States should be parties to it. He also stated that negotiations should be undertaken for a separate treaty to prohibit all nuclear weapon tests in the underground environment and attention should simultaneously be fixed on the need to conclude an agreement on underground nuclear explosions for peaceful purposes (see CCD/PV.552).

27. The delegation of Brazil discussed the context in which it was willing to collaborate with efforts to achieve an equitable solution to the question of the prohibition of underground nuclear weapon tests which would complement the partial test ban Treaty, reiterating the position of its Government with regard to the peaceful uses of nuclear energy, including nuclear explosions for peaceful purposes (see CCD/PV.557).

28. The delegation of Pakistan reiterated the views expressed in its working paper of 1971 (CCD/340)[3] concerning the prohibitions in an underground test ban that should apply to non-nuclear weapon and nuclear weapon States and concerning nuclear explosions for peaceful purposes (see CCD/PV.576).

29. Special attention was paid to the problem of the prohibition of underground nuclear weapon tests.

30. The delegation of Mexico urged the achievement of the cessation of underground nuclear weapon tests at the earliest possible date, adding that, if such agreement were not possible right away, perhaps a moratorium could be agreed upon (see CCD/PV.545 and 580).

31. The delegations of Canada (see CCD/PV.546, 571 and 581), Japan (see CCD/PV.547 and 553) and Italy (see CCD/PV.547), while stressing their preference for an immediate comprehensive test ban, expressed the desirability of considering interim measures or a step-by-step approach to the prohibition of underground nuclear tests.

32. The delegation of Canada suggested that two lines of approach might be followed: the imposition of interim measures of restraint such as commitment by the testing powers to reduce the size and number of their nuclear weapons tests, or an agreed moratorium, and the tabling by the testing powers of texts of their proposals for a comprehensive test ban (see CCD/PV.546).

33. The suggestion that measures of restraint might take the form of an agreed moratorium was supported by the delegations of Morocco (see CCD/PV.555), Japan (see CCD/PV.562), Sweden (see CCD/PV.572) and Nigeria (see CCD/PV.533).

34. The representative of Japan proposed a threshold ban in three phases and called on the United States and the USSR to undertake immediately uni-

[2] United Nations, *Treaty Series*, vol. 480, No. 6964.

[3] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234, annex C, sect. 22.

lateral or negotiated measures of restraint that would limit or reduce the size and number of nuclear tests substantially. He subsequently commented on several technical aspects of his proposal and posed a number of related questions (see CCD/PV.553 and 580).

35. The delegations of Poland (see CCD/PV.551), India (see CCD/PV.552), Egypt (see CCD/PV.555), Bulgaria (see CCD/PV.556), the Soviet Union (see CCD/PV.577), the Netherlands (see CCD/PV.572) and Morocco (see CCD/PV.574) stated that they favoured a comprehensive test ban instead of partial solutions.

36. The delegation of the Soviet Union expressed the view that a partial prohibition of underground nuclear weapon tests would not contribute to a solution of the problem as a whole or remove the dangers inherent in the improvement of nuclear weapons (see CCD/PV.557).

37. The representative of the United States stated that his country was giving careful consideration to the Canadian proposal concerning interim measures (see CCD/PV.546) as well as the Japanese proposal for a threshold ban (see CCD/PV.553), and referred (see CCD/PV.560) to technical questions regarding implementation of the latter.

38. Members of the Committee devoted detailed attention to the question of verification of a prohibition on underground nuclear weapon tests. International co-operation in the exchange of seismic data, the improvement of world-wide seismological capabilities, and further study of detection and identification of underground nuclear tests were also considered by the Committee and several members made specific contributions to those efforts during the sessions.

39. The delegation of the Soviet Union stated that the prohibition of underground nuclear weapon tests could and must be based on national means of detection and identification and that the Soviet Union was prepared to conclude an agreement on that basis. The delegation of the Soviet Union reiterated its willingness to participate in an international co-operative effort for the exchange of seismic data within the framework of a treaty banning underground nuclear tests if certain requirements were met (see CCD/PV.545, 557, 560, 561 and 577).

40. The delegation of the United States expressed the view that further progress towards restraints on testing was tied in closely with understanding and resolving the complex problem of verification, and stated that more work needed to be done with regard to still unresolved technical aspects (see CCD/PV.545).

41. The representative of Japan suggested that verification had become technically possible by solely seismological means, unless 100 per cent effectiveness was insisted upon (see CCD/PV.553).

42. The representative of Egypt stated that verification could be safely accomplished by national means complemented by an international exchange of seismic data and suggested that a comprehensive test ban provide for some form of verification by challenge (see CCD/PV.555).

43. The delegation of Bulgaria expressed the view that there was no need for on-site inspection to identify and locate nuclear explosions (see CCD/PV.556).

44. The delegation of Sweden stated that the main instrument for remote control, seismological monitoring had advanced so far that one could correctly identify a sufficiently large proportion of explosions so as to obtain an effective deterrence against attempts at clandestine testing (see CCD/PV.572).

45. The delegation of Pakistan stated that seismological means of detection, through national facilities and international co-operation and combined with verification by challenge, would constitute an effective method of verifying a comprehensive test ban (see CCD/PV.576).

46. The representative of the United Kingdom said (CCD/PV.559) agreement on the prohibition of underground testing would be effective only if parties could be assured that the prohibition was being observed. As a contribution to the further study needed on verification, he submitted a working paper on estimating yields of underground nuclear explosions from amplitudes of seismic signals (CCD/363/Rev.1).

47. The delegation of Canada expressed a desire to co-operate more closely with Japanese and other experts in seismological monitoring techniques (see CCD/PV.560).

48. The representative of Japan expressed the hope that the Committee would organize a series of meetings of experts to solve questions relating to the establishment of an international seismic network (see CCD/PV.562).

49. The representative of Yugoslavia (see CCD/PV.572), speaking in favour of an early cessation of all underground nuclear weapon tests, suggested that the Committee should take as a basic framework for discussion and negotiation the "Working paper suggesting possible provisions of a treaty banning underground nuclear weapon tests" submitted by Sweden and issued as document CCD/348.[4]

50. On 20 July 1972, the representatives of Canada, Japan and Sweden submitted a working paper on measures to improve tripartite co-operation by these countries in the detection, location and identification of underground nuclear explosions by seismological means (CCD/376).

51. On 25 July 1972, the representative of Canada submitted a working paper containing a bibliography of papers relevant to seismological verification problems (CCD/378).

52. On 27 July 1972, the representative of Sweden submitted as a Conference document a list of publications bearing on seismological discrimination of nuclear explosions and earthquakes (CCD/379).

53. On 27 July 1972, the representatives of Canada and Sweden submitted a working paper on international co-operation in short-period seismological discrimination of shallow earthquakes and underground nuclear explosions (CCD/380).

54. On 22 August 1972, the representative of the United Kingdom submitted a working paper (CCD/386) describing new data processing equipment for use by individual seismic stations in monitoring underground nuclear explosions. Such seismic array station processors could put States participating in the network proposed by the United Kingdom in 1970 in a better position to assess seismographic evidence for themselves and could result in appreciable reductions in cost (see CCD/PV.579).

55. The representative of the United States reiterated that his Government supported the achievement

[4] *Ibid.*, sect. 30.

of a comprehensive test ban treaty which was adequately verified. He explained why his Government believed that on-site inspections were necessary for adequate verification. He submitted and discussed a working paper (CCD/388) which reviews the progress made towards attaining research objectives outlined last year, describes the current status of the use of large seismic arrays for seismic identification and discusses United States plans regarding future research directed towards resolving important remaining problems (see CCD/PV.580 and 584).

Other measures

56. The subject of nuclear-weapon-free zones was also discussed.

57. On 14 March 1972, the representative of Mexico submitted a working paper listing Conference documents and statements by the Mexican delegation relating to the Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco)[5] (CCD/359). The representative recalled the appropriate General Assembly resolutions urging the nuclear weapon States that had not yet done so to sign and ratify Additional Protocol II of the Treaty. He discussed various points in connexion with that question and restated the interpretation of his Government of article 18 of the Treaty, which in his view, was shared by other States parties to the Treaty (see CCD/PV.551 and 553). Subsequently, the same representative specified which were the parties to the Treaty (see CCD/PV.554).

58. The representative of the Soviet Union expressed support for the creation of nuclear-weapon-free zones in different parts of the world and responded positively to Romania's proposal (see CCD/PV.550) to make the Balkans a nuclear-weapon-free zone. He commented on provisions of the Treaty for the Prohibition of Nuclear Weapons in Latin America (see CCD/PV.553 and 577).

59. The representatives of Argentina and Brazil reaffirmed the interpretation of their Governments of article 18 of the Treaty for the Prohibition of Nuclear Weapons in Latin America (see CCD/PV.554).

60. The delegation of Romania stated it attached particular importance to the establishment of nuclear-weapon-free zones and referred to its proposal to make the Balkan States a nuclear-weapon-free zone (see CCD/PV.559 and 574).

61. The delegations of Romania (see CCD/PV.550, 559 and 574), the Soviet Union (see CCD/PV.545 and 557) and Poland (see CCD/PV.551) expressed views on the importance of achieving agreement on the prohibition of the use of nuclear weapons.

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62. The delegation of Romania requested that the question of security guarantees for non-nuclear weapon States be examined and solved in an appropriate manner in disarmament negotiations (see CCD/PV.550, 559 and 574).

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63. The representative of Japan expressed the view that the Committee should promptly consider measures aimed at achieving the diversion of weapons-grade enriched uranium to peaceful purposes (see CCD/PV.547).

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64. The representatives of Romania (see CCD/PV.550 and 574) and the Soviet Union (see CCD/PV.577) called for the elimination of foreign military bases, particularly nuclear bases, and the ban on the creation of new such bases.

B. *Non-nuclear measures*

Question of chemical and bacteriological (biological) weapons

65. Having in mind the recommendations of General Assembly resolution 2827 (XXVI), the Conference continued its efforts to achieve progress on all aspects of the problem of the elimination of chemical weapons. Members of the Committee emphasized the importance and urgency which they attach to the prohibition of chemical weapons.

66. Possible steps for progress in this field were discussed in detail by members of the Committee in their statements in plenary.

67. On 21 March 1972, the delegation of the United States tabled a comprehensive work programme (CCD/360) which set forth detailed considerations concerning major categories of chemical agents and precursors as well as possible ways of defining those substances. The work programme also dealt with the questions of scope and verification and called attention to the relationship between these key elements of any convention prohibiting chemical weapons. Various means of verifying the observance of a convention as well as international consultative arrangements to review its implementation were discussed in the work programme. The delegation of the United States expressed the hope that its work programme would contribute to the essential work of exchanging ideas and studying intensively all the issues relating to possible prohibitions of chemical weapons (see CCD/PV.551).

68. On 28 March 1972, the delegations of Bulgaria, Czechoslovakia, Hungary, Mongolia, Poland, Romania and the USSR tabled a draft convention on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction, which proposed a comprehensive approach to the problem (CCD/361). These representatives stated that the draft convention provided for both national forms of control and international procedures, including the application to the Security Council and the conduct by it of investigations. They also stated that the draft contained provisions with regard to assistance to a State which might be exposed to a danger as a result of violation of the convention.

69. On behalf of the sponsors of the draft convention, the Soviet delegation expressed the hope that the draft would serve as a basis for a fruitful discussion, and proposed to begin concrete negotiations with a view to achieving an agreement on the comprehensive prohibition of chemical weapons (see CCD/PV.553, 557, 567 and 583).

70. Many delegations commented on this draft in their plenary statements.

71. The delegations of Morocco (see CCD/PV.555, and 581), Yugoslavia (see CCD/PV.569) and Egypt (see CCD/PV.572) expressed the view that the draft sub-

[5] United Nations, *Treaty Series*, vol. 634, No. 9068.

mitted by the socialist countries deserved careful consideration and made specific comments on that draft. The delegations of Sweden and Pakistan suggested amendments and additions to the draft convention of the socialist countries (see CCD/PV.569 and 571).

72. Several delegations expressed views with respect to the nature and scope of measures prohibiting chemical weapons.

73. The representative of Mexico underlined the importance of the close connexion expressly recognized by the General Assembly, between the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction[6] and negotiations regarding a chemical weapons agreement (see CCD/PV.545).

74. The delegations of Bulgaria, Czechoslovakia, Hungary, Mongolia, Poland, Romania and the USSR advocated a complete prohibition on the production, development and stockpiling of chemical weapons as weapons of mass destruction as set forth in their draft convention.

75. The representative of Poland, speaking in favour of a comprehensive prohibition, expressed the view that developing countries might not be concerned solely with prohibitions regarding highly toxic chemical agents, having in mind that the effectiveness of chemical weapons could depend to a great extent on the training and equipment facilities in the field of defence. He also stated that the extent of such facilities could have relevance to the question of the scope of the prohibition (see CCD/PV.551).

76. The representative of Yugoslavia expressed the view that the danger of chemical weapons did not solely depend on the degree of toxicity and other characteristics of particular chemical warfare agents, but also on the manner and conditions of their application, as well as on the degree of technical and medical protection of the country against which those chemical weapons might be used (see CCD/PV.569).

77. The delegations of Mexico (see CCD/PV.545), the Netherlands (see CCD/PV.552 and 572), Egypt (see CCD/PV.555 and 572), Sweden and Yugoslavia (see CCD/PV.569), Pakistan (see CCD/PV.571), Argentina and Canada (see CCD/PV.576) and Morocco (see CCD/PV.581) also spoke in favour of the comprehensive approach.

78. The representative of Italy, also examining the problem on the basis of a comprehensive approach, stressed the need of internationally adopted uniform criteria to be incorporated by all contracting States in their legislative provisions. In that connexion, he suggested that if the scope of prohibitions were defined in general terms, it would be necessary for the treaty to provide for the establishment of an international committee of experts to determine acceptable technical criteria for the identification of the agents to be banned and keep such criteria up to date. He also suggested that the Conference of the Committee on Disarmament should convene, during the current phase of negotiations, a temporary panel of experts for the elaboration of an annex to the treaty containing a first identification of the chemical agents to be banned (see CCD/PV.570).

79. The delegation of Nigeria expressed the view that one of the Committee's major problems concerned the scope of a chemical weapons ban and how to classify and identify the chemical agents to be banned (see CCD/PV.553).

80. The delegation of Brazil favoured the achievement as soon as possible of a comprehensive prohibition, but indicated its readiness to consider less ambitious alternatives if those seemed to be the only possible first steps. The delegation suggested that a comprehensive prohibition, in order to be equitable to all participants, could be implemented in two stages, facilitating the solution of problems of verification and control: the first stage would be the elimination of existing stockpiles, verified by direct international methods, with the cessation of production; and the second—in which indirect methods of verification might become politically acceptable—would be the prohibition of development and production. It also expressed the view that a chemical weapons agreement should not create any obstacles for the development, production and utilization of chemical agents for non-military purposes and that it should include provisions for the channelling to developing countries of a substantial portion of the derived savings (see CCD/PV.557 and 579).

81. The representative of the United Kingdom expressed the view that chemical agents covered by a ban should be carefully defined. He stated that the desired goal of his delegation was a comprehensive ban. He expressed the view that, as a method of proceeding, there could be advantage in isolating the easier problems and completing work on them first. He therefore wondered, having in mind the question of adequate verification, whether it would be possible to achieve the comprehensive objective in two stages: one, the elimination of stockpiles (with a freeze on production) and, the other, elimination of productive capacity. The question, he stated, was which stage should come first (see CCD PV.557 and 575).

82. The representative of the United States stated that his Government had not decided upon any preferred solution to the problem of chemical weapons control and suggested that the Committee consider carefully the characteristics of the substances and activities that might be prohibited (see CCD/PV.560 and 584).

83. The representative of Japan expressed the view that the Committee should examine carefully whether or not it was technically possible for any chemical agents available for weapons purposes to be prohibited outright without any hindrance to the peaceful uses of those agents (see CCD/PV.562).

84. The representative of the United States expressed the view that the question of definitions was central to an effective prohibition on chemical weapons. He submitted and discussed a United States working paper (CCD/365) which outlined how various criteria might apply to the principal known single-purpose and dual-purpose lethal agents and which highlighted the advantages and disadvantages of a number of possible criteria. He also expressed the view that comprehensive destruction of chemical agents and weapons would entail environmental and safety considerations for all involved and submitted a working paper (CCD/367) on the problem (see CCD/PV.561 and 584).

85. The delegations of Bulgaria, Czechoslovakia, Hungary, Mongolia, Poland, Romania and the USSR proposed the "purpose criterion", set forth in the draft convention (CCD/361), as an approach to the solution of the problem of the scope of prohibition. The Soviet delegation expressed the view that the "purpose

[6] General Assembly resolution 2826 (XXI), annex.

criterion" provided the most comprehensive scope of prohibition and covered all those types of chemical weapons which could fall outside the scope of prohibition if less general approaches were adopted. The delegation of Hungary expressed the hope that there could be a general agreement to define the substances prohibited in a chemical weapons ban in terms of the "purpose criterion", possibly supplemented, outside the text of the convention, by technical guidelines (see CCD/PV.567 and 577).

86. The delegation of Sweden stated that it favoured the use of the "purpose criterion" for the definition of the scope of the prohibition. It proposed to elaborate agreed interpretations in connexion with the definition of the scope of the prohibition which could be included in an annex (see CCD/PV.569).

87. The delegation of Pakistan commented on the issue of a "purpose criterion" (see CCD/PV.571).

88. The delegation of the Netherlands expressed the view that the definition of highly toxic chemical agents could be based on a "purpose criterion" in connexion with some technical guidelines, but expressed doubts about the use of this criterion with regard to dual-purpose agents (see CCD/PV.572).

89. The delegation of Egypt, in commenting on the purpose criterion, expressed the view, *inter alia*, that such criterion when formulated "exclusively" by describing the prohibited chemical agents as those which had no justification for peaceful purposes, reduced the risks of subjectivity in the definition, since the task of justification would rest mainly on objective technical and scientific grounds (*ibid.*).

90. The delegation of the United Kingdom expressed the view that while a general purpose criterion definition for the supertoxic agents would be necessary at some point it was not by itself sufficient and should be supplemented by technical definitions (see CCD/PV.575).

91. The representative of Argentina expressed the view that the security problems related to chemical weapons were more complex and covered more States than those connected with other weapons systems. He stated that his Government favoured wide prohibition of chemical weapons and stressed that the Committee must first solve the problems of the scope and verification of such a measure (see CCD/PV.576). He also commented on various proposals and documents relating to the scope and verification of a chemical weapons ban and suggested other provisions that might be included in such a ban (see CCD/PV.578).

92. The delegation of the Netherlands commented on the need for verification of the destruction of military stockpiles of chemical agents or of their diversion to peaceful uses. It also discussed the question of the monitoring of economic activity in connexion with verification and expressed the view that the possibility of inspections on or near the spot should be included in the framework of a complaints procedure (see CCD/PV.552, 560 and 572).

93. The delegation of Nigeria expressed the view that verification was one of the major problems with which the Committee must grapple in pursuing a chemical weapons ban (see CCD/PV.553).

94. The representative of Hungary expressed views (see CCD/PV.554) in support of the verification system stipulated in the draft convention on chemical weapons (CCD/361).

95. The delegation of Sweden, discussing possible national and international measures of verification, stated that an acceptable level of security must be ensured. The delegation expressed the view that the complaint formula of the bacteriological weapons convention was not a suitable precedent for a chemical weapons ban, since objective verification procedures should be available already before a matter was referred to the Security Council (see CDD/PV.549, 556 and 569).

96. The delegation of Japan expressed the view that the question of verification with regard to a ban on chemical weapons was far more important than in the case of biological weapons and discussed the utility of international measures of verification (see CCD/PV.559).

97. The representative of the United States stated that his Government welcomed further discussion on verification elements and that it had not decided at this stage which combination of elements might be necessary for an adequate verification system (see CCD/PV.560).

98. The representative of the United States discussed (see CCD/PV.561) a United States working paper on the difficulty of distinguishing storage of highly toxic chemical agents and weapons from the storage of other munitions and chemicals (CCD/366).

99. The representative of Poland stated that the most appropriate solution of the problem of guarantees of the observance of the convention prohibiting chemical weapons consisted of national means of verification.

100. He stated that he favoured a general formula concerning the scope of the prohibition on chemical weapons, expressing the view that such a formula would be consistent with the provisions of the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or other Gases, and of Bacteriological Methods of Warfare,[7] signed at Geneva in 1925. He also expressed the view that detailed technical definitions might be of particular importance when partial solutions were sought (see CCD/PV.565). The representative of Mongolia expressed similar views on this problem (see CCD/PV.571).

101. The delegation of Czechoslovakia expressed views on the complexity and difficulty of international on-site inspection (see CCD/PV.567).

102. The representative of the Soviet Union stated that the interrelationship between military and peaceful production of chemical agents made a system of international controls practically impossible and that there should be a reasonable combination of national and international forms of control as set forth in the draft convention of the socialist countries (CCD/361). He put forward some specific considerations with regard to practical implementation of national forms of control (see CCD/PV.567 and 583). Interest in these considerations was expressed by the delegations of Sweden (see CCD/PV.569), the Netherlands and Bulgaria (see CCD/PV.572).

103. The representative of Yugoslavia stated that any system of control must be based on a considerable degree of mutual confidence, on an appropriate combination of national and international measures of control, and in particular on self-control of States and wide international co-operation (see CCD/PV.569).

[7] League of Nations, *Treaty Series*, vol. XCIV, No. 2138.

104. The representative of Italy commented on his working papers CCD/335 of 8 July 1971[8] and CCD/373 of 21 July 1972. Pointing out that controls were also intended to ensure the effective and complete destruction of stocks, as an essential part of the treaty, he expressed the view that specific forms of international direct controls should receive careful attention for inclusion in a treaty (see CCD/PV.570).

105. The representative of Egypt stated that verification by international means should be made more readily available to the developing countries and that the Committee should address itself to the question of security guarantees and sanctions against violations of a chemical weapons ban (see CCD/PV.572).

106. The representative of the United Kingdom stated that there should be a strict proportion between the scope of the prohibitions in an agreement and the means of verification. He expressed the view that one should either accept the need for international on-site inspection with all the practical and political problems involved or decide what measures might be agreed without the assurances such inspection could provide (see CCD/PV.557 and 575).

107. Several delegations also discussed the role of an international body of experts in relation to the question of verification. A number of delegations expressed a preference for dividing the process of verification into two distinct phases, separating fact-finding from political decisions.

108. Working papers on the following questions were submitted to the Committee: definitions of controlled substances (United States, CCD/365); storage of chemical agents and weapons (United States, CCD/366); the destruction of chemical weapons (United States, CCD/367); statistics relating to production and trade of certain chemical substances in the United States (United States, CCD/368); United States domestic legislation regarding chemical substances (United States, CCD/369); remote detection of chemical weapon field tests (United Kingdom, CCD/371); two groups of chemical agents of warfare (Sweden, CCD/372); identification and classification of chemical agents and some aspects of the problem of verification (Italy, CCD/373); the question of a criterion to be used to characterize supertoxic chemical agents (Japan, CCD/374); some aspects of the definition, classification and prohibition of chemical agents (Yugoslavia, CCD/375); elements of a system for the control of the complete prohibition of chemical weapons (Yugoslavia, CCD/377); definitions of chemical warfare agents and technical possibilities for verification and control of chemical weapons (Finland, CCD/381); the possibility of delimitating nerve gases within the field of organophosphorus compounds (Netherlands, CCD/383); domestic legislation in Sweden regarding chemical substances (Sweden, CCD/384); toxicity of chemical substances, methods of estimation and applications to a chemical control agreement (Canada, CCD/387).

109. At the request of Italy and Sweden, informal meetings, in which technical experts from nine Member States participated, were held on 5 and 6 July 1972.

110. A fruitful discussion took place concerning various aspects of the question of defining the chemical agents to be covered by future chemical prohibitions. The discussion left the Committee in a better position to determine the usefulness of various criteria, including definitions based on general purpose, toxicity levels, chemical structural formulae and lists of substances.

111. The informal meetings also helped the Committee to acquire further background on various technical verification methods which might be applied to various categories of chemical agents. There was also a useful discussion of the utility of national and international methods of verification as well as of the adequacy of national methods for countries having different capabilities in this regard. The possible use in a verification system of trade data, declarations of activities and facilities and of other data exchanges was also considered. There was also discussion of the environmental and other aspects of the destruction of chemical agents and of practical questions regarding peaceful applications of certain agents.

112. The members of the Committee found the informal meetings of great value in promoting their work on the question of prohibitions regarding chemical weapons and shared the view that these technical exchanges would contribute to the implementation and effectiveness of any convention on controlling chemical weapons.

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113. The representative of the United States urged the Committee to begin the serious examination of the possibility of arms control measures related to conventional weapons (see CCD/PV.545 and 584).

114. The delegation of the Netherlands expressed its willingness to participate in the common search for practical measures in the field of conventional arms control (see CCD/PV.552).

115. The representative of Romania expressed support, also, for the examination of the problems of conventional disarmament, as part of the efforts towards general disarmament (see CCD/PV.550 and 574).

C. *Other collateral measures*

116. The delegations of the Soviet Union (see CCD/PV.545), Poland (see CCD/PV.552) and Czechoslovakia (see CCD/PV.567) called for further measures to achieve demilitarization of the sea-bed.

117. The delegations of Romania (see CCD/PV.550 and 574), Poland (see CCD/PV.551), Hungary (see CCD/PV.554), the Soviet Union and Czechoslovakia (see CCD/PV.561) expressed support for the convening of a conference on the question of European security and co-operation.

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118. The representative of Japan stated that Japan was prepared to extend positive co-operation in efforts towards regional disarmament (see CCD/PV.547).

119. The delegation of Romania advocated, also, the adoption of measures aimed at military disengagement and regional disarmament in Europe (see CCD/PV.550 and 574).

D. *Question of general and complete disarmament*

120. Taking into account General Assembly resolution 2825 B (XXVI), the Committee continued its discussion regarding the question of general and complete disarmament.

[8] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234, annex C, sect. 17.

121. The representative of the United Kingdom considered that the Committee, while recognizing the goal of general and complete disarmament, should continue to seek realistic ways to increase security for all nations and to save scarce resources (see CCD/PV.546).

122. The representative of Italy, in reaffirming the interest of his delegation in the formulation of a comprehensive programme, suggested the establishment of a working group to identify the points of agreement and disagreement revealed by the various documents submitted on general and complete disarmament between 1962 and the Committee's last session, with a view to the formulation in an agreed text of some basic principles likely to promote a discussion on the subject among all members of the international community (see CCD/PV.547).

123. The delegation of Romania reiterated its support for the objective of general disarmament and suggested the beginning of concrete negotiations for a draft treaty on general disarmament (see CCD/PV.550 and 574).

124. The representative of Poland cited various measures related to general and complete disarmament which he suggested the Committee consider (see CCD/PV.551).

125. The representative of the Netherlands expressed views on the ultimate goal of general and complete disarmament (see CCD/PV.552).

126. The representative of Mexico stated that the application of savings from disarmament to the raising of the living standards of the "third world" had become an appropriate topic for consideration by the United Nations (see CCD/PV.565).

127. The delegation of Czechoslovakia expressed the view that it was urgent to achieve progress in general and complete disarmament (see CCD/PV.567).

128. The delegation of the USSR reiterated its view that general and complete disarmament was the main final goal of all efforts in the field of disarmament (see CCD/PV.578).

* * * *

Question of a world disarmament conference

129. The Committee also devoted attention to the question of a world disarmament conference.

130. The representative of the Soviet Union expressed the view that conditions were now ripe for holding a world disarmament conference, open to all States, which could play an important role in unifying and stepping up the efforts of all States to bring about a successful solution of disarmament problems. He set forth specific considerations concerning the main aims of such a conference, its agenda, duration and place, preparations and relationship to the United Nations.

131. He stressed that the holding of a world disarmament conference must not reduce in any way the importance of the other disarmament negotiations, including those within the Committee (see CCD/PV.545, 560, 561 and 578).

132. The representative of Mexico expressed the view that one of the most important resolutions adopted by the General Assembly at its last session was resolution 2833 (XXVI) which, he stated, was intended to pave the way for a world disarmament conference, and he recalled the main provisions of that resolution (see CCD/PV.545).

133. The representative of Czechoslovakia expressed the view that a world disarmament conference should be open to all States and that all nuclear Powers should participate in its preparation (see CCD/PV.567).

134. The delegation of Romania reiterated its advocacy of the convening of a world disarmament conference and stated that the conference should cover all aspects with priority attention to nuclear disarmament (see CCD/PV.550 and 574).

135. The representative of the Netherlands expressed the view that a world disarmament conference would not be able to take the place of a limited negotiating forum (see CCD/PV.552).

136. The representative of Mongolia expressed support for the convening of a world disarmament conference and stated that that did not prejudice the role of the Committee (see CCD/PV.552 and 571).

137. The delegation of Nigeria expressed agreement in principle with the idea of a world disarmament conference and stated it should not become a forum to replace the Committee (see CCD/PV.553).

138. The representative of Hungary suggested that the Committee could play a positive role in preparation for a world disarmament conference and that all States should participate in such a conference (see CCD/PV.554).

139. The delegation of Egypt reaffirmed its support of General Assembly resolution 2833 (XXVI) calling for a world disarmament conference (see CCD/PV.555).

140. The representative of Bulgaria expressed the view that a world disarmament conference would concert the efforts of all countries in the spirit of General Assembly resolution 2833 (XXVI). He also expressed the view that conditions were ripe for convening such a conference within one or two years and commented on its preparations, participants and agenda (see CCD/PV.556 and 580).

141. The representative of the United States expressed scepticism about the value of a world disarmament conference at that time and raised questions concerning its need and likely results (see CCD/PV.560).

142. The representative of Japan stressed that the participation of all nuclear weapon States was an indispensable condition for the convening of a world disarmament conference and that such a conference should not prejudice the activities of the Committee (see CCD/PV.562).

143. The delegation of Canada stated that it looked to the permanent members of the Security Council to reach a consensus on an approach to a world disarmament conference (see CCD/PV.571).

144. The representative of Yugoslavia expressed the view that a world disarmament conference was indispensable and stated that the conference should establish a programme of action leading to the ultimate goal of general and complete disarmament (see CCD/PV.572).

145. On 27 July 1972, the representative of Mexico submitted as a working paper a memorandum containing his Government's views on the convening of a world disarmament conference (CCD/382).

146. The representative of Poland stated that a world disarmament conference should be held in 1974

to consider all aspects of disarmament and that such a conference would not undermine the role of the Committee. He expressed the view that the time was now ripe for a world disarmament conference to analyse past disarmament achievements and provide stimulus for the future. The conference should be attended by all nuclear weapon States and other militarily significant countries. A preparatory committee of 30 to 40 countries, including all nuclear weapon States and based on a proper geographic representation, could be set up (see CCD/PV.575).

147. The representative of Sweden stated that her Government favoured the convening of a world disarmament conference provided that the principle of universality was applied for the invitations, that the attendance of the permanent members of the Security Council was assured and that the conference was well prepared for (see CCD/PV.576).

148. The representative of Mexico expressed the view (see CCD/PV.580) that the main objective of the world disarmament conference should be to develop the possibility of effective action by the United Nations in the sphere of disarmament by supplementing existing international machinery through the addition of an organ open to all States, which would meet for two to three months every third or fourth year and would play in this sphere a role similar to that of the United Nations Conference on Trade and Development in economic and social questions. He suggested that the "comprehensive programme of disarmament" presented to the Committee in 1970 by Mexico, Sweden and Yugoslavia[9] could serve as the basis for the provisional agenda for the world disarmament conference.

149. The representative of Morocco stated that his Government would be in favour of the convening of a world disarmament conference for which adequate preparations had been made. He expressed views on the objectives, agenda, timing, location and duration of such a conference (see CCD/PV.581).

Question of the Committee's organization and procedures

150. During both of its sessions in 1972, members of the Committee discussed the question of its organization and procedures.

151. Many members of the Committee referred in their statements in plenary to the question of the Committee's organization and procedures.

152. The representative of Mexico stated that it was now timely to begin considering changes that would have to be made in the Committee. He suggested that the Committee express its readiness to increase its membership at the earliest possible moment in a manner satisfactory to all. He stated that the Committee should study what changes should be made in its procedures in order to give a better chance of enlisting the participation of all nuclear weapon States. The representative of Mexico also expressed the view that the Committee's co-chairmanship should be replaced with a system providing for an annually elected chairman or for the monthly rotation of the chairmanship (see CCD/PPV.545, 575 and 580).

153. The representative of the United States stated that his Government would welcome the participation of all nuclear weapon States in arms control and disarmament efforts in a manner satisfactory to all those States and reflecting the interests and concerns as well of the non-nuclear weapon States. He also stated that the United States attached importance to the maintenance of an effective, expert and experienced body of reasonably limited size for the purpose of multilateral arms control and disarmament negotiations (see CCD/PV.545).

154. The representative of the United Kingdom hoped that in the course of time all nuclear weapon States would consider it in their interest as well as the Committee's to join in disarmament negotiations. The Committee should continue substantially as then constituted until agreed changes would bring about the expansion desired (see CCD/PV.546).

155. The delegation of Italy expressed views set forth in working paper CCD/389 on the reorganization of negotiating structures.

156. The delegation of Yugoslavia stated that the Committee should examine without delay certain procedural, administrative and organizational questions concerning the work of the Committee to make it better able to satisfy existing requirements. He expressed the view that the Committee should address itself to the questions of establishing a precise agenda, creating working groups, facilitating contributions by non-member States, discontinuing the co-chairmanship system and appointing a rapporteur (see CCD/PV.548).

157. The representative of Bulgaria expressed the hope that any changes in the Committee would reaffirm its responsibility for disarmament negotiations, broaden its outlook and increase its productivity (see CCD/PV.549).

158. The representative of Czechoslovakia stated that his Government favoured the participation of all nuclear weapon States in the Committee but was opposed to any hurried or unstudied action concerning the Committee's organization which might jeopardize the positive aspects of the Committee (see CCD/PV.550).

159. The representative of Romania called for the improvement of the organization and procedures of the Committee with a view to ensuring the effectiveness of the negotiations on disarmament, the democratization of the Committee's activity and its submission to effective public control. He put forward a number of suggestions to that effect and stated that appropriate conditions should be created to enable all interested States to take part in disarmament negotiations (*ibid.*).

160. The representative of Poland expressed the view that the Committee had proved to be an appropriate and effective negotiating body and that its composition reflected in principle various political trends in a balanced manner. He stressed, however, the desirability of the participation of all nuclear weapon States in the work of the Committee and in disarmament efforts in general (see CCD/PV.551).

161. The delegation of India expressed the view that the cause of disarmament would receive a setback if the work of the Conference of the Committee on Disarmament were disrupted. It said that it would be difficult, if not impossible, to hold meaningful disarmament discussions if a proven forum were to be destroyed or changes made in it on the basis of preconceived expectations and wishful anticipation (see CCD/PV.552).

[9] *Ibid., Supplement for 1970,* document DC/233, annex C, sect. 42.

162. The representative of the Netherlands expressed the hope that in the course of time all nuclear weapon States would join in disarmament negotiations. He further stated that the Netherlands would be prepared to consider changes in the structure of the Committee if that might contribute to an improvement in the credibility and acceptability of the Committee (*ibid.*).

163. The representative of Mongolia stated that the Committee needed more time to find the best possible solution to organizational problems, and expressed the view that all militarily important States should take an active part in disarmament efforts (*ibid.*).

164. The representative of Nigeria stated that any enlargement of the Committee should be limited and that consideration should be given to the participation of all nuclear weapon States and other major military States. He suggested several procedural changes including the establishment of a definite calendar for the Committee's work (see CCD/PV.553).

165. The delegation of Hungary stated that the Committee's existing structure had never prevented it from carrying out constructive negotiations and reaching mutually acceptable agreements (see CCD/PV.554).

166. The representative of Morocco expressed the view that the non-participation of additional nuclear weapon States was not due to the structure of the Committee and that nothing should be done to force the issue of their participation (see CCD/PV.555 and 581).

167. The delegation of Brazil stated that changes of a methodological or procedural nature were less important than the achievement of effective measures of nuclear disarmament. Such an achievement would contribute to attracting all nuclear weapon States to disarmament negotiations. Dealing with the question of the reorganization of the Committee as an aim in itself, the delegation of Brazil expressed the view that the practice of the co-chairmanship should be discontinued and replaced by a procedure such as the election of an annual chairman who, among other duties, would be responsible for the preparation of the draft of the annual report (see CCD/PV.557).

168. The representative of the Soviet Union stated that the question of the Committee's procedures and organization should be approached with care and expressed his Government's view that all States possessing substantial armed forces, particularly those having nuclear weapons, should participate in disarmament negotiations (see CCD/PV.560).

169. The representative of Canada stated that his Government had long urged the participation of all the principal Powers in disarmament efforts and suggested ways of achieving this goal. He expressed the view that the Committee possessed the characteristics necessary to function as an effective multilateral body for disarmament negotiations. He also suggested that the permanent members of the United Nations Security Council should consult on ways to halt the arms race (see CCD/PV.571 and 581).

170. The representative of Mexico reaffirmed his Government's views on the question of increasing the Committee's membership so as to include all the nuclear weapon States and on the question of changing the system of having co-chairmen. He also reiterated his view that such changes were necessary if the Conference of the Committee on Disarmament were to play a role in preparatory work for a world disarmament conference as his Government had proposed. He expressed the view that the Committee, in preparing its annual report, should follow a procedure analogous to that followed by the Sixth Committee of the General Assembly, which enables the Secretariat to provide that Committee with valuable assistance, and that the Committee should adopt an annual calendar of meetings which would remain flexible but ensure a modicum of stability in the timing of the beginning and end of its sessions, such as by fixing the second or third Tuesday in February for the opening of the annual session and the last Thursday in August for its closing (see CCD/PV.575, 580 and 582).

171. The representative of Mexico also expressed the view that the negotiating body on disarmament should continue to work within the framework of the United Nations General Assembly, and independently of the Security Council, to avoid restricting the negotiating body's scope of action (see CCD/PV.580).

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172. On 8 August 1972, the representative of Mexico submitted a working paper (CCD/385) containing a subject index of opinions expressed on this question during the Committee's 1972 session (545th to 574th meetings) and on 28 August 1972 he also submitted a working paper (CCD/390) containing a list of statements made on this question at the Committee's plenary meetings from 29 February 1972 to 24 August 1972 (545th to 580th meetings).

173. At the request of the representative of Mexico, informal meetings were held on 16 and 17 August 1972 in order to discuss this question and a full and useful exchange of views took place. Views on possible changes in the Committee's organization and procedures were discussed. As a result of the exchange of views at the informal meetings, it became apparent that the participation of all of the nuclear weapon States in multilateral disarmament negotiations would be welcomed. The view was expressed that appropriate measures should be worked out, when advisable, to facilitate such participation. Some members of the Committee expressed the intention of holding informal consultations on that question with the States concerned.

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174. The Committee agreed to reconvene on a day to be established by the Co-Chairmen in consultation with all members of the Committee.

175. This report is transmitted by the Co-Chairmen on behalf of the Conference of the Committee on Disarmament.

(*Signed*) A. A. ROSHCHIN
Union of Soviet Socialist Republics

Joseph MARTIN Jr.
United States of America

ANNEX A

List of documents issued by the Conference of the Committee on Disarmament*

On 18 February 1972, the Secretary-General of the United Nations transmitted to the Co-Chairmen a letter containing the resolutions on disarmament adopted by the General Assembly at its twenty-sixth session (CCD/357).

On 2 March 1972, the representative of Mexico submitted as a Conference document the joint communiqué on the establishment of diplomatic relations between the United States of Mexico and the People's Republic of China (CCD/358).

On 14 March 1972, the representative of Mexico submitted a working paper listing Conference documents and statements by the Mexican delegation relating to the Treaty for the Prohibition of Nuclear Weapons in Latin America (CCD/359).

On 20 March 1972, the representative of the United States of America submitted a work programme regarding negotiations on the prohibition of chemical weapons (CCD/360).

On 28 March 1972, the representatives of Bulgaria, Czechoslovakia, Hungary, Mongolia, Poland, Romania, and the Union of Soviet Socialist Republics submitted a draft convention on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction (CCD/361).

On 6 April 1972, the representative of the Union of Soviet Socialist Republics submitted a letter to the Special Representative of the Secretary-General of the United Nations (CCD/362).

On 25 April 1972, the representative of the United Kingdom submitted a working paper on estimating yields of underground explosions from amplitudes of seismic signals (CCD/363/Rev.1).

On 20 June 1972, the Special Representative of the Secretary-General of the United Nations submitted as a Conference document a message from the Prime Ministers of Australia and New Zealand to the Co-Chairmen concerning the imminent series of atmospheric tests of nuclear weapons in the South Pacific (CCD/364).

On 20 June 1972, the representative of the United States of America submitted Working Papers on definitions of controlled substances (CCD/365), storage of chemical agents and weapons (CCD/366), the destruction of chemical weapons (CCD/367), statistics relating to production and trade of certain chemical substances in the United States (CCD/368), and on United States domestic legislation regarding chemical substances (CCD/369).

On 20 June 1972, the Special Representative of the Secretary-General of the United Nations submitted as a Conference document a letter from the Permanent Representative of Peru concerning the series of atmospheric nuclear weapons tests in the Pacific (CCD/370).

On 27 June 1972, the representative of the United Kingdom submitted a working paper on remote detection of chemical weapon field tests (CCD/371).

On 28 June 1972, the representative of Sweden submitted a working paper on two groups of chemical agents of warfare (CCD/372).

On 29 June 1972, the representative of Italy submitted a working paper on identification and classification of chemical warfare agents and on some aspects of the problem of verification (CCD/373).

On 5 July 1972, the representative of Japan submitted a working paper on the question of a criterion to be used to characterize supertoxic chemical agents (CCD/374).

On 5 July 1972, the representative of Yugoslavia submitted a working paper on some aspects of the definition, classification and prohibition of chemical agents (CCD/375).

On 20 July 1972, the representatives of Canada, Japan and Sweden submitted a working paper on measures to improve tripartite co-operation in the detection, location and identification of underground nuclear explosions by seismological means (CCD/376).

On 20 July 1972, the representative of Yugoslavia submitted a working paper on the elements of a system for the control of the complete prohibition of chemical weapons (CCD/377).

On 25 July 1972, the representative of Canada submitted a working paper containing a bibliography of papers relevant to seismological verification problems (CCD/378).

On 27 July 1972, the representative of Sweden submitted as a Conference document a list of publications bearing on seismological discrimination of nuclear explosions and earthquakes (CCD/379).

On 27 July 1972, the representatives of Canada and Sweden submitted a working paper on international co-operation in short-period seismological discrimination of shallow earthquakes and underground nuclear explosions (CDD/380).

On 27 July 1972, the Special Representative of the Secretary-General of the United Nations submitted a working paper by the Government of Finland on definitions of chemical warfare agents and on technical possibilities for verification and control of chemical weapons (CCD/381).

On 27 July 1972, the representative of Mexico submitted as a working paper a memorandum containing the opinion of the Government of Mexico on the convening of a world disarmament conference (CCD/382).

On 1 August 1972, the representative of the Netherlands submitted a working paper on the possibility of delimitating nerve gases within the field of organophosporus compounds (CCD/383).

On 8 August 1972, the representative of Sweden submitted a working paper on domestic legislation in Sweden regarding chemical substances (CCD/384).

On 8 August 1972, the representative of Mexico submitted a working paper containing a subject index of opinions expressed from 29 February to 3 August 1972 on the question of the reorganization of the Conference of the Committee on Disarmament (CCD/385).

On 22 August 1972, the representative of the United Kingdom submitted a working paper on seismic data handling and analysis for a comprehensive test ban (CCD/386).

On 24 August 1972, the representative of Canada submitted a working paper on the toxicity of chemical substances, methods of estimation and applications to a chemical control agreement (CCD/387).

On 24 August 1972, the representative of the United States submitted a working paper reviewing current progress and problems in seismic verification (CCD/388).

On 28 August 1972, the representative of Italy submitted a working paper on the problem of reorganization of the negotiating structures in the disarmament field (CCD/389).

* With the exception of document CCD/362, all the documents listed are printed in annex B.

On 28 August 1972, the representative of Mexico submitted a working paper containing a list of statements dealing with reorganization of the Conference of the Committee on Disarmament which were made at formal meetings of the Conference between 29 February and 24 August 1972 (CCD/390).

ANNEX B

Documents of the Conference of the Committee on Disarmament annexed to the report

Section	Title	Document No.
1.	Letter dated 18 February 1972 from the Secretary-General of the United Nations to the Co-Chairmen of the Conference of the Committee on Disarmament transmitting the resolutions on disarmament adopted by the General Assembly at its twenty-sixth session	CCD/357
2.	Mexico: letter dated 2 March 1972 from the representative of Mexico to the Special Representative of the Secretary-General of the United Nations to the Conference	CCD/358
3.	Mexico: working paper containing a list of the documents of the Conference of the Committee on Disarmament relating to the Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco) and of the statements by the Mexican delegation dealing with that Treaty	CCD/359
4.	United States of America: work programme regarding negotiations on prohibition of chemical weapons	CCD/360
5.	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	CCD/361
6.	United Kingdom of Great Britain and Northern Ireland: working paper on seismic yields of underground explosions—estimating yields of underground explosions from amplitudes of seismic signals	CCD/363/Rev.1
7.	Letter dated 20 June 1972 from the representatives of Australia and New Zealand to the Special Representative of the Secretary-General of the United Nations to the Conference	CCD/364
8.	United States of America: working paper on definitions of controlled substances	CCD/365
9.	United States of America: working paper on storage of chemical agents and weapons	CCD/366
10.	United States of America: working paper on the destruction of chemical weapons	CCD/367
11.	United States of America: working paper on statistics relating to production and trade of certain chemical substances in the United States	CCD/368
12.	United States of America: working paper on United States domestic legislation regarding chemical substances	CCD/369
13.	Letter dated 14 June 1972 from the representative of Peru to the Special Representative of the Secretary-General of the United Nations to the Conference	CCD/370
14.	United Kingdom of Great Britain and Northern Ireland: working paper on remote detection of chemical weapon field tests	CCD/371
15.	Sweden: working paper on two groups of chemical agents of warfare	CCD/372
16.	Italy: working paper on identification and classification of chemical warfare agents and on some aspects of the problem of verification	CCD/373
17.	Japan: working paper on the question of a criterion to be used to characterize supertoxic chemical agents	CCD/374
18.	Yugoslavia: working paper on some aspects of the definition, classification and prohibition of chemical agents	CCD/375
19.	Canada, Japan and Sweden: working paper on measures to improve tripartite co-operation among Canada, Japan and Sweden in the detection, location and identification of underground nuclear explosions by seismological means	CCD/376
20.	Yugoslavia: working paper on the elements of a system for the control of the complete prohibition of chemical weapons	CCD/377
21.	Canada: working paper containing bibliography of Department of Energy, Mines and Resources papers relevant to seismological verification problems	CCD/378
22.	Sweden: list of publications bearing on seismological discrimination of nuclear explosions and earthquakes and available from the Research Institute of National Defence, Stockholm	CCD/379
23.	Canada and Sweden: working paper on an experiment in international co-operation: short-period seismological discrimination of shallow earthquakes and underground nuclear explosions	CCD/380
24.	Letter dated 21 July 1972 from the representative of Finland to the Special Representative of the Secretary-General of the United Nations to the Conference	CCD/381
25.	Mexico: letter dated 25 July 1972 from the representative of Mexico to the Special Representative of the Secretary-General of the United Nations to the Conference	CCD/382
26.	The Netherlands: working paper on the possibility of delimitating nerve gases within the field of organophosphorus compounds	CCD/383
27.	Sweden: working paper on domestic legislation in Sweden regarding chemical substances	CCD/384
28.	Mexico: working paper containing a subject index of opinions expressed on the question of the reorganization of the Conference of the Committee on Disarmament during its meetings held from 29 February to 3 August 1972	CCD/385

Section	Title	Document No.
29.	United Kingdom of Great Britain and Northern Ireland: working paper on seismic data handling and analysis for a comprehensive test ban	CCD/386
30.	Canada: working paper on toxicity of chemical substances, methods of estimation and applications to a chemical control agreement	CCD/387
31.	United States of America: a review of current progress and problems in seismic verification	CCD/388
32.	Italy: working paper on the problem of reorganization of the negotiating structures in the disarmament field	CCD/389
33.	Mexico: working paper containing a list of statements dealing with reorganization of the Conference of the Committee on Disarmament which were made at formal meetings of the Conference between 29 February and 24 August 1972	CCD/390

1.

Letter dated 18 February 1972 from the Secretary-General of the United Nations to the Co-Chairmen of the Conference of the Committee on Disarmament transmitting the resolutions on disarmament adopted by the General Assembly at its twenty-sixth session

[*CCD/357 of 29 February 1972*]
[*Original: English*]

I have the honour to transmit herewith the following resolutions adopted by the General Assembly at its twenty-sixth session entrusting specific responsibilities to the Conference of the Committee on Disarmament or otherwise dealing with disarmament negotiations: resolution 2825 B (XXVI), entitled "General and complete disarmament", resolution 2827 A (XXVI), entitled "Question of chemical and bacteriological (biological) weapons", resolution 2828 C (XXVI), entitled "Urgent need for suspension of nuclear and thermonuclear tests" and resolution 2831 (XXVI), entitled "Economic and social consequences of the armaments race and its extremely harmful effects on world peace and security".

I wish to draw particular attention to the following provisions contained in the resolutions listed above.

In resolution 2825 B (XXVI), the Assembly, in paragraphs 2 and 3, urges the Conference, at its forthcoming session, to resume its efforts on the question of general and complete disarmament along the lines set forth in resolution 2661 C (XXV), and requests the Conference to report to the General Assembly at its twenty-seventh session on the results of those efforts.

In resolution 2827 A (XXVI), the Assembly, in paragraph 2, requests the Conference to continue, as a high priority item, negotiations with a view to reaching early agreement on effective measures for the prohibition of the development, production and stockpiling of chemical weapons and for their elimination from the arsenals of all States; in paragraph 3, it requests the Conference to take into account in its further work: (*a*) the elements contained in the joint memorandum on the prohibition of the development, production and stockpiling of chemical weapons and on their destruction, submitted on 28 September 1971 to the Conference by Argentina, Brazil, Burma, Egypt, Ethiopia, India, Mexico, Morocco, Nigeria, Pakistan, Sweden and Yugoslavia;[10] and (*b*) other proposals, suggestions, working papers and expert views put forward in the Conference and in the First Committee of the General Assembly; and in paragraph 7, it requests the Conference to submit a report on the results achieved to the General Assembly at its twenty-seventh session.

In resolution 2828 C (XXVI), the Assembly, in paragraph 5, requests the Conference to continue as a matter of highest priority its deliberations on a treaty banning underground nuclear weapon tests, taking into account the suggestions already made in the Conference, as well as the views expressed at the twenty-sixth session of the General Assembly; in paragraph 6, it requests particularly Governments that have been carrying out nuclear tests to take an active and constructive part in developing, in the Conference, specific proposals for an underground test ban treaty.

In resolution 2831 (XXVI), the Assembly in paragraph 5, recommends that the conclusions of the Secretary-General's report on the economic and social consequences of the arms race and of military expenditures[11] be taken into account in future disarmament negotiations.

In resolution 2827 A (XXVI), the Assembly, in paragraph 8, requests the Secretary-General to transmit to the Conference all documents and records of the First Committee relating to questions connected with the problems of chemical and bacteriological (biological) methods of warfare. The relevant documents and records are the following: A/8457,[12] A/8574 and the draft resolutions contained in that document[13] and the records of the 1827th to 1842nd, 1846th and 1847th meetings of the First Committee (A/C.1/PV.1827-1842, 1846 and 1847). All these documents and records were distributed during the twenty-sixth session of the General Assembly to all Members of the United Nations including all members of the Conference.

I also have the honour to transmit herewith, for the information of the members of the Conference, the following resolutions adopted by the General Assembly at its twenty-sixth session which deal with disarmament matters: resolution 2825 A (XXVI) and resolution 2825 C (XXVI) entitled "General and complete disarmament", resolution 2826 (XXVI), entitled "Convention on the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction", resolution 2827 B (XXVI), entitled "Question of chemical and bacteriological (biological) weapons", resolutions 2828 A (XXVI) and 2828 B (XXVI), entitled "Urgent need for suspension of nuclear and thermonuclear tests", resolution 2829 (XXVI), entitled "Establishment, within the framework of the International Atomic Energy Agency, of an international service for nuclear explosions for peaceful purposes under appropriate international control", resolution 2830 (XXVI), entitled "Status of the implementation of General Assembly resolution 2666 (XXV) concerning the signature and ratification of Additional Protocol II of the Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco)", resolution 2832 (XXVI), entitled "Declaration of the Indian Ocean as a zone of peace" and resolution 2833 (XXVI), entitled "World Disarmament Conference".

I also wish to refer, for the information of the Conference, to General Assembly resolutions 2852 (XXVI) and 2880 (XXVI). In resolution 2852 (XXVI) on "Respect for human rights in armed conflicts", paragraph 5, the Assembly requested the Secretary-General, in line with paragraph 126 of his report on respect for human rights in armed conflicts, "to prepare as soon as possible, with the help of qualified governmental consultant experts, a report on napalm and other incendiary weapons and all aspects of their possible use". In resolution

[10] See *Ibid., Supplement for 1971*, document DC/234, annex C, sect. 33.

[11] United Nations publication, Sales No. E.72.IX.16.

[12] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234.

[13] See *Official Records of the General Assembly, Twenty-sixth Session, Annexes*, agenda items 26, 27, 30, 31, 32, 33 and 34.

2880 (XXVI), on "Implementation of the Declaratiton on the Strengthening of International Security", paragraph 8, the Assembly affirmed *inter alia*, 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 developing countries".

[*For the text of resolutions 2825 (XXVI), 2826 (XXVI), 2827 (XXVI), 2828 (XXVI), 2829 (XXVI), 2830 (XXVI), 2831 (XXVI), 2832 (XXVI), and 2833 (XXVI), see* Official Records of the General Assembly, Twenty-sixth Session, Supplement No. 29.]

2.

Mexico: letter dated 2 March 1972 from the representative of Mexico to the Special Representative of the Secretary-General of the United Nations to the Conference

[*CCD/358 of 2 March 1972*]
[*Original: Spanish*]

I request you to reproduce as a document of the Conference of the Committee on Disarmament the joint communiqué on the establishment of diplomatic relations between the United States of Mexico and the People's Republic of China, signed in New York on 14 February 1972, in virtue whereof that document contains a declaration by the Chinese Government on nuclear-weapon-free zones, and specifically on the zone established by the Treaty for the Prohibition of Nuclear Weapons in Latin America[14] (Treaty of Tlatelolco) which, as you know, is one of the subjects on the agenda of the Conference.

(*Signed*) Alfonso García ROBLES
Chairman of the Mexican Delegation to the Committee on Disarmament

[14] United Nations, *Treaty Series*, vol. 634, No. 9068.

JOINT COMMUNIQUÉ ON THE ESTABLISHMENT OF DIPLOMATIC RELATIONS BETWEEN THE UNITED STATES OF MEXICO AND THE PEOPLE'S REPUBLIC OF CHINA

The permanent representatives of the United States of Mexico and of the People's Republic of China to the United Nations, as a result of negotiations carried out with due authorization from their respective Governments, have agreed upon the following:

1. In accordance with the principles of juridical equality of the States, mutual respect for their sovereignty, independence and territorial integrity, non-aggression, and non-intervention in their internal or external affairs, the Governments of the United States of Mexico and of the People's Republic of China have decided to establish diplomatic relations, effective from this date, and to exchange Ambassadors as soon as possible.

2. The Mexican Government and the Chinese Government have agreed to mutually provide all necessary assistance for the establishment of diplomatic missions in their respective capitals and the performance of their functions, on the basis of equality and reciprocity and in accordance with international law and practice.

3. The Chinese Government supports the just position of Mexico and other Latin American States on the establishment of a nuclear-weapon-free zone in Latin America and holds that all nuclear weapon States should undertake the obligation not to use nuclear weapons against the zone or States mentioned above. The Mexican Government takes note with appreciation of this position of the Chinese Government.

(*Signed*) Alfonso García ROBLES
Permanent Representative of Mexico to the United Nations

(*Signed*) HUANG Hua
Permanent Representative of China to the United Nations

3.

Mexico: working paper containing a list of the documents of the Conference of the Committee on Disarmament relating to the Treaty for the Prohibition of Nuclear Weapons in Latin America[14] (Treaty of Tlatelolco) and of the statements by the Mexican delegation dealing with that Treaty

[*CCD/359 of 14 March 1972*]
[*Original: Spanish*]

I.

DOCUMENTS

Symbol	*Title*	*Date*
ENDC/186[15]	Final Act of the fourth session of the Preparatory Commission for the Denuclearization of Latin America	21 February 1967
ENDC/241 and Add.1[16]	Establishment of nuclear-free-zones—working documents submitted by Mexico	24 March 1969 and 24 March 1970
CCD/268[17]	Report on the first session of the General Conference of the Agency for the Prohibition of Nuclear Weapons in Latin America (OPANAL)	15 September 1969
CCD/342[18]	Working paper dealing with certain basic facts regarding the Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco) and its Additional Protocol II—working paper submitted by Mexico	19 August 1971
CCD/358[19]	Letter dated 2 March 1972 from the representative of Mexico to the Special Representative of the Secretary-General of the United Nations	2 March 1972

[15] See *Official Records of the Disarmament Commission, Supplement for 1967 and 1968,* document DC/230 and Add.1, annex IV, sect. 2.

[16] *Ibid., Supplement for 1969,* document DC/232, annex C, sect. 5 and *Supplement for 1970,* document DC/233, annex C, sect. 1.

[17] *Ibid., Supplement for 1969,* document DC/232, annex C, sect. 33.

[18] *Ibid., Supplement for 1971,* document DC/234, annex C, sect. 24.

[19] See section 2 of the present report.

II.

STATEMENTS BY THE MEXICAN DELEGATION

Date		Records	Paragraphs
1967	21 February	ENDC/PV.287	47–77
	21 March	ENDC/PV.295	2–24
	18 May	ENDC/PV.297	51–55
	19 September	ENDC/PV.331	2–26
1968	15 February	ENDC/PV.365	2–13
	6 March	ENDC/PV.374	2–25
	13 August	ENDC/PV.389	36–61
1969	10 April	ENDC/PV.402	2–39
	29 April	ENDC/PV.407	24–25
	3 July	ENDC/PV.416	42–49
	9 September	ENDC/PV.435	2–7
	30 September	ENDC/PV.448	42–54 and 97
1970	17 February	CCD/PV.449	61–99
	26 February	CCD/PV.453	31–46
	2 April	CCD/PV.461	38–40
1971	23 February	CCD/PV.495	71–73
	22 April	CCD/PV.510	75–78
	13 May	CCD/PV.516	58
	27 July	CCD/PV.524	46–48
	19 August	CCD/PV.531	25–31

4.

United States of America: work programme regarding negotiations on prohibition of chemical weapons

[*CCD/360 of 20 March 1972*]
[*Original: English*]

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

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

A. *Major categories*

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 the First World War, 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 chemical warfare 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 submitted by the United States on 16 March 1970.[20]

[20] See *Official Records of the Disarmament Commission, Supplement for 1970*, document DC/233, annex C, sect. 12.

3. *Precursors*. Intermediates of modern agents may or may not have civilian applications. Phosphorus trichloride, for example, a key precursor in the production or 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 supertoxic 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 structure 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 by the Netherlands in a working paper on 2 March 1971.[21]

4. *Criterion based on purpose*. The biological weapons Convention[22] 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 formulæ of known agents and specification of toxicity levels. Binary

[21] *Ibid., Supplement for 1971*, document DC/234, annex C, sect. 3.

[22] Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (General Assembly resolution 2826 (XXVI), annex).

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 chemical weapon 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 determing 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 programmes together with relevant arms limitation factors.

1. *Production of agents*. 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 any time 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 environment, 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*) 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 chemical warfare 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 on the relationship between the scope of prohibitions and verification, and regarding the feasibility of possible specific verification elements such as seals and monitoring devices, information exchange, declarations, remote sensing devices, inspection visits, and monitoring of imports and shipments of certain specific materials.

A. *Relationship between verification and scope*

Various possible combinations of chemical weapons 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 chemical weapons 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 chemical warfare 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 chemical weapons 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 chemical weapons production facilities are shut down but not initially dismantled. During the last session of the Conference of the Committee on Disarmament, the delegation of the United States submitted a working paper on 5 July 1971 which describes the nature and possible utility of sealing and monitoring devices.[23]

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: quantity, types, and uses of organophosphorus products; quantity, types, and uses of dual purpose chemicals; and 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 declarations concerning activities or facilities:

(*a*) 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 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 chemical weapons 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 possible consultative arrangements, relationship to the Security Council of the United Nations, and 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 chemical weapons 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 chemical weapons.

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 or identification of specific agents. A consultative body might perform the func-

[23] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234, annex C, sect. 14.

tion 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 chemical weapons 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*) With regard to 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 chemical weapons 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*) 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 chemical weapons 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*) The relationship of such a body to existing international organizations might also be considered, 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. 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 Security Council, the 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 chemical weapons 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 relationship to the Geneva Protocol,[24] facilitation of international co-operation in the field of peaceful applications, prohibitions of assistance to third parties with respect to proscribed activities, entry into force, duration and withdrawal, and 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.[25] 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.

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[24] Protocol for the Prohibition of the Use in War of Asphyxiating, Poisons or Other Gases, and of Bacteriological Methods of Warfare (League of Nations, *Treaty Series* vol. XCIV, No. 2138.)

[25] General Assembly resolution 2373 (XXII), annex.

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 over-all 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. *Amendments*

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.

5.

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*

[*CCD/361 of 28 March 1972*]
[*Original: Russian*]

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[26] affirms the recognized objective of effective prohibition of chemical weapons,

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[27] signed at Geneva on 17 June 1925, 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 2827 A (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 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

* The draft convention was also submitted in the names of the Byelorussian Soviet Socialist Republic and the Ukrainian Soviet Socialist Republic.

26 General Assembly resolution 2826 (XXVI), annex.

27 League of Nations, *Treaty Series* vol. XCIV, No. 2138.

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 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 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 acordance 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 notices 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 acordance 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 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 . .

6.

United Kingdom of Great Britain and Northern Ireland: working paper on seismic yields of underground explosions—estimating yields of underground explosions from amplitudes of seismic signals

[*CCD/363/Rev.1 of 25 April 1972*]
[*Original: English*]

Definition of yield and magnitude

By making seismic measurements close to an explosion in a previously calibrated area, the energy release (size) of the explosion can be estimated. Such estimates of explosion size are generally referred to as the "seismic" yield of the explosion and are expressed in terms of kilotons. Recent testimony before the United States Joint Committee of the Atomic Energy Commission suggests that yields of nuclear explosions in the Nevada Test Site can be estimated from such measurements to within 15 to 20 per cent of the yields estimated from radio-chemical measurements.

In the context of the comprehensive nuclear test ban discussions, the Conference of the Committee on Disarmament has been concerned with the more difficult problem of estimating yields of nuclear explosions from seismic waves which have traversed uncalibrated paths of much greater length. A brief recapitulation of the principles involved may be convenient. A small part of the energy released by underground explosions is converted to elastic energy and transmitted to distant parts of the earth as seismic waves. From the amplitudes of these waves, seismologists can determine a "seismic magnitude" for the explosion using magnitude scales devised to measure the relative size of earthquakes. The amplitudes of the seismic waves cannot be used directly as a measure of the size of a seismic event because the recorded amplitude depends on the distance of the recording station from the explosion: in general, the greater the distance the smaller the recorded signal. In computing the magnitude, a factor is applied to the recorded amplitude to correct for the effects of distance, after which all recording stations ideally give the same magnitude for a given event regardless of distance from the source of the event.

In this working paper we discuss the relationship between the seismic magnitude scales and explosion yields and demonstrate some of the difficulties in arriving at a consistent relationship, and hence in relating the detection and identification thresholds, expressed as magnitudes, of a given recording system to explosion yields.

When the comprehensive nuclear test ban discussions began in 1958, the problem of estimating the relative sizes of earthquakes from recordings at distant stations already had a long history of careful experimental work. The principal objective of the research was the provision of universal distance factors and the following section summarizes the development of this work.

The seismic magnitude scales

A scale for measuring the relative sizes of earthquakes was initiated by Dr. Charles Richter at the Californian Institute of Technology some 40 years ago. A local scale was developed for use with events within 600 kilometres of recording stations, particularly in California, in order to eliminate subjective assessments of size by affected populations. The seismic magnitude scale is logarithmic, that is, differences in amplitudes of 10 at a given station from events at similar distances represent differences of one magnitude unit in the size of the events; the larger the number the greater is the size of the event.

Richter's scale turned out to be more successful than had been expected, and attempts were made to extend its usefulness beyond the local seismic problems of California. With Dr. B. Gutenberg, Richter attempted the task using the combined surface waves recorded by two horizontal components. (In those days, sensitive vertical component seismographs could not be built because of technical problems concerned with the length and stability of springs.) This still left out deep focus earthquakes which do not generate such large surface waves, so Gutenberg went a step further and created a magnitude scale based on the amplitudes of long-period (low frequency) body waves, including, of course, the first arriving P waves. The results of this work were published in 1945. Finally, in 1956, Gutenberg and Richter published what is called the unified scale which makes use of data from all sources, including short-period P waves. The authors used the term m_b to identify unified magnitudes, and it is this scale which has been in common use for comprehensive nuclear test ban discussions since 1958 because for distant events more data for short-period than for long-period P waves have been available from the Benioff and Willmore vertical component seismographs. In recent years, however, surface (Rayleigh) wave data have been provided by more sensitive long-period vertical component seismographs. The value of magnitudes (M_s) derived from them for discriminating between explosions and earthquakes is well known. This paper demonstrates that surface waves are also useful for estimating the yield of explosions.

Data from small events located at great distances were not numerous in the early days of comprehensive nuclear test ban discussions and the various problems arising in these discussions focused attention much more than before on the relative sizes and numbers of small seismic events. The problem of relating the original magnitude scale for local events (which included a sufficient number of small earthquakes) to the unified scale (which did not) proved difficult to solve during the lifetime of Technical Working Group II at Geneva in 1959.[28] Long-period instruments sensitive enough to record surface waves of such small events had not been developed at the time, and the Kirnos instruments of the Soviet Union, though technically ideal for resolving inconsistencies in the body-wave magnitude scales, detect only the larger distant events above the seismic noise which is also well recorded by these seismographs. Some of the early difficulties encountered in applying the unified, or as it is now called, the m_b scale to the detailed seismological problems of a comprehensive nuclear test ban remain unresolved insofar as international agreement is concerned, and an appendix is devoted to the problem in the report of the Conference on Seismic Methods for Monitoring Underground Explosions, published by the Stockholm International Peace Research Institute in 1968.

Specific examples of the problem insofar as it relates to estimating seismic yield for explosions are provided below. They are selected (*a*) from the United Kingdom studies, on the well-documented explosions code-named Gasbuggy, Rulison and Medeo, which were circulated by the United Kingdom delegation to the Conference of the Committee on Disarmament in August 1970 and (*b*) from the explosion on Amchitka Island in the Aleutians, two of which are equally well documented (for example in Atomic Weapons Research Establishment reports 0-67/66 of October 1966, and 0-47/70 of August 1970), and which provide a useful frame of reference over a wider range of yields. No attempt is made to summarize the whole of the m_b—yield data which has accumulated since 1958; this is the subject of a detailed analysis which is being prepared for publication.

The curve which accompanies this paper (appendix A) does, however, summarize the more consistent surface wave magnitude (M_s)—yield data. The M_s values plotted on this curve have been measured in accordance with the recommendations outlined in the Canadian working paper of June 1971 (CCD/327),[29] and detailed in a technical paper soon to be published in the *Geophysical Journal* of the Royal Astronomical Society, London. Some of the data on which the M_s—yield curve is based are presented in the technical paper at appendix B.

m_b—yield

Common sense would suggest that m_b values should increase with increasing explosion yield. This idea can be demonstrated experimentally when source to receiver paths are identical, or nearly so, for successive explosions. Take for example the three explosions on Amchitka Island in the Aleutians as recorded at Eskdalemuir in Scotland. (Yield and magnitude values are rounded off to the nearest significant figure in all the following tables.)

[28] Group established by the Conference on the cessation of nuclear weapons tests which met from 31 October 1958 to 29 January 1962.

[29] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234, annex C, sect. 9.

TABLE OF YIELDS AND MAGNITUDES FOR EXPLOSIONS ON AMCHITKA ISLAND RECORDED AT ESKDALEMUIR

Explosion	*Yield (kilotons)*	*Yield ratio*	*Relative size from seismic amplitudes at Eskdalemuir*	*Seismic magnitude at Eskdalemuir (m_b)*
Longshot	100	1	1	6.2
Milrow	1000	10	2½	6.6
Cannikin	5000	50	5	6.9

It might also be expected that the seismic amplitudes would increase in the same ratio as the yields, but this is manifestly not true for the Amchitka to Eskdalemuir path for the observed range of yields.

Nevertheless the result fulfils expectations more closely than the following example of two explosions separated by 300 km on the same continent, which were also recorded at Eskdalemuir.

TABLE OF YIELDS AND MAGNITUDES FOR GASBUGGY AND RULISON RECORDED AT ESKDALEMUIR

Explosion	*Yield (kilotons)*	*Yield ratio*	*Relative size from seismic amplitudes at Eskdalemuir (Corrected for distance)*	*Seismic magnitude at Eskdalemuir (m_b)*
Gasbuggy (New Mexico)	26	1	1 (4)	5.3
Rulison (Colorado)	40	1½	0.25 (1)	4.7

On the face of it, the smaller explosion has given the larger seismic signal. A special study by the United Kingdom of the signal amplitudes recorded by distant (teleseismic) stations and omitting the close-in stations of North America confirms that the result is not a peculiarity of Eskdalemuir: the average figures are, for Gasbuggy, m_b 5.0 and for Rulison m_b 4.9.

The next example is even more remarkable. It compares readings at Eskdalemuir of Rulison in the United States with two chemical explosions (Medeo) in the Alma Ata region of the Soviet Union.

TABLE OF YIELDS AND MAGNITUDES FOR RULISON AND MEDEO RECORDED AT ESKDALEMUIR

Explosion	*Yield (kilotons)*	*Yield ratio*	*Relative size from seismic amplitudes at Eskdalemuir (Corrected for distance)*	*Seismic magnitude at Eskdalemuir (m_b)*
Rulison	40	24	1	4.7
Medeo 1 (chemical)	1.7	1	2	5.0
Medeo 2	3.6	2	3	5.2

The relative size of Medeo 1 as estimated from seismic amplitudes was double that of the explosion which was 24 times more powerful.

These are well documented and accurately made observations which cannot be disputed. Since they were made in the real world, the observations must have rational explanations. The explanations, however, are in dispute and have been the subject of much debate in recent years. Some possible explanations are listed in the following paragraphs, but no attempt is made to arrive at degrees of plausibility or priority, nor to make detailed quantitative assessments. These topics are being dealt with at length in the detailed study referred to earlier.

Discussion of m_b—yield anomalies

Along with most seismograph systems Eskdalemuir was designed to detect the characteristic band of frequencies in which the seismic energy of small events is radiated. The centre point of this band moves towards lower frequencies as the size of explosions increases, and because for an explosion of one megaton the centre point of the radiated energy lies on a different part of the sensitivity curve than for one of 1 kiloton, the recorded amplitudes may be that much smaller. (The analogy of radiation from the sun is opposite: the human eye cannot perceive beyond the ultraviolet and infra-red ends of the light spectrum.) The importance of the effect for estimating magnitude (m_b) of explosions may be uncertain, but its effect in assessing the relative sizes of larger earthquakes is obvious when comparing the m_b values of "standard" (WWSSN) stations with those of the wide band Kirnos instruments of the Soviet Union. The Kirnos also records a great deal of earth noise and has consequently been held to be less useful since the comprehensive nuclear test ban discussion stimulated efforts for the detection of ever smaller events and thereby pushed research teams into recording two narrow samples of the total seismic spectrum. Nowadays there is a much greater understanding of the structure of earth noise, and the means for reducing its effects, and a new look might with advantage be taken at the Kirnos type system, for discrimination problems as well as those of magnitude and yield.

Another source of the observed anomalies may be due to differences in coupling efficiency. The Committee is already aware that media in which nuclear explosives are emplaced can affect the size of the P-wave signals by factors of 10 or more when comparing coupling efficiency in dry alluvium with that of a massive rock like granite. In the case of Gasbuggy and Rulison the rocks are shale and sandstone (see AWRE report 0-46/70), which, though very different types of rock, are seismically not so different from each other as are dry alluvium and granite. The Medeo explosions were designed to move earth rather than generate seismic energy, and were therefore incompletely contained; and though that gives the results an even more extraordinary aspect, it must be said that the more slowly reacting chemical explosions are more efficient generators of seismic energy than are nuclear explosions; only a factor of about 2 or 3 has ever been suggested, however.

The amplitude of short-period P waves is also sensitive to source depth. The depths at which Gasbuggy (1,300 metres) and Rulison (2,574 metres) were buried are unusually large for the yields involved because the experiments were designed for the purpose of improving the flow of natural gas in strata at those depths. (For weapon tests, it is necessary to bury the device only to a depth sufficient for containment of radioactive debris.) This depth would have the effect of increasing the seismic coupling efficiency, but would tend to separate the surface-reflected signal away from the direct signal. This would be particularly true of Rulison, for which the surface reflection can be clearly observed arriving some one and a half seconds after the direct P wave at Eskdalemuir (figures 2 and 3, AWRE report 046/70). In the case of Gasbuggy (and all nuclear weapon tests of similar size which were buried at shallower depths) the surface reflection adds to the direct signal and can thereby double the amplitude of the direct signal. The yields of weapons such as Milrow and Cannikin, however, are so large that the depths for full containment of the debris are sufficient to separate the reflected and direct signals, and the magnitudes of both these events may thereby be under-estimated relative to Longshot; factors nearer to 2 than to 10 are involved.

However, possibly the most important cause of m_b anomalies has been revealed in the last 12 months by studies in the United Kingdom, which indicate that there are deep-seated geological structures, in areas which are associated with earthquake belts and with mountain ranges, having a greater capacity for absorbing high frequency seismic energy (short-period P waves) than the ocean floor and those ancient blocks in the interior of continents known as shields. Such structures may also cause the P-wave radiation to take two or more paths (multi-pathing) just different enough to cause the signals to interfere one with the other at the recording stations. By means of computers, models of these possible structures have been designed and the passage of seismic signals in them have been studied. The results do suggest that the geophysical causes of the more extraordinary anomalies may be found to underlie seismic and recently seismic areas. As explosion seismologists develop techniques for using larger chemical explosions for the study of earth structure, more evidence accumulates to illustrate the effects because the detonations are often in stable, aseismic areas. The most recent example, an explosion of 10 tons in the North Sea, was reported in the journal *Nature* as having been recorded as far away as Brasilia and Brisbane, and was given a seismic magnitude of m_b 4.8 at Vinta Basin in Utah. The United Kingdom studies predict that explosions in continental shield areas recorded by stations on shields will be assigned m_b magnitudes some two units greater than recordings of the same yield on seismic area to seismic area paths. When the Soviet Union releases more yields of explosions, great progress in this field of research will be possible because of the variety of geologic structures and seismicity in that country.

But, whatever the explanation, the observations of m_b are a matter for concern since one conclusion to which they lead is that it is at present almost impossible to estimate the relative size of explosions from m_b unless they are fired at one site and compared at one station. This is a very serious constraint in the context of a comprehensive nuclear test ban. Whether for counting numbers of earthquakes at a given yield equivalent, or for defining magnitude yield thresholds, a method for estimating the relative sizes of earthquakes and explosions, much less sensitive to source, path, and receiver and which provides for easily evaluated path corrections, is highly desirable.

In recent years the United Kingdom has therefore devoted some effort to the study of this problem. The successful development of sensitive long-period vertical seismographs by the United States has made possible the accumulation of surface-wave data of small events. The principal impact of these data has, of course, been on the $m_b : M_s$ criterion for discriminating between earthquakes and explosions but the United Kingdom has taken another look at the use of surface-wave magnitudes (M_s) for estimating yield, and the principal results of this study are reviewed in the final paragraphs of this paper.

M_s—yield

What has always been attractive about using surface waves for estimating relative size is firstly, that the much larger wave lengths make them less sensitive to the vagaries of geologic structure, so that gross path corrections can be applied on a continent-wide basis (as was amply demonstrated in the Canadian working paper) and secondly, that the frequencies of the recorded signals fall within the usual recording band of frequencies of long-period seismographs over a much greater range of yield than is the case for the P signals recorded by high-gain short-period seismographs. Surface-wave magnitudes are also preferred because seismographs in the Soviet Union provide almost identical M_s values to those estimated elsewhere. The difficulty in the use of M_s has been that surface waves were recorded only from relatively large events.

The following table gives the surface-wave magnitude-yield comparisons for the set of explosions which have been looked at earlier when considering the m_b—yield relationship. The Medeo explosions cannot be included because no surface waves from them have been detected outside the Soviet Union. The surface-wave magnitudes have been determined in accordance with the recommendations of the Canadian working paper.

TABLE OF YIELDS AND MAGNITUDES (M_s) FOR UNDERGROUND EXPLOSIONS IN THE UNITED STATES

Explosion	*Yield (kilotons)*	*Yield ratio*	*Relative size from seismic amplitudes (corrected for distance and path according to CCD/327)*	*Average seismic magnitude (M_s)*
Gasbuggy	26	1	1	3.4
Rulison	40	1½	1.6	3.6
Longshot	100	4	5	4.1
Milrow	1000	40	60	5.2
Cannikin	5000	200	200	5.7

It is immediately obvious that the M_s values are much more consistent over the whole range of yields than any of the m_b values listed in the earlier tables, not only in relation to yield, but also from site to site. This very satisfactory result has been confirmed by detailed analysis of all the surface-wave data available to the United Kingdom from explosions for which the yields have been announced, by France, the Soviet Union and the United States.

The attached curve at appendix A summarizes the analysis. For completeness, the M_s—yield theoretical curve for atmospheric explosions is also summarized. The theoretical basis for the curve was published in AWRE report 088/70 of November 1970 and is of special interest at lower yields (less than 50 kilotons) because it applies also to underground explosions in dry alluvium or other unconsolidated rocks. The curve for underground explosions applies to containment in any consolidated rock, in any part of the world. The dotted lines, which bracket the solid, show the maximum scatter of the observations used in the analysis. The release of more yield data, together with more refined path corrections, is expected to decrease the width of the error bands.

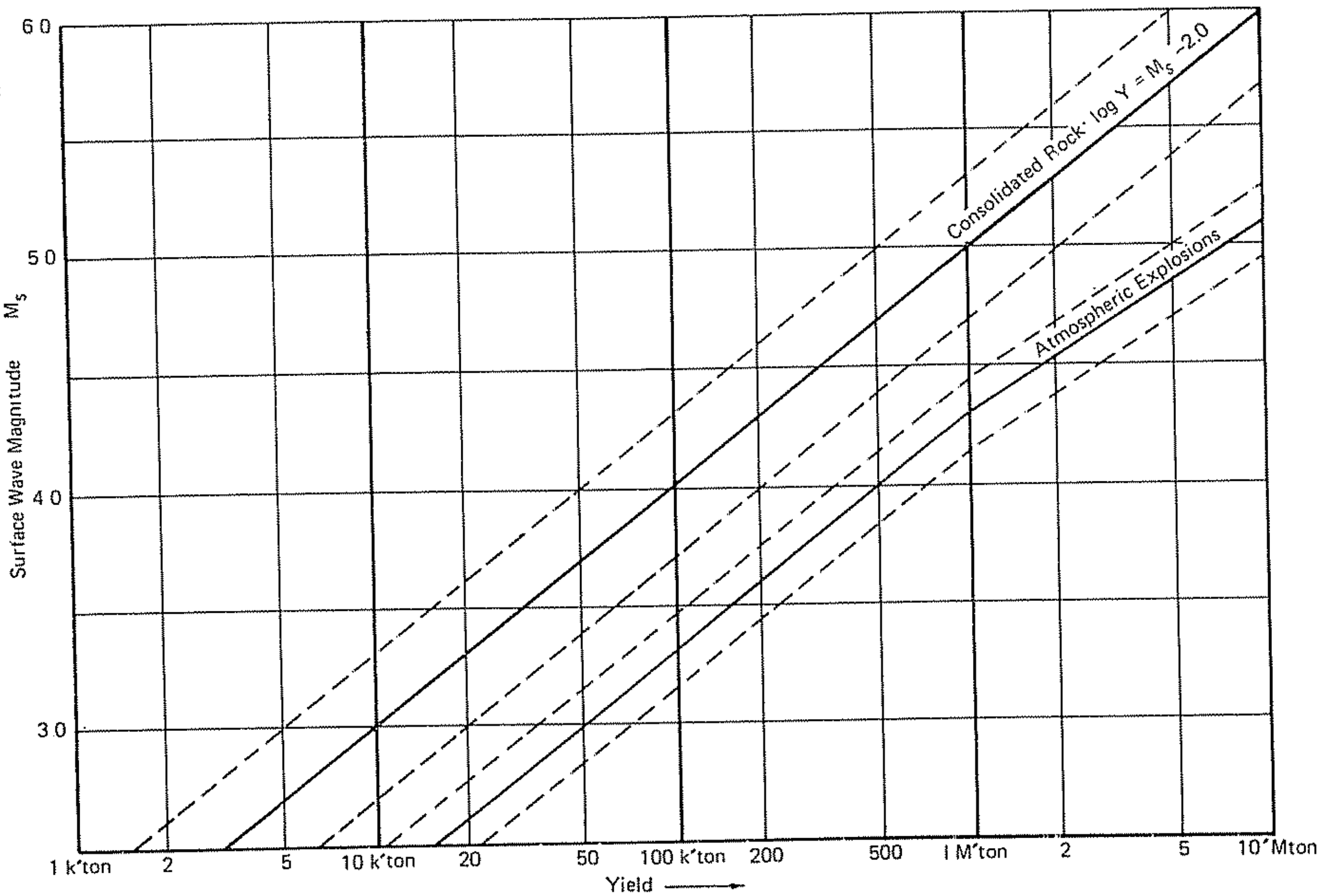
These curves are now used by the United Kingdom for obtaining the best estimates of seismic yield. Low-yield explosions, for which surface waves are not detected, must still be estimated from m_b with all their inherent uncertainties, but explosions as small as 5 kilotons have provided surface-wave records from the closer stations. As more surface-wave data are released, and better long-period stations are deployed, the limit of the method will be established, and this limit is also of interest as representing the technical threshold for discrimination by the $m_b : M_s$ criterion.

In using the curves, delegations may find it interesting to make estimates of yield from M_s values provided by their national stations or by world data centres. The path corrections will be found in the technical paper on which the Canadian working paper is based. As an example on which to conclude, the following estimates of the yields of some of the larger underground explosions, which have occurred at each of the world's principal nuclear test sites, are estimated from the path corrected world average M_s values, and the recommended M_s—yield relationship.

Site	Explosion	Average, path corrected M_s	Yield estimates from curve, or log $Y = M_s - 2$ (kiloton)
Sahara	Saphir	4.1	125
Kazakh	13 February 1966	4.4	250
Nevada	Greeley	5.1	1 250
Nevada	Benham	5.1	1 250
Novaya Zemlya	14 October 1970	5.1	1 250
Novaya Zemlya	27 September 1971	5.1	1 250
Aleutian Islands	Milrow	5.2	1 600
Aleutian Islands	Cannikin	5.7	5 000

Appendix A

SURFACE WAVE MAGNITUDE–YIELD CURVE



Appendix B

SURFACE WAVES FROM UNDERGROUND EXPLOSIONS

(Reprinted from *Nature,* Vol. 234, No. 5323, 5 November 1971)

Several authors[30] have published data on the surface wave magnitude (M_s) and yield (Y) for underground explosions at test sites in North America. Figure 1 shows the dependence of M_s on yield for all test sites for which we could obtain explosion yield data. The details of the explosions are given in table 1. From figure 1 it is clear that for explosions in consolidated rock (tuff, salt, granite, andesite and sandstone) all the observations lie close to the line $M_s = \log Y + 2.0$ for yields from 4 k'ton to 1,300 k'ton. Only for Discus Thrower and Duryea does the observed value of M_s deviate by more than 0.3 magnitude units from this line, so only for these explosions would the yield estimated from M_s differ by more than a factor of 2 from the published yield. For explosions in unconsolidated rock (alluvium) the curve of M_s against yield seems to be more like $M_s = \log Y + 1.0$, at least for yields less than 100 k'ton, but more data are required to define this curve. The M_s values plotted in Figure 1 are means of individual station determinations of M_s, each of which is corrected for deviations of the source to receiver path from an average path. After correction, the standard deviation (SD) of an observation for a given explosion is usually 0.25 magnitude units and the SD on the mean value of M_s is about 0.1. Corrections are applied for the effect of the path on the propagation of surface waves of different periods. Over

[30] D. E. Wagner, in "Nuclear Yields From Rayleigh Waves", *Annual Technical Report No. 1,* AFCRL-70-0582 (Department of Earth and Atmospheric Sciences, St. Louis University), and J. F. Evernden and J. Filson, in *Journal of Geophysical Research,* 1971, vol. 76, p. 3303.

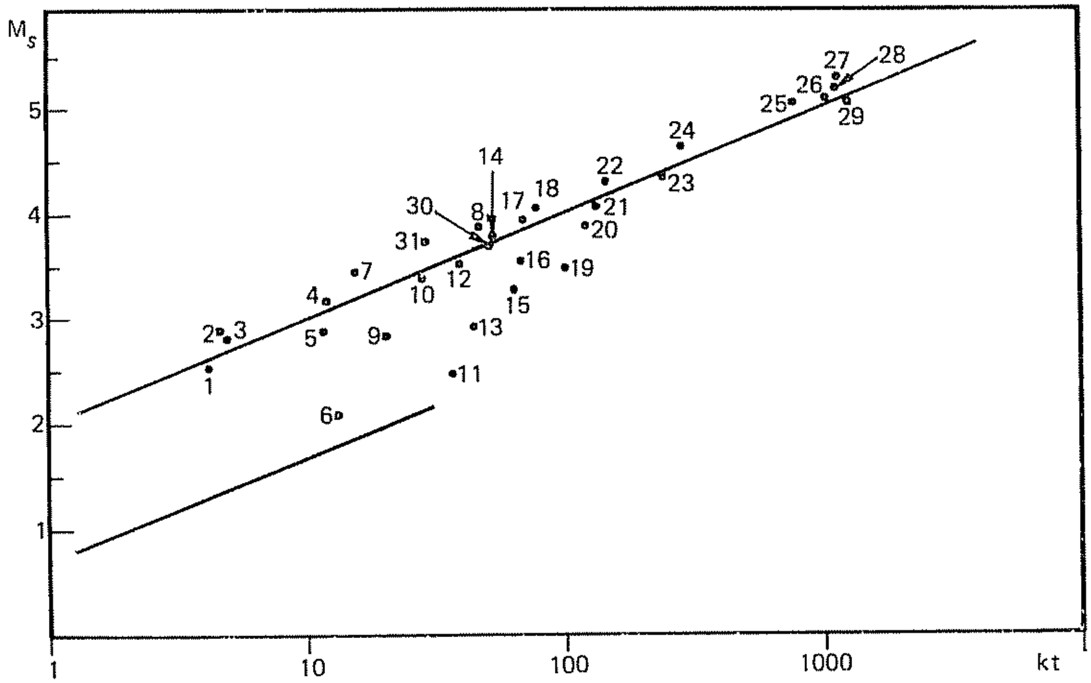


Figure 1

Surface wave magnitude (M_s)
against yield (k'ton) for explosions in various parts of the world

short paths in North America, for example, the large amplitude pulse-like arrival observed on wide-band long-period instruments is made up of period components close to a minimum value in the group velocity curve. This apparent large amplitude is due to the path and not to the source; the path effect can be estimated as a function of frequency and a correction determined (P. D. M. and P. Basham, to be published). It should be pointed out that path corrections are significant only for short transmission paths over which there is little dispersion. If these transmission path corrections are not applied, the data do not display a consistent relationship between M_s and yield when data from different test sites are combined.

Theoretical curves of M_s against yield computed using the theory described by Hudson[31] and using the explosion source functions of Haskell[32] are also shown in figure 1. These theoretical computations have also been corrected to an average crust. For consolidated rocks, the fit of the computed curve with the observations is very good; for unconsolidated rocks the predicted value of M_s for a given yield seems to be rather low. (Theoretical predictions were only made up to 30 k'ton in unconsolidated rocks because this is approximately the maximum yield for containment in a surface layer of alluvium 0.5 km thick—the depth of the alluvium layer in the crustal model of the Nevada Test Site.)[33]

From the data presented in figure 1 we conclude that, provided one assumes that explosions at any location have been fired in consolidated rock, yields can usually be estimated to within a factor of two. This is a great improvement on routine calculations using body wave magnitude. For example, the body wave magnitudes (m_b) of the Medeo explosions (1.6 k'ton and 3.7 k'ton chemical explosions) were 5.0 and 5.2 respectively at Eskdalemuir (EKA)[34] whereas the value of m_b for the 40 k'ton Rulison explosion in Colorado was found to be 4.7 at EKA.[35] Figure 1 also shows that the use of the $m_b : M_s$ criterion[36] to identify explosions at the teleseismic detection limit of $M_s \sim$ 2:5 implies yields of about 40 k'ton in dry alluvium and 3 k'ton in consolidated rock. Long period arrays on low-noise sites are required to record such low magnitudes at distances greater than 15 degrees from the firing site.

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7.

Letter dated 20 June 1972 from the representatives of Australia and New Zealand to the Special Representative of the Secretary-General of the United Nations to the Conference

[CCD/364 of 20 June 1972]
[Original: English]

We have the honour to enclose a joint message dated 20 June 1972, from the Prime Ministers of Australia and New Zealand, who are at present meeting in Canberra, concerning the

[31] See *Geophysical Journal,* Royal Astronomical Society, 1969, vol. 18, pp. 233 and 353.

[32] See *Journal of Geophysical Research,* 1967, vol. 72, p. 2583.

[33] G. C. Werth and R. F. Herbst, *Journal of Geophysical Research,* 1963, vol. 68, p. 1463.

[34] P. D. Marshall, "Some Seismic Results of the MEDEO Explosions in the Alma Ata Region of the USSR", *Atomic Weapons Research Establishment Report No. 033/70,* London, H.M. Stationery Office, 1970.

[35] D. J. Corbishley, "Some Seismic Results of the US GASBUGGY and RULISON Underground Nuclear Explosions", *Atomic Weapons Research Establishment Report No. 046/70,* London, H.M. Stationery Office, 1970.

[36] *Seismic Methods for Monitoring Underground Explosions,* SIPRI, Stockholm, Almqvist and Wiksell, 1969.

TABLE 1. DETAILS OF SOME UNDERGROUND EXPLOSIONS

Event No.	Date	Name	Region	Medium	Yield(k'ton)
1	April 14, 1965	Palanquin	Nevada	Rhyolite	4.3[a]
2	February 15, 1962	Hardhat	Nevada	Granite	4.8[a]
3	October 22, 1964	Salmon	Mississippi	Salt	5.3[a]
4	October 26, 1963	Shoal	Nevada	Granite	12.2[a]
5	November 5, 1964	Handcar	Nevada	Dolomite	12 [a]
6	December 3, 1961	Fisher	Nevada	Alluvium	13.5[a]
7	February 24, 1966	Rex	Nevada	Tuff	16 [a]
8	September 30, 1966	Bukhara I	Bukhara	Clay	30 [f]
9	May 27, 1966	Discus Thrower	Nevada	Tuff	21 [a]
10	December 10, 1967	Gasbuggy	New Mexico	Shale	29 [a]
11	October 9, 1964	Par	Nevada	Alluvium	38 [a]
12	September 10, 1969	Rulison	Colorado	Shale	40 [a]
13	June 27, 1962	Haymaker	Nevada	Alluvium	45.5[a]
14	June 2, 1966	Piledriver	Nevada	Granite	56 [a]
15	April 14, 1966	Duryea	Nevada	Rhyolite	65 [a]
16	May 6, 1966	Chartreuse	Nevada	Rhyolite	70 [a]
17	May 26, 1967	Knicker Bocker	Nevada	Tuff	71 [a]
18	October 29, 1965	Longshot	Aleutians	Andesite	85 [a]
19	July 6, 1962	Sedan	Nevada	Alluvium	100 [b]
20	January 15, 1965	Kazakh	Kazakh	Sandstone	125 [c]
21	February 27, 1965	Saphir	Algeria	Granite	135 [d]
22	May 23, 1967	Scotch	Nevada	Tuff	150 [a]
23	September 13, 1963	Bilby	Nevada	Tuff	250 [a]
24	June 30, 1966	Half Beak	Nevada	Rhyolite	300 [a]
25	December 20, 1966	Greeley	Nevada	Tuff	825 [a]
26	December 19, 1968	Benham	Nevada	Tuff	1,100 [a]
27	April 26, 1968	Box Car	Nevada	Tuff/Rhyolite	1,200 [a]
28	October 2, 1969	Milrow	Aleutians	Lava	1,200 [e]
29	March 26, 1970	Handley	Nevada	Mesa	1,200 [e]
30	May 1, 1962	Beryl	Algeria	Granite	52 [g]
31	May 21, 1968	Bukhara II	Bukhara	Salt	47 [f]

[a] G. H. Higgins, *Lawrence Radiation Laboratory Report*, UCRL-50853, 1970.

[b] Vela "Uniform" Information Digest, No. 11, p. 2.

[c] *New Scientist*, 19 May 1966, 437, and G. C. Werth, *Lawrence Radiation Laboratory Report*, UCRL-72573.

[d] *Seismic Method of Monitoring Underground Explosions*, SIPRI, Stockholm, Almqvist and Wiksell, 1969.

[e] Press reports.

[f] Press reports and *Practical Aspects of Applications of Contained Peaceful Nuclear Explosions for Industrial Purposes* (IAEA Panel, Vienna, 1971), translated by W. E. Jones, *Atomic Weapons Research Establishment translation*, No. 63, London, H.M. Stationery Office, 1971.

[g] I. P. Pasechnik, *The Characteristics of Seismic Waves from Nuclear Explosions and Earthquakes*, Moscow, NAUKA, 1970.

imminent series of atmospheric tests of nuclear weapons in the South Pacific. We have been requested to pass this message to you for urgent transmission to the Co-Chairman of the Conference of the Committee on Disarmament.

(*Signed*) H. M. LOVEDAY
Permanent Representative of Australia to the United Nations at Geneva

B. S. LENDRUM
Permanent Representative of New Zealand to the United Nations at Geneva

MESSAGE FROM THE PRIME MINISTERS OF AUSTRALIA AND NEW ZEALAND

Upon the resumption of the meetings of the Conference of the Committee on Disarmament, it is a matter of the deepest regret that it should prove necessary for the Australian and New Zealand Prime Ministers, meeting in Canberra, to address themselves to you to express their joint protest that a further series of atmospheric tests of nuclear weapons should be imminent in the South Pacific. The Government of France must bear the full responsibility for the decision which it has apparently taken to proceed with such tests. It does so contrary to the appeals made to it by many Pacific countries, contrary to the urging of the General Assembly and contrary to the recent call by the United Nations Conference on the Human Environment, held at Stockholm, which has especially condemned those tests carried out in the atmosphere.

The Australian and New Zealand Governments, reflecting the grave conccern felt throughout their communities and conscious that the problem of atmospheric testing in their region is only part of a broader problem, recalling their support at the United Nations General Assembly in November 1971 for resolution 2828 C (XXVI) which stressed the urgency of bringing to a halt all nuclear weapon testing in all environments by all States, call jointly on the Conference of the Committee on Disarmament to continue to accord high priority to the question of the urgent need for the suspension of such tests and the formulation of a comprehensive test ban treaty.

We should be grateful if you would take steps to arrange for this message to be circulated as an official document of the Conference of the Committee on Disarmament.

(*Signed*) William MCMAHON
Prime Minister of Australia

J. R. MARSHALL
Prime Minister of New Zealand

8.

United States of America: working paper on definitions of controlled substances

[CCD/365 of 26 June 1972]
[Original: English]

In the work programme regarding negotiations on prohibition of chemical weapons (see sect. 4 above) 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

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.

At certain points in the nervous system there are gaps in the electrical pathway along which signals travel. A chemical substance, 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 paralysed. 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 formulae 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 formulae which describe the spectrum of organophosphorus and carbamate compounds which are most likely to be developed as lethal agents (see appendix A).

All supertoxic organophosphorus and carbamate compounds known to us could be described by two general structural formulae. 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 formulae would not be applicable to all supertoxic 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 compounds 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 the First World War. 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 formulae shown below might be used to describe the sulphur and nitrogen mustards:

sulphur mustards: $R—S—CH_2—CH_2—Cl$

nitrogen mustards: $\genfrac{}{}{0pt}{}{R}{R'}\!\!>N—CH_2—CH_2—Cl$

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 supertoxic substances or any supertoxic 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 formulae of a number of known single purpose agents and precursors are given in appendix 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 supertoxic agent.

Purpose criterion

A general criterion, such as that in the biological weapons Convention,[37] 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 formulae 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 the First World War.

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 the First World War 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:

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

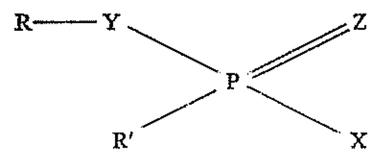
In the area of dual purpose agents it might be desirable to consider a definition based on a purpose criterion and a list of known dual purpose agents.

Appendix A

POSSIBLE STRUCTURAL FORMULAE FOR NERVE AGENTS

1. *Organophosphorus compounds*

The general structure formula for potential organophosphorus agents proposed by the Netherlands in CCD/320,[38] as shown below



in which:

Y = O or S

Z = O or S

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

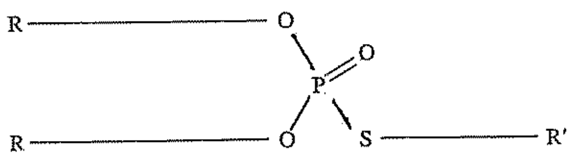
R = (substituted) alkyl, cycloalkyl or hydrogen

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 supertoxic 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 the Netherlands document) were changed so that R′ = alkyl, dialkylamino, alkoxy.

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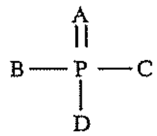
[37] Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and Their Destruction (General Assembly resolution 2826 (XXVI), annex 1).

[38] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234, annex C, sect. 3.

Another feature of the formula in the Netherlands document 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:



in which:

A = O, S, Se

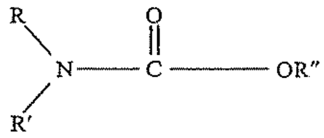
and B, C, D may be any atom or group of atoms.

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

2. *Carbamates*

The carbamates are another class of chemicals from which extraordinary 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 ($\text{-O-}\overset{\text{O}}{\overset{\|}{\text{C}}}\text{-N} <$), 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 a spectrum as complete as possible of supertoxic carbamate compounds:



in which:

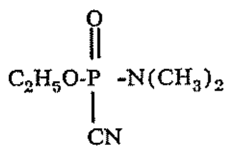
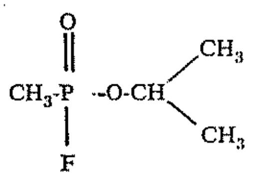
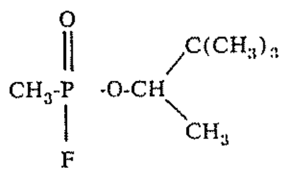
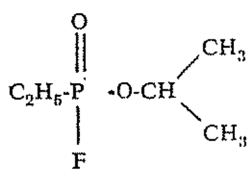
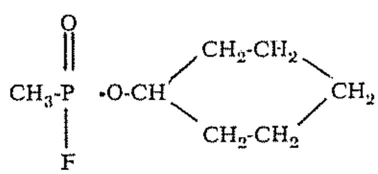
R = hydrogen, alkyl   R′ = alkyl

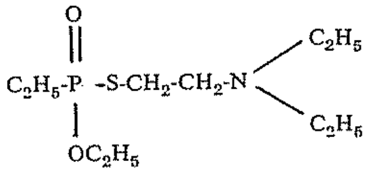
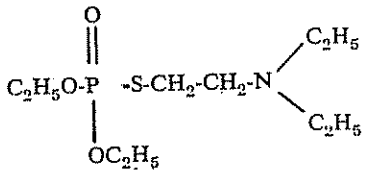
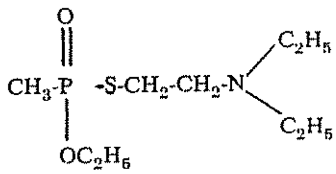
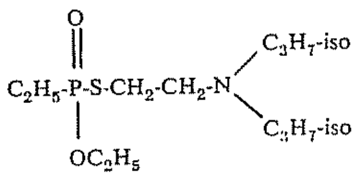
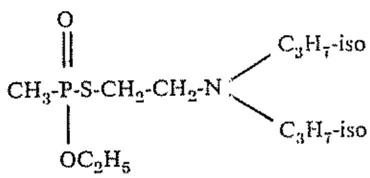
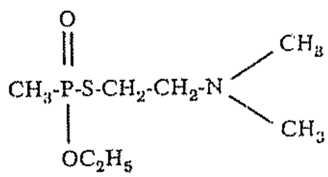
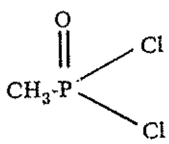
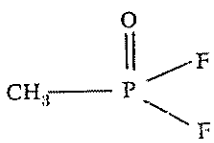
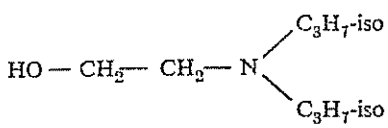
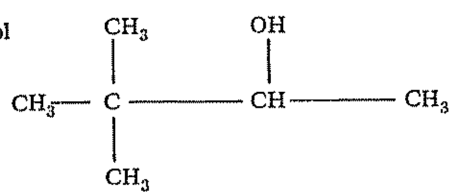
R″ = any alkyl or aryl group

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 supertoxic carbamates.

Appendix 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 methylphosphonofluoridate	
4. Ethyl Sarin, GE ..	Isopropyl ethylphosphonofluoridate	
5. GF	Cyclohexyl methylphosphonofluoridate	

Common Name	*Chemical Name*	*Structural Formula*
6. VE	O-Ethyl S-2 diethylaminoethyl ethylphosphonothiolate	
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	
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	
2. Difluor	Methylphosphonic difluoride	
3. None	N,N-diisopropylethanolamine, 2-Diisopropylaminoethanol	
4. Pinacolyl alcohol	3,3-Dimethyl-2-propanol	

Appendix B (continued)

Common Name	*Chemical Name*	*Structural Formula*
B. *Mustard-type agents*		
1. Mustard gas*	*Bis*(2-chloroethyl) sulfide	S—(—$CH_2CH_2Cl)_2$
2. HN-1	Ethyl-*bis*(2-chloroethyl) amine	C_2H_5-N—(—$CH_2CH_2Cl)_2$
3. HN-2	Methyl-*bis*(2-chloro-ethyl)amine	CH_3-N—(—$CH_2CH_2Cl)_2$
4. HN-3	*Tris*(2-chloroethyl) amine	N—(—$CH_2CH_2Cl)_3$
5. Sesquimustard	1,2-*bis*(2-chloroethyl-thio)ethane	$(CH_2SCH_2CH_2Cl)_2$
6. T	*Bis*(2-chloroethylthio-ethyl)ether	O—(—$CH_2CH_2SCH_2CH_2Cl)_2$
7. Lewisite	2-chlorovinyl dichloroarsine	CHClCH—$AsCl_2$

* United States standard agent.

9.

United States of America: working paper on storage of chemical agents and weapons

[*CCD/366 of 20 June 1972*]
[*Original: English*]

Introduction

The United States work programme on chemical weapons (see sect. 4 above) 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 over-all configuration of storage areas, as well as features of storage, such as security, maintenance, and safety. The United States delegation believes than an examination of these questions is relevant in considering verification questions connected with possible prohibitions regarding possession and stockpiling of chemical weapons and agents.

The information set forth below is drawn largely from United States experience. While similar features could be expected to apply to chemical weapons storage elsewhere, it is not known whether all States possessing stocks of those weapons employ analogous methods to cope with such problems as security and personal safety. By making available information concerning United States 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 is unique to chemical weapons storage.

Perimeter safety measures to protect personnel against possible leakage, on the other hand, may be indicative of chemical weapons storage. Regular sampling of the air around the perimeter is one measure common to such 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 is made to withhold knowledge from persons in the immediate area, might be warning signs. Such signs could be posted along perimeters of chemical weapons 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 the First World War, 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 United States 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 United States 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 United States practice, 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 connexion 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 chemical weapons 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 stockpiling of chemical weapons.

10.

United States of America: working paper on the destruction of chemical weapons

[CCD/367 of 20 June 1972]
[Original: English]

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 18 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 (methylisoppropoxy-fluoro-phosphine oxide) and a 0.55 pound tetryl central burster. The M34 clusters were manufactured in the mid 1950s, 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 accidently occur. The facility has explosion-proof doors and automatic blast valves that will insure that the facility is gas-tight 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 vapour subsequently will be bled to the scrubbers (cleansing devices). During normal operations the area will be continuously 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 follow-up 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 chemical weapons destruction operation involving a limited quantity of weapons indicate that destruction of chemical weapons is a complex and time-consuminng task which requires the most detailed preparations. Comprehensive destruction of all lethal chemical weapons 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.

11.

United States of America: working paper on statistics relating to production and trade of certain chemical substances in the United States

[*CCD/368 of 20 June 1972*]
[*Original: English*]

The Canadian and Japanese delegations have suggested (CCD/300, 301, 344,)[39] that it would be useful to review the possibility of compiling production and trade data on certain chemical substances used in the preparation of lethal chemical agents. In response to this suggestion, the United States wishes to share with other members of the Committee the following information regarding the production and trade of chemical substances in the United States.

[39] For documents CCD/300 and 301, see *Official Records of the Disarmament Commission, Supplement for 1970*, document DC/233, annex C, sect. 29 and 30; for document CCD/344, see *ibid., Supplement for 1971*, document DC/234, annex C, sect. 26.

United States production statistics

The United States presently releases considerable data on chemical production. Annual production figures for eight of the 16 chemicals listed in the Canadian and Japanese papers are available in United States Census Bureau or United States Tariff Commission publications.

Statistics on the eight other chemicals on the Canadian and Japanese lists are not published by the United States Government, either because production is minute or nil or because United States 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 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 the First World War and data on organphosphorus insecticides because of the similarity of their chemical structure and mode of action to nerve agents.

Table 1

PRODUCTION OF SELECTED CHEMICALS IN THE UNITED STATES (IN METRIC TONS)

	1966	*1967*	*1968*	*1969*	*1970*	*1971a*
Elemental Phosphorus	513,067	532,532	556,425	570,590	548,918	494,486
Phosphorus Trichloride	39,987	46,391	49,460	51,993	41,768	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	138,050	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[b]	34,414[b]	41,939[b]	60,100	—

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

[b] 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.

Production figures cover all chemicals produced in the United States 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 United States. 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 United States 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 chemical weapons purposes 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 United States imports and exports of chemicals with a potential for chemical weapons use are very small. The exception is organophosphorus insecticides for

Table 2

NUMBER AND LOCATION OF UNITED STATES PLANTS PRODUCING SELECTED CHEMICALS[a]

	Elemental phosphorus	*Phosphorus trichloride*	*Phosphorus oxychloride*	*Phosphorus pentasulfide*	*Ethylene oxide*	*Phosgene*	*Hydrogen cyanide*	*Cyanogen chloride*	*Chlorine*
North-east (North Atlantic)	2	3	2	1	1	2	—	2	10
South-east (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[b]	16	9	7	68

[a] 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.

[b] There is also one plant in Puerto Rico.

which exports represented 30 per cent of United States production in 1970. The only other chemical for which separately published trade statistics can be compared with production is chlorine. Exports as a percentage 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 United States 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 3

UNITED STATES 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[a]	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	[b]	.014	.004	.007	[c]	.004

[a] In addition, during 1966-1971, United States 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.

[b] Not reported separately.

[c] Less than half a kilogram.

12.

United States of America: working paper on United States domestic legislation regarding chemical substances

[*CCD/369 of 20 June 1972*]
[*Original: English*]

This paper describes relevant provisions of domestic United States 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 (see CCD/PV.556). 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 United States 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 foot-notes. 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 United States 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[40] 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 wilful 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.[41]

Among the "implements of war" designated by regulation are "chemical agents",[42] and "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 United States 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 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 detoxified or made harmless to man and his environment, unless immediate disposal is clearly necessary to safeguard human life or in an 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.

[40] 22 USC 1934 (1970).

[41] Executive Order No. 11432, 3 CFR 751 (Comp. 1966-1970)

[42] 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.

A. Federal legislation regulating the production and sale of various chemical substances

1. *Federal Hazardous Substances Labeling Act*

The Federal Hazardous Substances Labeling Act[43] 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 hazardous substance which is highly toxic.[44] 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[45] 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.[46] 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.

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.[47] The Federal Food,

[43] 15 USC 1261 *et seq.* (1970).

[44] 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 14 days in half or more than half of a group of 10 or more laboratory white rats each weighing between 200 and 300 grams, at a single dose of 50 milligrams or less per kilogram of body weight, when orally administered; or (*b*) produces death within 14 days in half or more than half of a group of 10 or more laboratory white rats each weighing between 200 and 300 grams, when inhaled continuously for a period of one hour or less at an atmospheric concentration of 200 parts per million by volume or less of gas or vapor or two milligrams per litre 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 14 days in half or more than half of a group of 10 or more rabbits tested in a dosage of 200 milligrams or less per kilogram of body weight, when administered by continuous contact with the bare skin for 24 hours or less". 15 USC 1261 (h) (1) (1970).

[45] 7 USC 135 (1970).

[46] This Act prohibits the sale of pesticides containing the arsenate, arsenite, fluoride and fluosilicate compounds listed below unless these compounds are distinctively coloured to identify their presence in the pesticide. A pesticide containing such an uncoloured 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.

[47] 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 . . .".

Drug and Cosmetic Act,[48] 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.[49] 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 United States of etiologic (disease causing) agents unless authorized by the Secretary of Transportation. The 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 United States 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.[50] 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[51] regulates the transportation and distribution of merchandise into the customs jurisdiction of the United States. Another section of the United States Code contains a list of the controlled merchandise.[52] 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.[53]

C. *Federal laws controlling the disposal of chemical substances*

Under Federal water pollution legislation[54] the Federal Environmental Protection Agency 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.[55]

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[56] 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 considerably diversity and is in many cases not as comprehensive as Federal regulation In some areas where the United States 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 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.[57]

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 sub-

[48] 21 USC 301 *et seq.* (1970).

[49] An example of a general statutory definition is by 21 USC 351 (1970) which defines adultered 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.

[50] The regulations promulgated by the Secretary of Transportation list many chemical agents; see 49 CFR 172.5.

[51] 19 USC 1701 *et seq.* (1970).

[52] 19 USC 1202 (Sub-chapter 4) (1970).

[53] 19 CFR 12.17, 12.21.

[54] 33 USC 1162 (1970) (Hazardous).

[55] 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".

[56] 42 USC 4321 (1970).

[57] 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).

stances,[58] 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.[59] 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 governinng the manufacture and sale of drugs, the distribution and sale of pesticides and the disposal of chemical pollutants.[60] It does 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.[61]

13.

Letter dated 14 June 1972 from the representative of Peru to the Special Representative of the Secretary-General of the United Nations to the Conference

[*CCD/370 of 20 June 1972*]
[*Original: Spanish*]

I have the honour to express to you, on instructions from my Government, the vital interest of my country in the question entitled "Urgent need for suspension of nuclear and thermonuclear tests", which is a high-priority item before the Conference of the Committee on Disarmament. In a number of international fora my Government has stated its profound anxiety at the alarming persistence of nuclear tests, and feels that it should reaffirm its conviction that the continuance of these tests is manifestly contrary to the interests of peace.

In particular, my country wishes to reiterate the strongest possible protest against the series of tests of nuclear weapons in the atmosphere which France is carrying out and intends to continue in the Pacific. I do not feel it necessary to detail, since they are well known, the hazardous effects which these explosions entail for the coastal States of the Pacific Ocean, not only for the health and welfare of their peoples but also for the ecological balance of the area.

I should therefore be very grateful if you would take the necessary steps for the secretariat of the Committee to issue this letter as an official document of the Committee on Disarmament.

(*Signed*) Carlos ALZAMORA
Permanent Representative of Peru to the United Nations at Geneva

[58] 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).

[59] 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).

[60] 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 Marketing Law Sec.149 (McKinney 1954); chemical pollution of water by N.Y. Public Health Law Sec.1200 *et seq.* (McKinney 1954).

[61] N.Y. Vehicle and Traffic Law Sec.1630 (McKinney 1954) authorizes certain localities to regulate the transportation of dangerous chemical substances.

14.

United Kingdom of Great Britain and Northern Ireland: working paper on remote detection of chemical weapon field tests

[*CCD/371 of 27 June 1972*]
[*Original: English*]

A. *Introduction*

1. In an earlier working paper (CCD 308)[62] the requirements for verification of chemical weapon arms control measures were reviewed in broad terms in order to put the over-all 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 focused 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 usable frequencies to "windows" in the near ultraviolet, visible light, infra-red, microwave and radio-frequency regions. Of these regions only the infra-red will produce chemical data on all molecules and of the available windows in the infra-red region, that from 8-15 μ is preferred because:

(*a*) It is a region in which many characteristic infra-red absorption bands are found; and

(*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 per cent overlap on successive days. The ground velocity of the satellite is 6.7

[62] See *Official Records of the Disarmament Commission, Supplement for 1970*, document DC/233, annex C, Sect. 37.

km sec^{-1} which imposes severe constraints on the infra-red 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 line-scanning 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 infra-red 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 infra-red 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 observation 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 line-scan 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 seconds 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 μ 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 digitized for transmission to earth and commercial converters have speeds up to 15 MHz. 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 4 MHz. 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 infra-red 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 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 m^{-2} is the most that appears practicable. Essentially, it appears that the intrinsic sensitivity of existing infra-red detectors is adequate, but that the limiting factor is likely to be the random noise level of the over-all 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, that is that the sensor is an infra-red 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 over-all surveillance system is given in figure 1 below. 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)

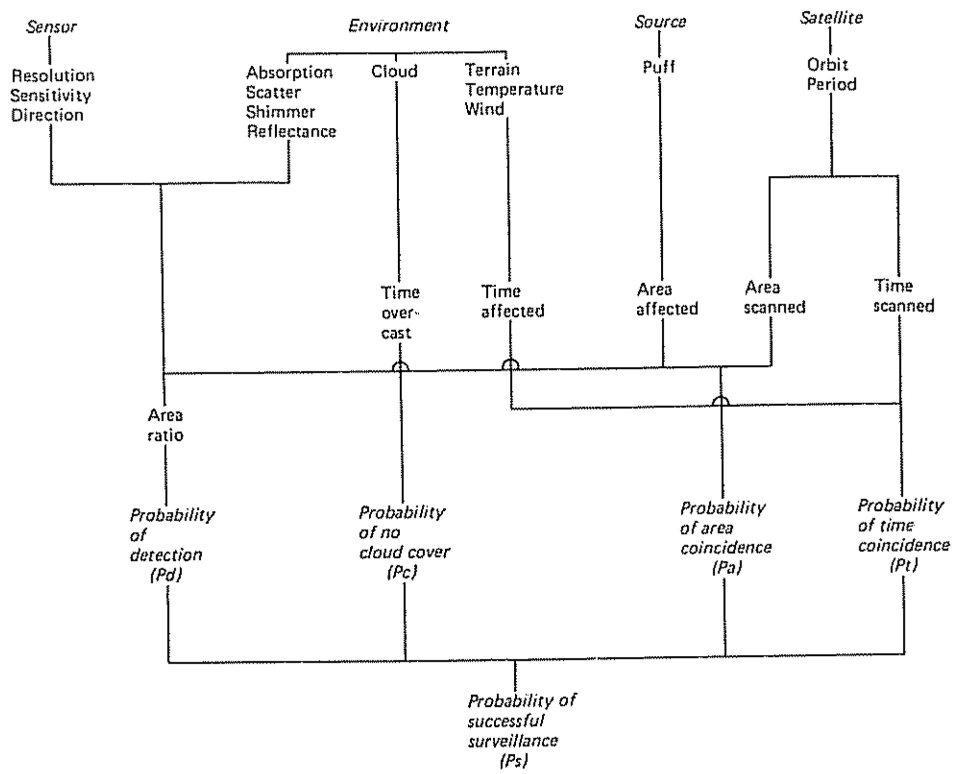


Figure 1

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 over-all 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 × 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 1 below. 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 × Pt = 0.02 for 0.1 mg m^{-2} sensor sensitivity.

(*b*) *Inclined orbits.* The elliptical sun-synchronous inclined orbit with a period of 12 hours may be used to scan the northern hemisphere for two 8-hour periods during each

Table 1

SOME POSSIBLE SATELLITE ORBITS (APPROXIMATE VALUES)

Type	*Polar*	*Inclined*		*Equatorial*	
Orbit	*Circular*	*Circular*	*Elliptic*	*Circular*	*Circular*
Altitude, km	880	1,000	—	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)	—	MOLNYA (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′

24 hours at apogee. In view of the persistence of the puff at detectable levels for a sufficient time, Pa × Pt = 1. Scanning of perigee would give a lower Pt value. The relatively low circular inclined orbit will result in less favourable Pa × Pt terms than the elliptical orbit.

(*c*) *Circular equatorial orbits*. A satellite in a geostationary orbit having a sensor aligned and focused on a 7,200 km square centred on the puff release point can carry out constant surveillance. Thus Pa × 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 hours. As with inclined orbits Pa × 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, that is, 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 below and show that only with equatorial orbits at low sensor sensitivity (1.0 and 0.1 mg 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 focusing 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 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

Table 2

RATIO OF PUFF AREA/SENSOR RESOLVED AREA

Type	*Satellite altitude km*	*Resolution radius (km)*	*Puff area/Sensor resolution for Sensor sensitivity (mg m^{-2})* 1.0	0.1	0.01	0.001
Polar	880	0.11	92	744	9258	
Inclined	1000	0.125	71	577	7180	
	Elliptic	Variable		not calculated		
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

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 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 below.

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).

Table 3

SUMMARY OF PROBABILITY TERMS

Satellite type and altitude km	*Sensor sensitivity mg m^{-2}*	*Probabilities**					
		Pc(W)	*Pc(S)*	*Pa × 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 1,000	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
	0.1	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	not calculated			
	0.01	0.3	0.7	not calculated			
Equatorial 10,000	1.0	0.3	0.7	1	0	0	0
	0.01	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 × Pt = probability of the coincidence of the agent puff and scanned area and coincidence in time

Pd = probability of detection by the sensor

Ps = over-all probability of successful surveillance in winter Ps(W) and summer Ps(S)

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 infra-red 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.

15.

Sweden: working paper on two groups of chemical agents of warfare

[CCD/372 of 28 June 1972]
[Original: English]

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[63] and the report of the United Nations on chemical agents of warfare[64] might be divided into two groups with such characteristics that different verification procedures would seem meaningful.

[63] Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (League of Nations, *Treaty Series*, vol. XCIV, No. 2138).

[64] *Chemical and Bacteriological (Biological) Weapons and the Effects of Their Possible Use* (United Nations publication, Sales No. E.69.1.24).

Chemical substances, whether gaseous, liquid or solid, which are suitable to be employed in warfare because of their toxic effects on men, 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, for example the reports of the United Nations and of the World Health Organization[65] 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, namely 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 Conference of the Committee on Disarmament the following concepts have been used for different delimiting purposes.

(*a*) Conditional or unconditional prohibition of production: Swedish statements of 12 March 1970 (CCD/PV.457) and 13 April 1972 (CCD/PV.556).

(*b*) Supertoxic or toxic agents: Swedish statement of 9 March 1971 (CCD/PV.499).

(*c*) Single or dual purpose agents: United States working paper on a work programme regarding negotiations on prohibition of chemical weapons, submitted on 20 March 1972 in document CCD/360 (see sect. 4 above).

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, that is, 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, that is, 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, dealing 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, for example, 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:

(*a*) High toxicity;

(*b*) Rapid onset of effect—minutes to hours;

(*c*) Physico-chemical properties allowing storage and dissemination (or, in the case of binary weapons, only dissemination);

(*d*) 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 below. The delimitation is based upon known facts and data about some known compounds.

Technical basis and procedure for delimitation

Since the supertoxic agents will have to be treated differently within a comprehensive ban of production 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, for example, 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 on man and his environment, United Nations Scientific Committee on the Effects of Atomic Radiation (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 the United Nations authorities just discussed might also perform this task.

Conclusion

There is need for a delimitation of particularly dangerous chemical agents of warfare, that is, supertoxic agents, as a basis for different means of control within a comprehensive treaty prohibiting production 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 warfare 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 specialities.

Data on chemical agents of warfare are available in literature, for example, 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,

[65] *Health Aspects of Chemical and Biological Weapons* World Health Organization (Geneva, 1970).

Table

A TENTATIVE DELIMITATION OF SUPERTOXIC CHEMICAL AGENTS OF WARFARE EVALUATED FROM DATA OBTAINED MAINLY FROM UN AND WHO REPORTS ON BIOLOGICAL AND CHEMICAL WEAPONS

Evaluation properties	*Supertoxic agents*					*Other toxic agents*		
	Botulinal toxin A	*Staphylococcal enterotoxin*	*Nerve agents*[d]	*Mustard gas*		*Phosgene*	*Hydrogen cyanide*	*CS*
Lethal dose[a] (LCt_{50} mg min/m^3)	0.02	—	10 400[e]	1 500		3 200	5 000[h]	50 000
Effective dose[a] (ECt_{50} mg min/m^3)	—	0.03[c]	2-20[e]	100		1 600	2 000[h]	<10
Time to onset of effect	hours	hours	minutes	hours		hours	minutes	<minutes
Duration of effect	weeks	< 24 hours	days-weeks	weeks-months		weeks-months	days	minutes
Dual purpose[b]	no	no	no	(no)[f]	Tentative line of delimitation	yes[g]	yes[g]	yes[i]

[a] The values are estimated for man (see UN and WHO reports) when not otherwise stated.

[b] According to United States working paper CCD/360.

[c] Inhaled dose in mg, which caused emesis in rhesus monkey (see WHO report).

[d] Larger groups of agents may be characterized more strictly, see working papers on this subject submitted by the Netherlands in document CCD/320 of 2 March 1971 (see *Official Records of the Disarmament Commission Supplement for 1971*, document DC/234, annex C, sect. 3) and by the United States in document CCD/365 of 20 June 1972 (see sect. 8 of the present report).

[e] Sarin, VX: see UN and WHO reports; Tabun: for estimated doses see S. Franke, *Lehrbuch der Militärchemie*, Berlin Deutscher Militärverlag, vol. I, 1967.

[f] Might be used as an intermediate in laboratory scale synthesis; at present of no known industrial value.

[g] Raw material.

[h] Varies with the concentration in air during exposition due to the rapid destruction of the agent in the body.

[i] Police use.

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.

16.

Italy: working paper on identification and classification of chemical warfare agents and on some aspects of the problem of verification

[*CCD/373 of 29 June 1972*]
[*Original: English*]

I. CHEMICAL AGENTS THAT COULD BE BANNED

During past meetings of the Conference of the Committee on Disarmament 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 chemical 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, artillery, 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 (in the case of dual purpose agents, their peaceful uses are italicized):

Phosgene or Carbonyl Chlorine ($COCl_2$)

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 ($F\text{-}(CH_2)_nCOOR$, in which n = odd and R = alkly or halogenalkyl)

General toxic action.

Chloropicrin or Nitrochloroform ($O_2N\text{-}CCl_3$)

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 Sulphide ($S(CH_2CH_2Cl)_2$)
Blister agent.

Ethyl Chlorosulphonate ($Cl\text{-}SO_2\text{-}OC_2H_5$)
Blister and tear agent.

Nitrogen Mustards and Tertiary 2,2' Dinalo Dialkyl Amines ($R\text{-}N\text{-}R_2'$, in which R = Alkyl, halogenalkyl and 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.*

Lewisite 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 ($AsCl(C_6H_4)_2NH$)
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.

Organophosphorus 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 in document CCD/320 of 2 March 1971[66] could also be used.

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:

(i) Single purpose agents;

(ii) Duel purpose agents;

According to their degree of toxicity:

(i) 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.)

(ii) 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 a previous working paper, CCD/335 of 8 July 1971[67], 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 the Committee on Disarmament 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 analytical to reveal meaningful deviations either in the average or in the forecast indexes.

[66] See *Official Records of the Disarmament Commission, Supplement for 1971*, **document DC/234, annex C, sect. 3.**

[67] *Ibid.*, sect. 17.

17.

Japan: working paper on the question of a criterion to be used to characterize supertoxic chemical agents

[*CCD/374 of 5 July 1972*]
[*Original: English*]

1. *Determination of a toxic criterion*

The LD_{50} of all chemical substances, if plotted according to the degree of 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 8 August 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).[08] 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, subcutaneous) 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, 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, for example, 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 130 organophosphorus compounds, the group to which the above-mentioned nerve agents belong, are known. The LD_{50} of organophosporus agents for use as insecticides and in medicine are shown in tables 1 and 2 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 3 and 4.

[08] *Ibid., Supplement for 1970*, document DC/233, annex C, sect. 30.

Table 1

Name	LD_{50} (mg/kg)		
Acethion	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.

Table 1 (continued)

Name	LD_{50} (mg/kg)		
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.
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.
PAP	34	mice	p.o.
	3.5	rats	i.p.
Phosdrin	8.9	mice	p.o.
PMP	34	mice	p.o.
Potasan	25	mice	s.c.
	15	rats	i.p.

Table 1 (continued)

Name	LD_{50} (mg/kg)		
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 2

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.

Table 3

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.	K. P. 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)
	0.06	rats	i.v.	K. P. DuBois (1963)
	0.12	rats	i.v.	J. H. Fleisher (1960)
	3.7	rats	p.c.	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)

p.o. = oral; s.c. = subcutaneous; i.p. = intraperitoneal; i.v. = intravenous; p.c. = percutaneous

Table 4

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.
Methylisoproproxyphosphorylthiocholine	0.12	mice	i.p.
Tetraethylmonothionopyrophosphate	0.7	mice	i.p.

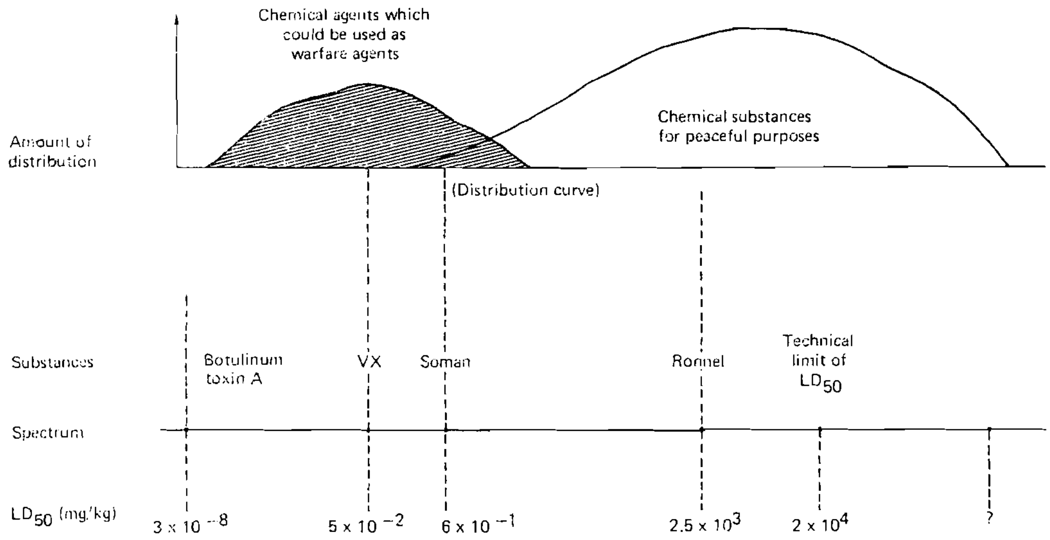
Many of the data were obtained in tests with mice and rats, while the administration route was mostly intraperitoneal or oral. As to organophosphorus agents for use as chemical weapons, there are many data available on intraperitoneal injections. In the case of insecticides, many statistics are obtained 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, intraperitoneal 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 1, there will be one insecticide (tetram: 0.5 mg/kg, mice, intraperitoneal) and two medicines (paraxon: 0.6 mg/kg, mice, subcutaneous, echothiophate: 0.14 mg/kg, mice, intraperitoneal). Table 4 gives 13 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 organophosphorus compounds, there is a strong possibility of their being used as chemical warfare agents, while the above-mentioned 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 organophosphorus compounds, out of the many existing ones, 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, that 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.

Chart 1



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 (for example, 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

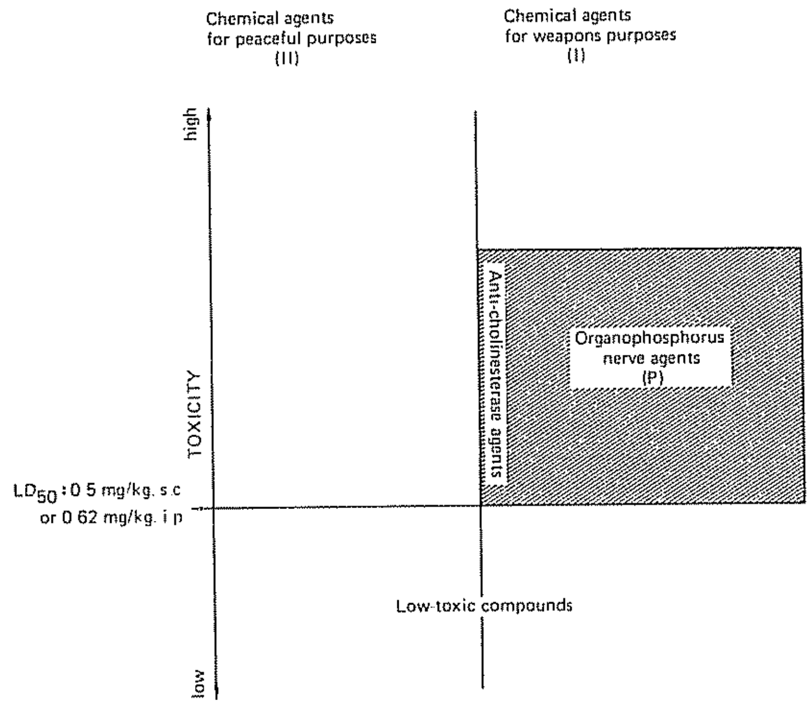
(iii) Duration of observation, etc.

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 category II of chart 2.

Accordingly, we could limit the scope of chemical agents in a more clearcut way by selecting supertoxic 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 supertoxic compounds using our toxicity criterion. In the light of such a consideration, it might be appropriate that we concentrate ourselves on supertoxic organophosphorus compounds (the square indicated by P on chart 2.)

Chart 2



This is because organophosphorus compounds have the following characteristics: (1) the supertoxic 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 paragraphs 3 and 4, we could detect the relevant supertoxic organophosphorus compounds by means of gascromatography or by measuring cholinesterase activity.

4. *Possible chemical structural formula for organphosphorus compounds for weapon purposes*

As to the method for defining such supertoxic organophosphorus compounds, the Netherlands representative suggested a method using chemical structural formula (CCD/320).[69]

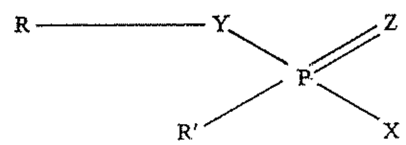
The common characteristics of organophosphorus nerve agents for weapon purposes, such as sarin, soman, and the V agents are that there are methyl and phosphorus (CH_3-P) bonds in their molecules. On the other hand, though the mechanism of their action is the same, organophosphorus insecticides, which 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 microanalysis of CH_3-P bonds, it should contribute greatly to the detection of organophosporus nerve agents.

However, some supertoxic organophosphorus compounds have bonds of lower alkyl radical and phosphorus. The representative of the Netherlands presented in the above-mentioned working paper a general structural formula (see chart 3) as a criterion by which to define supertoxic agents. As we consider 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 4 is the most suitable. (For details, see appendix.)

Chart 3

A general formula proposed by Netherlands (CCD/320)



in which:

Y = O or S

Z = O or S

X = F, CN, N_3, SR″, $S(CH_2)_nSR''$, $S(CH_2)_n$ S + $(R'')_2$, $S(CH_2)_nN(R'')_2$, $S(CH_2)_n$ N + $(R'')_3$

R = (Substituted) alkyl, cycloalkyl or hydrogen

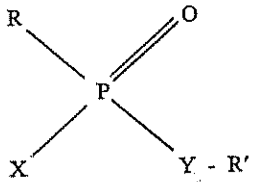
R′ = Alkyl, dialkylamino

R″ = Alkyl

[69] *Ibid., Supplement for 1971,* document DC/234, annex C, sect. 3.

Chart 4

A general structural formula for our study



in which:

R = Alkyl, dialkylamino or alkoxy

R′ = (Substituted) alkyl, cycloalkyl or hydrogen

Y = O or S

X = F, CN, $S(CH_2)_nSR''$, $S(CH_2)_nNR''_2$, $S(CH_2)_n{+}SR''_2$, $S(CH_2)_n{+}NR''_3$, $S(CH_2)_nNHR''$, $S(CH_2)_nSO_2R''$

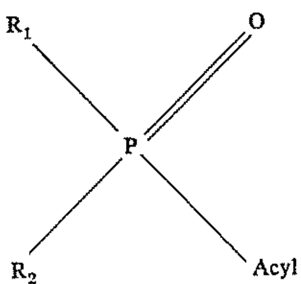
R″ = Alkyl

Appendix

EXPLANATION OF THE GENERAL FORMULA FOR THE DESIGNATION OF SUPERTOXIC ORGANOPHOSPHORUS COMPOUNDS

In this appendix a detailed explanation of the possible general formula proposed for the supertoxic organophosphorus compounds is presented for consideration in connexion with the discussion in the Conference of the Committee on Disarmament to find a 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 supertoxic organophosphorus compounds.

A general formula (I) has been proposed by G. Schrader[70] for those organophosphorus compounds which have high toxic properties:



(I)

in which:

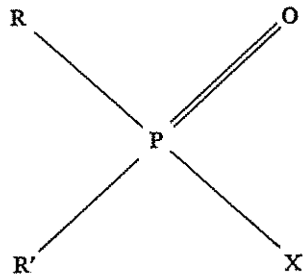
R_1, R_2 = alkoxy, alkyl, or amine

Acyl = inorganic or organic radical groups (for example, -F, -Cl, -SCN, -S, phenol, enol, etc.)

Among the compounds with this formula, there are many supertoxic nerve agents, many of which are the so-called chemical warfare nerve agents.

[70] See *Angewandte Chemie*, vol. 62, 1950, p. 471.

M. F. Sartori and others also proposed,[71] a general formula (II) for some of those supertoxic 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)

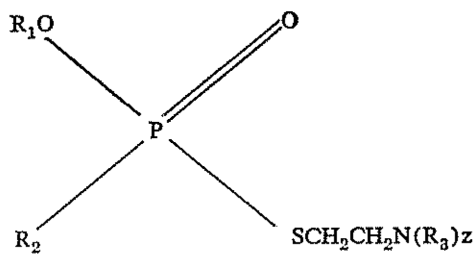
in which:

R = C_2H_5O, CH_3 CH_3 > CHO

R′ = $(CH_3)_2N$, C_6H_5NH, CH_3

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. Tables 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 the First World War, 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 16 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 chemical weapons establishment, namely:



(III)

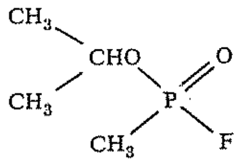
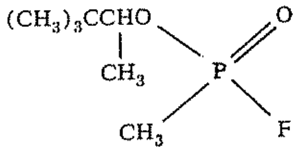
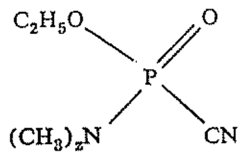
in which:

R_1, R_2, R_3 = alkyl or aryl

[71] See *Chemical Review*, vol. 225, 1951.

Table 1

TOXICITY OF G NERVE AGENTS

Chemical structure (name)	*LD_{50} (mg/kg)*	*Animals used*	*Administration route*
	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.
(Sarin)	0.016	rabbits	i.v.
	0.2	mice	i.p.
	0.62	mice	i.p.
	7.8	mice	p.c.
(Soman)			
	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.
(Tabun)	0.08	dogs	i.v.
	8	dogs	p.o.
(VX)	0.05	mice	i.p.

SOURCE: S. Francke, *Lehrbuch der Militärchemie*, Berlin, Deutscher Militärverlag, vol. 1, 1967.

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±0.23	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-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-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-min/m^3)	DuBois
	inhalation	0.0235	W. S. Koor *et al.*

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 supertoxic 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.

Table 3

THE TOXICITY OF TYPICAL NERVE AGENTS

Name	*Lethal dosage on bare skin (mg)*
Tabun	200-400
Sarin	100-200
Soman	50-100
VE	2-10

SOURCE: BC-stridsmedel, FOA, Stockholm, 1964.

Table 4

V AGENTS THAT HAVE BEEN DESCRIBED IN THE PUBLISHED LITERATURE

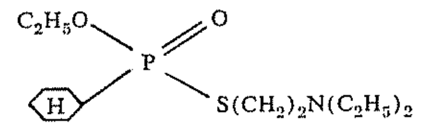
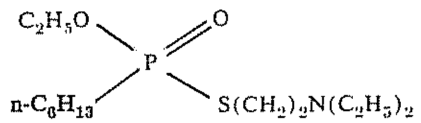
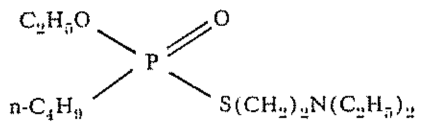
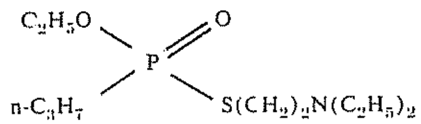
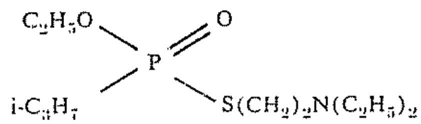
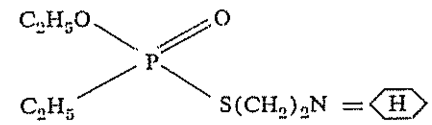
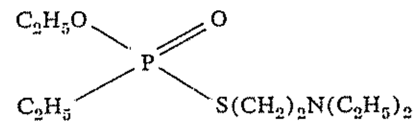
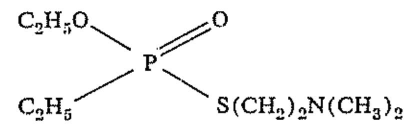
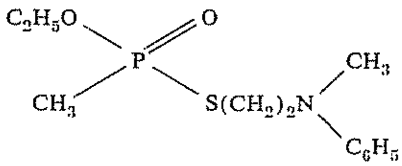
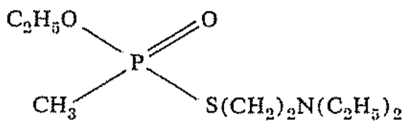
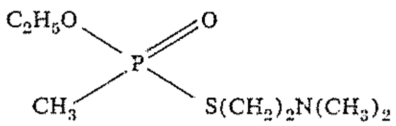
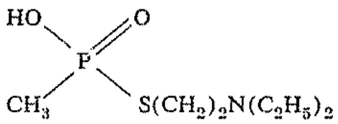
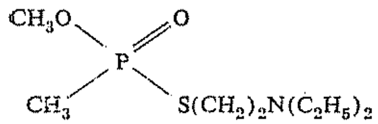
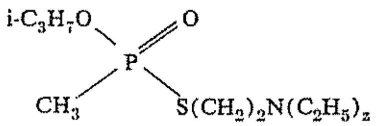
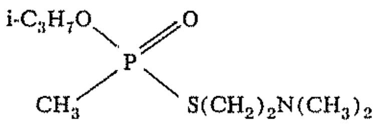
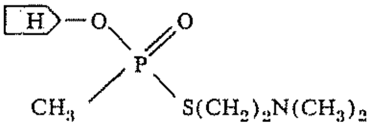
Formula	*Name*
	Ethyl S-2-diethylaminoethyl cyclohexyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl n-hexyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl n-butyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl n-propyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl i-propyl phosphonothiolate
	Ethyl S-2-piperidylaminoethyl ethyl phosphonothiolate
	Ethyl S-2-diethylaminoethyl ethyl phosphonothiolate
	Ethyl S-2-dimethylaminoethyl ethyl phosphonothiolate

Table 4 (continued)

Formula	*Name*	
	Ethyl S-2 methylphenylaminoethyl methyl phosphonothiolate	(GT 23)
	Ethyl S-2-diethylaminoethyl methyl phosphonothiolate	(F-gas)
	Ethyl S-2-dimethyl aminoethyl methyl phosphonothiolate	(VX)
		(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-dimethylamino-ethyl methyl phosphonothiolate	

SOURCE: *The problem of chemical and biological warfare*, SIPRI, Stockholm,, Almqvist and Wiksell, vol. 1, 1971.

Table 5

COMPOUNDS ANALOGOUS TO THE V NERVE AGENTS

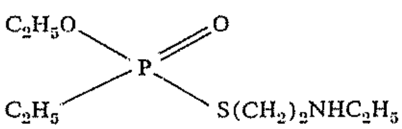
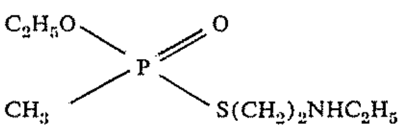
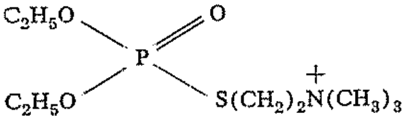
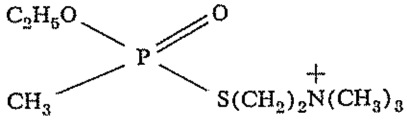
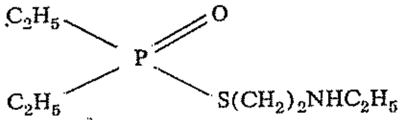
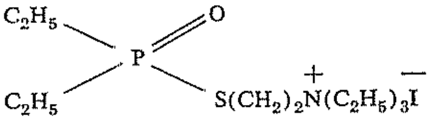
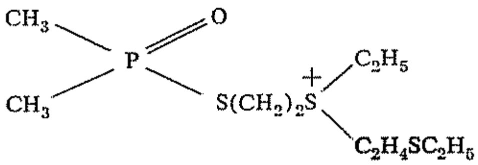
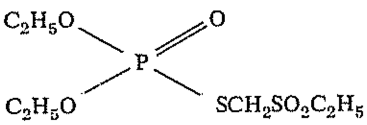
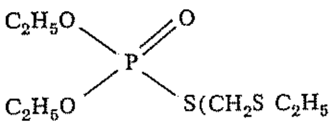
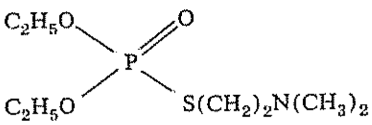
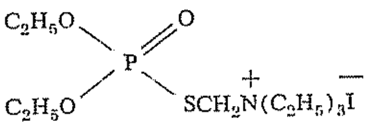
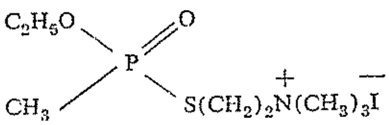
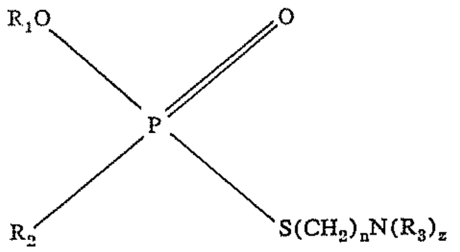
Formula	*Name*	*Animals used*	*Administration route*	*LD_{50} (mg/kg)*
	Ethoxy S-2-ethyl-aminoethyl ethyl phospine oxide	rats	p.o.	0.25
	Ethoxy S-2-ethyl-aminoethyl methyl phosphine oxide	rats	p.o.	0.25

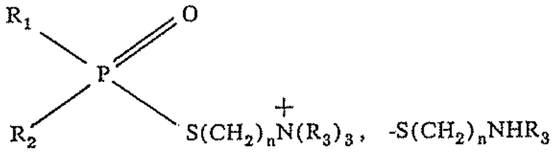
Table 5 (continued)

Formula	*Name*	*Animals used*	*Administration route*	LD_{50} *(mg/kg)*
	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-dimethylamino-ethyl) thiophosphate	mice	i.p.	0.41
	Diethoxy S-(2-triethylammonium methyl) thiophosphate iodide (DST)	mice	i.p.	0.17
	Ethoxy methylphosphoryl thiocolin iodide	mice	i.p.	0.03

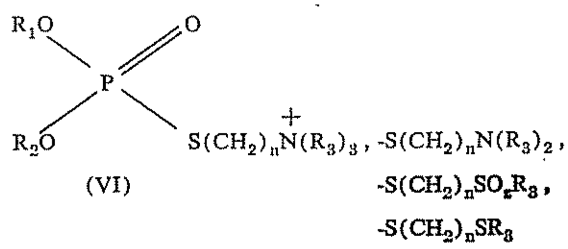
SOURCE: S. Francke, *Lehrbuch der Militärchemie,* Berlin, Deutscher Militärverlag, vol. 1, 1967 and *Handbuch der Experimentellen pharmakologie,* Cholinesterase and Anticholinesterase, Springer Verlag, vol. 15, 1963.



(IV)



(V)



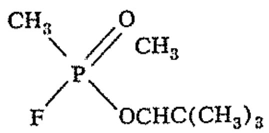
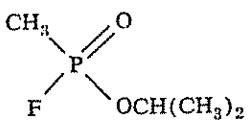
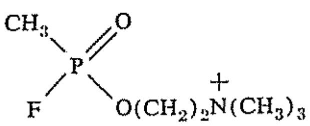
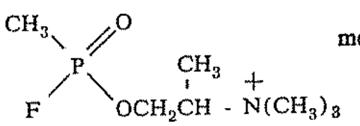
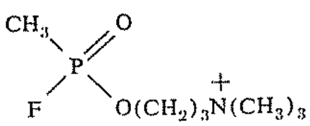
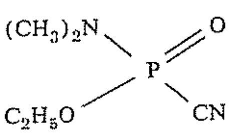
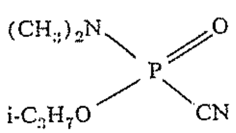
in which:

R_1, R_2, R_3 = alkyl

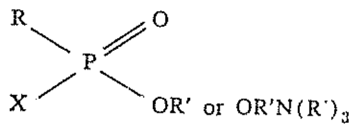
Similarly, the following two sub-general formulae (VII) and (VIII) are summarized from table 6, in which the chemical structure and the toxicity of the compounds are almost the same as those of the G agents.

Table 6

COMPOUNDS ANALOGOUS TO THE G NERVE AGENTS

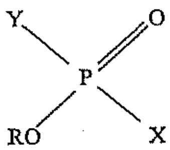
Formula	*Name*	*Animals used*	*Administration route*	*LD_{50} (mg/kg)*
	3, 3-dimethylbutoxy(2)-methyl phosphoryl fluoride (Soman)	mice	s.c.	0.04 0.1
	propoxy-(2)-methyl phosphoryl fluoride (Sarin)	mice	i.p. s.c.	0.2 0.05 0.2
	methyl fluoro phosphoryl cholin	mice	i.p.	0.1
	methyl fluoro phosphoryl 2-methyl cholin	mice	i.p.	0.03
	methyl fluoro phosphoryl nomo cholin	mice	i.p.	0.05
	dimenthylamino ethoxy phosphoryl cyanide (Tabun)	mice	i.p.	0.6
	dimethylamino isopropoxy phosphoryl cyanide	mice	i.p.	0.5
	methyl fluorophosphoryl carbo cholin	mice	i.p.	0.8

SOURCE: Same as Table 5.



(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 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.

Table 7

POSSIBLE SUB-GENERAL FORMULA FOR RELATIVELY HIGH TOXIC ORGANPHOSPHORUS COMPOUNDS

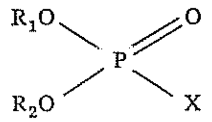
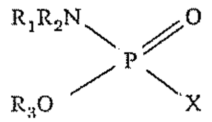
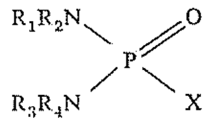
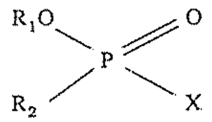
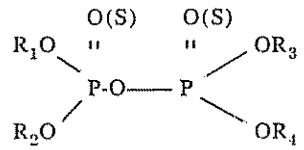
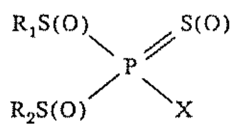
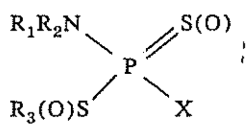
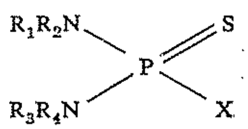
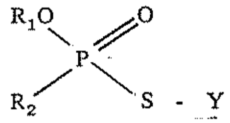
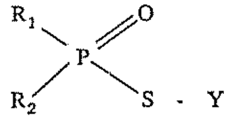
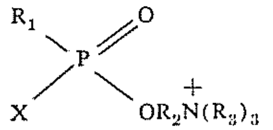
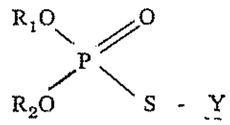
Group	*Sub-general formula*	*Radical groups*
1		X = F, Cl, OR_3 R_1, R_2, R_3 = alkyl, aryl
2		X = F, CN, Cl, OCN, SCN, OR_4 R_1, R_2, R_3, R_4 = alkyl, aryl
3		X = F, Cl, OR_5 R_1, R_2, R_3, R_4, R_5 = alkyl, aryl
4		X = F, OR_3 R_1, R_2, R_3 = alkyl, aryl
5		R_1, R_2, R_3 R_4 = alkyl, aryl RO exchangeable 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 = $-(CH_2)_nNHR3$, $-(CH_2)_nN(R_3)_2$ $-(CH_2)_n\overset{+}{N}(R_3)_3$
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 = $(CH_2)_n\overset{+}{N}(R_3)_3$, $(CH_2)_nN(R_3)_2$, $(CH_2)_nSO_2R_3$, $(CH_2)_nSR_3$

The supertoxic group mentioned previously is, of course, covered by these sub-general formulae, but not all the compounds which have these general formulae are supertoxic 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 supertoxic 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,

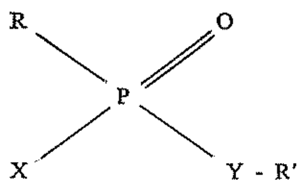
$$X = -SCH_2CH_2\overset{+}{N}(C_2H_5)_3,\quad -SCH_2CH_2\underset{\displaystyle CH_3}{\overset{+}{S}}C_2H_5$$

$$-SCH_2CH_2\overset{+}{N}(CH_3)_3,\quad -OCH_2CH_2\overset{+}{N}(CH_3)_3,\ \text{etc.}$$

As mentioned above, we have here dealt with the principal supertoxic 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, subcutaneous were to be adopted as the line of demarcation, as our delegation proposed at the Conference of the Committee on Disarmament last year,[72] 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



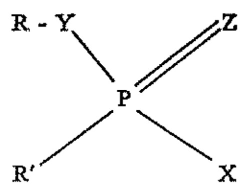
(IX)

in which:

R, R′, Y, X } = see table 9

all supertoxic nerve agents with toxic effects equal to or exceeding toxicity level 0.5 mg/kg subcutaneous, 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 Conference of the Committee on Disarmament 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

[72] *Official Records of the Disarmament Commission, Supplement for 1971,* document DC/234, annex C, sect. 26.

Table 8

THE ORGANOPHOSPHORUS COMPOUNDS WHICH SHOULD BE STUDIED

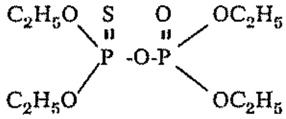
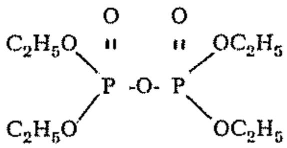
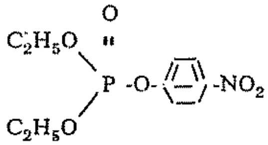
Formula	*Name*	*Animal used*	*Administration route*	*LD_{50} (mg/kg)*
	tetra-ethyl monothiono pyrophosphate	mice	i.p.	0.7
	T E PP	mice	i.p.	0.7
	Echothiophate	mice	i.p.	0.14
	Paraoxon	mice	i.p.	0.6 0.8

Table 9

THE RADICALS SUGGESTED FOR INCLUSION IN GENERAL FORMULA (IX)

R	*Y*	*R'*	*X*
alkyl	0	(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

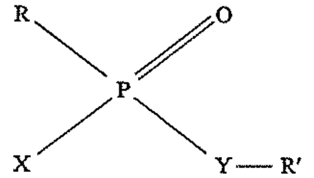
This suggestion of the Netherlands seems to be very reasonable. Basically, we give our support to this approach.

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 supertoxic 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, $P^1{}_1 = 0$, 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, subcutaneous.

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

18.

Yugoslavia: working paper on some aspects of the definition, classification and prohibition of chemical agents

[*CCD/375 of 5 July 1972*]
[*Original: English*]

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 10 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 organophosphorus 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*,[73] in the report of WHO entitled *Health Aspects of Chemical and Biological Weapons*,[74] and also in Protocol III[75] to the Brussels Treaty of 23 October 1954 relating to the renunciation of those weapons by the Federal Republic of Germany.

[73] United Nations publication, Sales No. E.69.I.24.
[74] World Health Organization, Geneva, 1970.
[75] United Nations, *Treaty Series*, vol. 211, No. 304.

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 and 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 us say, 10X, for which there is 100X 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 the Secretary-General and the report of 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 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 the Geneva Protocol of 1925[76] 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, that is, it must cover all kinds of chemical weapons and all phases of their development, production, stockpiling and destruction.

19.

Canada, Japan and Sweden: working paper on measures to improve tripartite co-operation among Canada, Japan and Sweden in the detection, location and identification of underground nuclear explosions by seismological means

[*CCD/376 of 20 July 1972*]
[*Original: English*]

1. At an informal scientific conference held in Tokyo from 7-13 June, representatives of scientific institutions from Canada, Japan and Sweden exchanged extensive technical reports and views on the seismological discrimination research being undertaken in each country and reached agreement on steps to improve trilateral co-operation, including data exchange for future research on this subject.

2. From the full exchange of information on the capabilities for the detection of seismic waves by key national seismograph facilities, it was concluded that these stations, in co-operation with the currently operating routine international programme of earthquake reporting, are sufficient for the detection and approximate location of siesmic events at least as small as underground consolidated rock nuclear explosions of intermediate yield or larger. It was agreed to collect the tripartite data for the continuing study of the identification of underground consolidated rock explosions of intermediate yield and larger, at which explosion yield levels it was agreed that there is already a high probability of explosion identification.

3. The two most effective seismological earthquake-explosion discrimination criteria known to the Governments are the surface-wave magnitude–body-wave magnitude method and short-period discriminants based upon the frequency and time-domain information in the short period body-wave signals. The individual national research and development programmes using these methods were examined, and it was concluded that it would now be advantageous to develop a programme of trilateral data exchange in order to evaluate tripartite capabilities in these fields. The primary requirement for this evaluation is the acquisition of a common event data base in mutually compatible recording formats for earthquakes from important seismic regions and detected explosions which continue to be detonated at the present time at the principal test sites. To facilitate tripartite evaluation of seismic events of mutual interest an agreement was reached on the form and quantity of data exchange, such data to be exchanged between scientific institutions on request from and as available in the respective countries.

4. Agreement was reached on measures to strengthen exchanges, not only of seismological data but also of scientific information in the field of seismic discrimination. In addition, it was agreed to continue to exchange views on the capabilities for discrimination achieved using nationally acquired data, acquired from key observing stations in the three countries and data generally made available to the international seismological community by the very valuable currently existing mechanisms of international seismic data exchange.

20.

Yugoslavia: working paper on the elements of a system for the control of the complete prohibition of chemical weapons

[*CCD/377 of 20 July 1972*]
[*Original: English*]

I. GENERAL PRINCIPLES

In the efforts exerted so far to find solutions for the complete prohibition of the development, production and stockpiling of chemical weapons, it is broadly accepted that the establishment of an effective system of control is one of the most complex and important tasks.

In its working paper CCD/302, submitted to the Committee on Disarmament on 6 August 1970,[77] the Yugoslav delegation has put forward its views and suggested some proposals on certain elements of the system for the control of the prohibition of chemical weapons.

The Yugoslav delegation considers that the majority of these proposals have not lost their validity and actuality.

In elaborating the system for the control of the complete prohibition of chemical weapons, particular attention should also be given to the following:

(1) The system of control should nowadays be based predominantly upon measures of national control, that is, on the self-control of States, as well as on the development of broad international co-operation as one of the most important means of mutual control.

(2) However, it is indispensable to envisage that in certain cases and in accordance with the United Nations Charter, appropriate measures of international control should be undertaken according to a procedure strictly defined or specifically agreed between the parties concerned.

(3) The system of control, which would have to represent an appropriate combination of national and international

[76] Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (League of Nations, *Treaty Series*, vol. XCIV, No. 2138).

[77] *Official Records of the Disarmament Commission, Supplement for 1970*, document DC/233, annex C, sect. 31.

measures of control, should be based to a great extent on confidence between States.

(4) For the operation of international control, it would be necessary to establish an appropriate international organ, which could become in the future an important element of an integral international machinery for disarmament control.

(5) Having in mind that the prohibition should cover all areas of activities of States relative to the preparation and eventual waging of chemical war, the system of control should encompass all activities of states aimed at:

(*a*) Development, production, and stockpiling of chemical warfare agents;

(*b*) Development, production and stockpiling of other elements of the chemical weapons system; and

(*c*) Training of troops and other preparation of military forces for eventual waging of chemical war.

(6) It is indispensable that the system of control should be both flexible and gradual in application before final measures of international control have been undertaken.

(7) The system of control should be constantly improved, taking into account the evolution of international political relations and new scientific and technological achievements, in order to become more reliable and more effective.

(8) The system of control should be organized and implemented in a manner designed to avoid hampering the development and the application of the achievements of chemical science for peaceful purposes.

II. National control

It is possible to foresee a number of national measures which, mutually interrelated, would provide for a comprehensive system of national control, that is, of self-control.

The working paper of the Yugoslav delegation, CCD/302, contains a certain number of national legislative measures of renunciation and self-control by each country.

Further measures to that effect could, *inter alia*, cover:

(1) Statement by governments, at the time of the entering into force of the convention on the prohibition of chemical weapons, about national activities carried out up to that time in the field of development, production and stockpiling of chemical weapons and also as regards chemical substances as a whole.

(2) The enactment of national legislative and administrative acts on:

(*a*) The organization and functioning of the national system of self-control including establishment of a group of experts with full authorization to act on the national level and to co-operate closely with the international control organ;

(*b*) The relationship between national and international control, and the national obligations in regard to the submission of regular reports to the international control organ according to a uniform standard, as well as the submission of special reports at the initiative of States Parties to the convention or the international control organ.

(*c*) The organization of the control of imports and exports of all chemical substances.

(3) Declassification of all data on the research and production of chemical warfare agents.

(4) The exchange of national experts between States.

III. International control

A. *International control organ*

1. In order to achieve the objective of the convention on the prohibition of chemical weapons, it would be indispensable to create an international organ, entrusted, on the one hand, with the task of reviewing the operation of the convention and the fulfilment of the obligations of States Parties to the convention on the basis of the appropriately regulated procedure; to stimulate their mutual co-operation and assist in co-ordinating their activities in this field; to analyse and classify new achievements in the field of chemical science and its applications and, on the other hand of carrying out on-site inspection in precisely determined cases upon instructions of the United Nations Security Council.

In order to be able to discharge its functions, this international organ should have at its disposal adequate expert services and necessary equipment.

2. An expert body, that is, a council of experts, might be set up within the international control organ, the members of which would be elected according to an internationally agreed procedure with precisely determined tasks and authorization to carry out on-site inspection if the need arose and when a decision to that effect was taken by the Security Council. The council of experts would also be entrusted to prepare proposals for the improvement of the system and methods of control and to perform other functions which might be entrusted to it.

B. *Procedure of international control*

In order to preserve the essential principle upon which the system of control is based, that is, predominant reliance on the measures of national control and the development of international co-operation as an important element of international control, it would be indispensable that the application of measures of international control be introduced gradually. Such approach is implicitly contained in the working paper of the Yugoslav delegation, CCD/302, proposing measures in case of suspicion of violation of the provisions of the convention by any party.

In addition, it would also be necessary to envisage the possibility that the group of national experts of the Parties concerned be engaged in solving in a satisfactory manner any case involving suspicion of such a violation as well as the possibility of acceptance of certain forms of international mediation by the parties concerned.

If a party to the convention lodges a complaint to the United Nations Security Council with a request that on-site inspection should be carried out, the Security Council might for that purpose consult the council of experts before deciding about the request itself, about the procedure for on-site control, the manner of its being carried out and the appropriate measures against the violator of the convention on the prohibition of chemical weapons. The Security Council should also decide on collective measures of assistance to a country which is exposed to danger as a result of violation of the convention by another party or parties.

21.

Canada: working paper containing bibliography of Department of Energy, Mines and Resources papers relevant to seismological verification problems

[*CCD/378 of 25 July 1972*]
[*Original: English*]

Since 1964 a small Seismic Applications Section of the Division of Seismology, Earth Physics Branch, Department of Energy, Mines and Resources, has conducted a broadly-based research and development programme into the problems of seismological verification of a comprehensive nuclear test ban.

This bibliography lists papers, reports, etc., published by members of the Section, those in press or submitted to scientific journals on 30 April 1972. Reprints can be supplied on request for all papers except those asterisked, for which reprints are not yet available. For these asterisked articles, only a limited number of xerox preprints exist or can be furnished on request.

In addition to the material listed herein, the Section has contributed to the SIPRI Seismic Study Group Report and its annual updating.

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22.

Sweden: list of publications bearing on seismological discrimination of nuclear explosions and earthquakes and available from the Research Institute of National Defence, Stockholm

[*CCD/379 of 27 July 1972*]
[*Original: English*]

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U. Ericsson. On seismic waves from explosions in the atmosphere. FOA 4 report A 4334, Research Institute of National Defence, Stockholm

1965

U. Ericsson. The detection club paper. FOA 4 report A 4462, Research Institute of National Defence, Stockholm

1966

U. Ericsson and O. Dahlman. On the dependence of short-period P-waves on yield, height and epicenter properties of nuclear airshots. FOA 4 report C 4261, Research Institute of National Defence, Stockholm

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O. Dahlman. On Scandinavian crustal traveltimes. FOA 4 report C 4295, Research Institute of National Defence, Stockholm

O. Dahlman. Seismologic test explosions in Western Sweden, March 1967. FOA 4 report C 4317, Research Institute of National Defence, Stockholm

U. Ericsson. Approaches to some test ban control problems. FOA 4 report C 4286, Research Institute of National Defence, Stockholm

1968

O. Dahlman, H. Axelsson and K. Edin. Charge, mass and elevation influence on seismic waves from small chemical explosions above ground. FOA 4 report C 4375, Research Institute of National Defence, Stockholm

O. Dahlman. Seismic records from the US nuclear explosion faultless 19/1/1968 obtained at Hagfors temporary seismological station. FOA 4 report C 4376, Research Institute of National Defence, Stockholm

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K. Kogeus. Teleseismic relative location of closely spaced epicenters. FOA 4 report C 4370, Research Institute of National Defence, Stockholm

1969

O. Dahlman. Shortperiod seismic noise in Western Central Sweden. FOA 4 report C 4388, Research Institute of National Defence, Stockholm

U. Ericsson. The question of nuclear explosions for peaceful purposes by non-nuclear weapon States and the possibility of misuse of such technology for the production of nuclear weapons. FOA 4 report C 4399, Research Institute of National Defence, Stockholm

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O. Dahlman, H. Israelson and H. Wägner. Ground motion and atmospheric pressure waves from nuclear explosions. *Nature Physical Science*, vol. 232, no. 30.

U. Ericsson. A linear model for the yield dependence of magnitudes measured by a seismographic network. *Geophysical Journal*, Royal Astronomical Society, vol. 25, p. 49. Also available as FOA 4 report C 4455-26, Research Institute of National Defence, Stockholm

U. Ericsson. Seismometric estimates of underground nuclear explosion yields. FOA 4 report C 4464-26, Research Institute of National Defence, Stockholm

U. Ericsson. Maximum likelihood linear fitting when both variables have normal and correlated errors. FOA 4 report C 4474 Research Institute of National Defence, Stockholm

U. Ericsson. Event identification by m(M) observations from networks. FOA 4 report C 4480-A 1, Research Institute of National Defence, Stockholm

H. Israelson. Identification of earthquakes and explosions with seismic data from Hagfors Observatory. FOA 4 report C 4468, Research Institute of National Defence, Stockholm

U. Ericsson. Identification of underground nuclear explosions and earthquakes. FOA reports, vol. 5, no. 8, Research Institute of National Defence, Stockholm

H. Israelson. Spectral content of teleseismic P-waves recorded at the Hagfors Observatory. *Geophysical Journal*, Royal Astronomical Society, vol. 25, p. 89.

1972

Event report No. 1, US nuclear explosion Cannikin. November 6, 1971, FOA 4 report C 4486-A 1, Research Institute of National Defence, Stockholm

Event report No. 2, earthquake in Hindu Kush, January 20, 1972. FOA 4 report C 4495-A 1 Research Institute of National Defence, Stockholm

Event report No. 3, USSR Explosion in Western Kazakhstan. December 23, 1972, FOA 4 report C 4499-A 1, Research Institute of National Defence, Stockholm

23.

Canada and Sweden: working paper on an experiment in international co-operation: short-period seismological discrimination of shallow earthquakes and underground nuclear explosions

[*CCD/380 of 27 July 1972*]
[*Original: English*]

1. *Introduction*

Working paper CCD/327, of 29 June 1972,[78] described the results obtained in an extensive case-study of seismological discrimination between a suite of Eurasian shallow earthquakes and underground explosions using the surface-wave magnitude (M_s)—body-wave magnitude (m_b) technique. This study utilized the recordings from standard conventional seismographic stations in Europe and Asia in order to obtain detectable long-period surface-wave signals from the smaller events in the data set. Further progress towards lower yield discrimination using this method now awaits scientific analysis and discussion of the results being obtained by the United States of America and Norway with their large aperture, long-period arrays (LASA, NORSAR and ALPA) and by the Very-Long-Period Experiment of the United States of America.

[78] *Ibid., Supplement for 1971*, document DC/234, annex C, sect. 9.

It therefore seemed useful to re-examine the power of seismological discriminants which depend only on short-period seismic observations. One discriminant initially suggested by the United Kingdom used the "complexity" in the P-wave or first body-wave arrival. In the mid-1960s, it was believed that 90 per cent of all shallow earthquakes could be classed as such on the basis of complexity, leaving only 10 per cent of events unclassifiable. However, this early estimate was downgraded once underground nuclear explosions occurred in Novaya Zemlya. Some further Canadian studies based on 35 underground explosions and more than 700 world-wide earthquakes of unrestricted depth, using other parameters which define the characteristics of the P-signal development with time, indicated that 10 per cent of the earthquakes in the sample violated a criterion which had only a 50 per cent chance of identifying an underground nuclear explosion as such. On the basis of studies such as these, the discrimination power of "complexity" was widely questioned.

Parallel to this work, studies in the Union of Soviet Socialist Republics, Japan, United States of America, Canada and Sweden were being made on the spectral content in the P-wave, attempting to utilize as a discriminant the fact that shallow earthquakes tend to have relatively more low frequency energy in the P-wave than do explosions of the same body-wave magnitude. However, the available statistics were too poorly defined to be of value in a rigorous discussion of the potential of the method.

In the United States of America, a modification of the spectral method called the spectral ratio method has been shown to have a high probability of correctly identifying both earthquakes and explosions using signals with adequate signal-to-noise ratio recorded on the LASA short-period array from certain Asian regions. Some Canadian studies suggested a further effective variant of the process and used a data sample going down to Yellowknife magnitude $m_b 4.5$ for earthquakes and $m_b 4.8$ for explosions. It was found that for Eurasia events, about 80 per cent of the shallow earthquakes overlapped 20 per cent of the explosions using this criterion with the data from the Yellowknife short-period array suitably regionalized.

2. *Recent developments in Canada*

The $M_s : m_b$ study described in CCD/327 provided the opportunity for a rigorous re-examination of independent short-period capabilities. Of the events described in CCD/327, a population of 57 shallow earthquakes and 27 explosions was available in the digital tape library extracted from the Canadian Yellowknife short-period array (YKA) data.

An intensive study was made of a number of parameters which define the characteristics in time of the P-wave signals, and a parallel study was made of the frequency content of these events using a number of different frequency ranges. Discrimination parameters were chosen for investigation that could later, in principle, be utilized in a real-time data system in an automatic mode, and personal bias was also eliminated. The results of this study have been published in a scientific journal: it was found that a combination of the information obtained in the time and frequency domains separated this data set into two distinct populations of earthquakes and explosions. Thus the combination of frequency and time characteristics provided a much more effective discriminant than any based on time-information or frequency-information alone. It might be noted that the Ural explosions described in CCD/327 which gave the greatest difficulty with the $M_s : m_b$ method were clearly identified with the short-period technique.

The results of this bivariate case-study were sufficiently encouraging that the data base was extended to include a total of 92 shallow earthquakes and 56 underground nuclear explosions. It was then found that a small overlap occurred for the higher yield explosions of the data set but otherwise the populations remained distinct down to the lower limits of available data. This study is described in a journal article which is in press at this time.

3. *Swedish studies of short-period seismological discrimination*

Somewhat similar studies were undertaken in Sweden using short-period data recorded at the Hagfors Observatory (HFS) with event populations comprised of 32 Eurasian explosions and 177 earthquakes. Although in detail some parameter definitions were slightly different, a result similar to the Canadian one was obtained in that a combined use of the time and frequency information enhanced the discrimination. As with the YKA data, it was found that earthquakes having depths greater than about 100 km tended to appear explosion-like using these parameters. Furthermore, the Swedish work indicated that the time and frequency discriminants differed considerably when examined on a regional basis, but were not observed to differ greatly between the large-scale tectonic belts.

The Swedish study also used multivariate statistical analysis with discriminants defined from detailed information in the time and frequency domains. These results were inter-compared using identification curves. Such curves are essentially graphs of the false alarm probability versus the identification probability, where the false alarm probability is defined as that of mistaking an earthquake for an explosion, and the identification probability is defined as that of correctly classifying an explosion as such.

In this way the multivariate discriminants appeared to be more efficient than discriminants obtained using simpler concepts in the time and frequency domains. In addition, classification experiments with the total event population were conducted with the multivariate discriminants. A 90 per cent identification probability corresponded to a false alarm probability of about 3 per cent. Most of the false alarms were produced by deep earthquakes in this HFS data set. This study is described in a journal article in press at the present time.

4. *Combined Canadian-Swedish study*

To establish more generally the applicability of short-period discriminants, using widely separated stations observing an extended region of Eurasia, Canadian and Swedish scientists have been cooperating in a study of a data set common to YKA and HFS.

Seismic data available from the YKA tape library and also common to the data of the HFS tape library for the period from June 1969 to March 1972 contained 135 shallow Eurasian earthquakes with an estimated depth less than or equal to 50 km, and with National Oceanic and Atmospheric Administration (NOAA) body-wave magnitudes (m_b) between 4.1 and 5.9. In addition, 30 presumed Eurasian explosions with a body-wave magnitude m_b between 4.6 and 5.8 were common to both libraries. These data covered a number of explosion sites in Eurasia, and earthquakes from a variety of Eurasian regions. The locations of YKA and HFS are such that the azimuths of the propagation paths between an event and the two recording stations were quite different for most of the events.

Discrimination parameters involving both the time and frequency characteristics of the P-wave signal were combined in various multivariate modes. In order to compare the relative discrimination capabilities for YKA data alone, HFS data alone and the combination of YKA and HFS data, identification curves were calculated. The two-station case significantly improves the identification probability at a fixed false alarm probability. With this data set, an identification criterion was defined giving an identification probability of more than 95 per cent with a false alarm probability of 1 per cent. The power of this discriminant appears approximately equivalent to that of the widely accepted $M_s : m_b$ discriminant. These results have been submitted to a scientific journal for publication.

5. *Further studies*

The Canadian and Swedish scientists involved in this joint study intend to pursue the matter by making further studies on existing data sets, and by increasing the statistical significance of their results using more extensive data sets. It seems reasonable to assume that a very effective discriminant with a very low false alarm probability is potentially possible by this technique or some modification of it.

There are, however, two serious limitations. First, although the method appears powerful where it can be used, it is premature to define the applicability of the method in the low magnitude range. However, it would appear that the method has a potentially high probability of application down to low-yield hard rock explosions in Eurasia. Although the detection capability of YKA and HFS and their regional variability have been studied, systematic studies of the level of applicability of the short-period discriminant remain to be made.

Secondly, it must be realized that the method, although physically reasonable, has not been given a theoretical basis generally applicable. Since complex effects near a source can probably never be treated adequately for all conceivable locations, it appears unlikely that a universally applicable theoretical basis for the technique can be devised. Accordingly, it therefore is extremely important to extend the data sets to obtain results from a variety of locations in order to strengthen the statistical basis of the results obtained.

Similar studies of earthquakes and explosions in North America should be attempted with sensitive tape recording seismic observatories or medium-aperture arrays at a sufficient distance; the above results demonstrate capabilities only for Eurasian events.

24.

Letter dated 21 July 1972 from the representative of Finland to the Special Representative of the Secretary-General of the United Nations to the Conference

[*CCD/381 of 27 July 1972*]
[*Original: English*]

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.

(*Signed*) Klaus A. SAHLGREN
Permanent Representative of Finland to the United Nations at Geneva

WORKING PAPER SUBMITTED BY THE GOVERNMENT OF FINLAND TO THE CONFERENCE OF THE COMMITTEE ON DISARMAMENT ON DEFINITIONS OF CHEMICAL WARFARE AGENTS AND ON TECHNICAL POSSIBILITIES FOR VERIFICATION AND CONTROL OF CHEMICAL WEAPONS WITH PARTICULAR REGARD TO A FINNISH PROJECT ON CREATION ON A NATIONAL BASIS OF CHEMICAL WEAPONS 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 chemical weapons treaty now under consideration in the Conference of the Committee on Disarmament. 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 Conference or not, have a vital interest in promoting concrete progress in disarmament. By its project designed to create a national chemical weapons control capacity for possible future international use, the Finnish Government is endeavouring to make a practical contribution towards this end.

2. In pursuance of General Assembly resolution 2827 A (XXVI), of 16 December 1971, which in paragraph 3 requested the Conference of the Committee on Disarmament "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 Conference of the Committee on Disarmament the following working paper on definitions of chemical warfare agents and on technical possibilities for verification and control of chemical weapons with particular regard to a Finnish project on creation on a national basis of a chemical weapons 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 17 November 1971.[79] He stated *inter alia*:

"In the opinion of the Finnish Government, the chances of success in the negotiations on chemical weapons would be improved by paying special attention . . . to the following issues: first, by international co-operation, methods which would make available to all interested Governments expert information on verification and control of chemical agents and chemical weapons should be studied and developed. . . . Secondly, technical capacity should be developed and the facilities should be acquired on the national level for verification of chemical agents and 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 chemical warfare agents are concerned a purpose criterion would provide the simplest and most comprehensive definition of those 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 chemical warfare agents the nerve agents form the group of compounds of greatest concern. As suggested by the Netherlands delegation in 1971 (CCD/320)[80] they can be defined with a general chemical formula connected with a toxicity level criterion (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 in document CCD/374 and by the United States in document CCD/365 (see sect. 17 and 8 above). In the latter document a very general formula is proposed, which would cover practically all derivatives of orthophosphoric acid. Between the Netherlands and Japanese formulae, there seem to be only minor differences and it seems not too difficult to come to an agreement on a definition of organophosphorus nerve agents on the basis of these proposals. The Italian working paper CCD/373 and the Swedish working paper, CCD/372 (see sect. 16 and 15 above) provide a further valuable contribution on these problems.

It has been pointed out in the working paper of the United States delegation that carbamates present a second type of nerve agent. 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 if organophosphate nerve agents (and possibly also carbamates) 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 the Conference of the Committee on Disarmament.

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 pro-

[79] *Official Records of the General Assembly, Twenty-sixth Session, First Committee*, 1830th meeting.

[80] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234, annex C, sect. 3.

vide the basis for an eventual international mechanism. The Finnish Government has taken cognizance with great interest of the views put forward by the expert from the USSR at the informal meeting of the Conference on 5 July 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 also.

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 mentioned toxicity value (LD_{50}) equal to or more than 0.5 mg/kg body weight. This group would contain for example 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 for 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 intially. The Finnish efforts visualizing the creation of a national chemical weapons 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 chemical weapons. All efforts to find a basis for a comprehensive political solution, as for example the draft convention presented by seven socialist members of the Conference of the Committee on Disarmament on 28 March 1972 in document CCD/361 (see sect. 5 above), are indispensable and welcome. It is obvious that in the final analysis, the achievement of a chemical weapons treaty will depend on political will rather than on solving problems of a technical character. Besides the obvious need for adequate verification, the purpose of efforts to solve the most obvious technical problems connected with a chemical weapons 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: to assure that the prohibition against the manufacturing of chemical warfare agents is observed; verification of the destruction of existing stocks of chemical warfare agents; and to investigate a possible complaint about the use of chemical weapons in the field. Although the first function is the more important in the context of an eventual chemical weapons treaty, the third one should not be forgotten, either. The use of chemical weapons, at least those of the traditional First World War type, might still occur, despite the prohibitions of the Geneva Protocol of 1925,[81] in certain cases of limited warfare. However, it is mainly the problem of verification of the production of chemical warfare 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 the Conference of the Committee on Disarmament, for example, by Mrs. Myrdal of Sweden on 14 March 1972, the work on a chemical weapons treaty could be concentrated in the beginning on those agents which correspond to the double criterion of being produced solely for military purposes and being 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 p. 14). Ambassador Rosenberg Polak of the Netherlands stated on 23 March 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).

7. Although the ultimate goal is, of course, a comprehensive treaty banning all chemical 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 chemical weapons treaty. In his speech on 17 November 1971 in the First Committee of the General Assembly, 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, a verification and control capacity on chemical weapons for possible international use. The study has proceeded as planned. A survey of resources has been made, and the Government of Finland is considering the necessary bugetary allocations for an initial research and training programme for this purpose.

25.

Mexico: letter dated 25 July 1972 from the representative of Mexico to the Special Representative of the Secretary-General of the United Nations to the Conference

[*CCD/382 of 27 July 1972*]
[*Original: Spanish*]

I have the honour to transmit to you the memorandum entitled "Opinion of the Government of Mexico on the convening of a world disarmament conference", together with an annex. Since this memorandum not only deals with a question of obvious interest to the Conference of the Committee on Disarmament but also contains various observations on the part which the Conference could play in this respect, I should be grateful if you would have the memorandum circulated as a working paper of the Conference.

(*Signed*) Alfonso García Robles
Chairman of the Mexican Delegation to the Conference of the Committee on Disarmament

Opinion of the Government of Mexico on the convening of a world disarmament conference

1. At its 2022nd plenary meeting, held on 16 December 1971, the General Assembly of the United Nations adopted resolution 2833 (XXVI) entitled "World Disarmament Conference" by acclamation.

2. The resolution, which was undoubtedly one of those adopted by the Assembly at its twenty-sixth session which may reasonably be expected to yield the most beneficial results, contains an invitation to "all States" to communicate to the Secretary-General before 31 August 1972 "their views and suggestions on any relevant questions relating to a world disarmament conference", and in particular on the six points listed in paragraph 2 of the resolution.

3. This memorandum, submitted in compliance with the General Assembly's invitation, summarizes the Mexican Government's opinion on those specific points and on the question as a whole.

1. *Main objectives*

4. The aim of the Conference should be to take the requisite decisions to provide the United Nations with an effective

[81] Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare (League of Nations, *Treaty Series*, vol. XCIV, No. 2138).

disarmament system capable of obtaining more encouraging results than those achieved to date in the vitally important task which the Charter conferred on the Organization by specifically instructing it to turn its attention to promoting "the establishment and maintenance of international peace and security with the least diversion for armaments of the world's human and economic resources".

5. In order to achieve this end and make tangible progress both towards the ultimate goal of the elimination of nuclear weapons and general and complete disarmament under effective international control and towards the immediate adoption of partial measures to limit and reduce nuclear armaments and suppress other weapons of mass destruction, it will be necessary to strengthen principles, review rules, develop procedures and bring up to date the international machinery dealing with these questions.

6. With regard to that machinery it would seem advisable, in the light of the experience acquired during the more than 25 years since the San Francisco Conference was held in 1945, for the Conference to recommend to the General Assembly that in future there should be three main organs for the promotion of disarmament.

(1) The General Assembly, which should continue to be the supreme organ, would receive and consider reports from the other two, which it could entrust with specific tasks;

(2) The world disarmament conference—replacing the Disarmament Commission, which would be dissolved in order to avoid duplication and for other obvious reasons—would be open to "all States"; it would meet every three or four years in order to review progress in the field of disarmament, compare the development in regard to armaments and disarmament and adopt the decisions which the general review calls for. In short, within the United Nations the World Conference would have the same position in the field of disarmament as the United Nations Conference on Trade and Development in the economic and social field.

(3) A negotiating body of about 30 members, preferably the Conference of the Committee on Disarmament, which celebrated its tenth anniversary this year. Naturally, for this to be possible, various changes would have to be made which would both increase its effectiveness and enable the People's Republic of China and France to take part in its work. First and foremost among such changes should be the abolition of the unusual institution whereby the nuclear super-Powers act as Co-Chairmen, and its replacement by a procedure more consistent with the principle of the sovereign equality of States, such as the annual election of a chairman from among the non-nuclear States members or monthly rotation among all members as in the Security Council.

2. *Provisional agenda*

7. The body which the General Assembly entrusts with the preparatory work should, in consultation with "all States", work out a realistic and ambitious, detailed and flexible provisional agenda for the Conference.

8. The starting point for the preparation of the provisional agenda could be the comprehensive programme of disarmament which was originally introduced in the Conference of the Committee on Disarmament in August 1970 by the delegations of Mexico, Sweden and Yugoslavia and subsequently submitted to the General Assembly at its twenty-fifth session, sponsored by Ireland, Mexico, Morocco, Pakistan, Sweden and Yugoslavia.

9. As will be recalled, the full text of the comprehensive programme of disarmament was reproduced in document A/8191 of 2 December 1970 and the General Assembly specifically recommended in resolution 2661 C (XXV) of 7 December 1970 that it should be taken into account in further work and negotiations relating to disarmament.

3. *Site favoured*

10. In line with the preference usually shown for the venue of meetings of this kind, Geneva would seem to be the most appropriate site for the world disarmament conference.

4. *Date and contemplated duration of the conference*

11. In view of the urgent need to enhance the effectiveness of efforts to promote disarmament, the Conference should ideally take place in 1973. It should not be forgotten, however, that one of the basic prerequisites for its success, as Mexico pointed out in the debate at the twenty-sixth session of the General Assembly, is that thorough preparations should be made before the Conference, since the latter will arouse expectations on the part of world public opinion which must not be disappointed. It would therefore probably be more realistic and convenient to plan the conference for spring 1974.

12. In view of the breadth and complexity of the general subject with which the conference will deal, it would seem advisable to envisage a duration of two to three months. It should be recalled that that has been the duration of various United Nations conferences, such as the first United Nations Conference on the Law of the Sea (24 February to 27 April 1958), the first session of the United Nations Conference on Trade and Development (23 March to 16 June 1964) and the first part of the United Nations Conference on the Law of Treaties (26 March to 24 May 1968). It might also be appropriate to consider the advisability of dividing the first session of the world disarmament conference into two parts, as was done in the case of the last of the above-mentioned three Conferences, the first part to be held in the spring of 1974 and the second in the spring of 1975. In that way the new body would be able to take its first steps, which as always will be the most difficult, without haste, and would have enough time for judicious consideration of the enormous problems involved.

5. *Procedures to be adopted for carrying out the preparatory work*

13. It would seem essential that the General Assembly should entrust the preparatory work to an *ad hoc* body whose membership would be sufficiently broad to ensure adequate geographical and political representation and yet compact enough for the work entrusted to it to proceed quickly.

14. In view of the foregoing and bearing in mind the composition of the Conference of the Committee on Disarmament (26 members), the Preparatory Committee for the United Nations Conference on the Human Environment (27 members) and the Committee on the Peaceful Uses of Outer Space (28 members), it may be concluded that a membership of about 30 would be appropriate for the body in charge of preparations for the world disarmament conference.

15. On the other hand, it should not be forgotten that although, as has been said, the preparatory body would *de facto* have a restricted membership, in principle or *de jure* it should be open to "all States", as would the conference in accordance with the provisions of General Assembly resolution 2833 (XXVI), and that it would be extremely desirable for all the nuclear Powers to be members.

16. Accordingly, in the event that the Conference of the Committee on Disarmament should be the body entrusted with the preparatory work, it should be reorganized beforehand, as was said in the first section of this memorandum. This could be done by a General Assembly resolution similar to resolution 2602 B (XXIV), by which the membership of the Committee was increased from 18 to 26 in 1969.

17. Another particularly important element in the success of the preparatory work would be to request the Secretary-General to prepare authoritative studies on concrete questions relating to the arms race and particularly the nuclear arms race, control thereof and disarmament, in such a way that they would be available sufficiently in advance of the opening of the conference. They should include a study on the establishment of nuclear-weapon-free zones and the obligations which nuclear weapon States should assume with regard to them.

18. It can be seen from the many useful working documents which the Secretary-General provided for the first United Nations Conference on the Law of the Sea and the Conference of Non-Nuclear-Weapon States how valuable a similar contribution could be in this case.

6. *Relationship of the conference to the United Nations*

19. As has been said, the world disarmament conference should be an organ of the General Assembly which would co-operate with it as UNCTAD does in the field of trade and development in order to help it discharge its functions under the Charter in the field of disarmament.

20. The conference could hold regular spring sessions at three-year intervals and special sessions whenever the General Assembly of the United Nations—to which the conference would report periodically—deemed fit to convene them.

7. *Final observations*

21. The Government of Mexico is firmly convinced that, as the General Assembly stated in the preamble to its resolution on the convening of a world disarmament conference, "it is imperative that all States exert further efforts for the adoption of effective measures of disarmament and, more particularly, nuclear disarmament".

22. A general review of developments during the past decade and of the serious situation prevailing today shows that that conviction is well founded.

23. Such an analysis provides positive proof that the resources which the world has squandered for military purposes amounted to approximately $120,000 million in 1962 and rose to over $200,000 million in 1971, an increase of 70 per cent during the period. Moreover, the number of nuclear weapons tests, although conducted largely underground, far from decreasing as a result of the partial prohibitions embodied in the Treaty of Moscow of 1963[82] increased during the period by approximately 60 per cent. Furthermore, it is estimated that the nuclear bombs amassed in the arsenals of Powers possessing those terrible instruments of mass destruction today represent the incredible equivalent of about 15 tons of dynamite for every person on earth.

24. It is thus obvious and axiomatic that, in the face of the potential threat which that situation poses to mankind's very survival, "all peoples of the world have a vital interest in the success of disarmament negotiations", as affirmed in General Assembly resolution 2833 (XXVI), and that the United Nations should strive with ever-increasing energy to discharge its responsibilities in the quest for disarmament, in the conviction that, as was stated in 1959 and reiterated 10 years later, the question of general and complete disarmament is the most important one confronting the modern world.

25. It would truly be somewhat ironic if the proclamation of the decade of the 1970s as the Disarmament Decade led only to words, not deeds. The convening of a world disarmament conference and its institutionalization within the United Nations would undoubtedly be an excellent way to promote and facilitate the simultaneous cessation of the nuclear arms race at an early date—which would require a strict moratorium followed by specific limitations and substantial reductions—and the conclusion of additional agreements on specific related measures, without thereby losing sight of the ultimate objective, namely, the elimination of nuclear weapons and all other weapons of mass destruction and the conclusion of a treaty on general and complete disarmament under effective international control.

26. In order to facilitate the convening of the conference and avoid problems such as those which the Secretary-General unfortunately had to face in connexion with the circulation of resolution 2833 (XXVI)—problems to which, it might be observed in passing, his note A/8681 of 2 May 1972 provided a suitable and practical solution—it would appear that the General Assembly, in taking a decision at its forthcoming session on the various matters still pending with respect to the convening of the conference, should define the scope which should be ascribed to the phrase "all States". The Government of Mexico, which has always favoured using that general expression in all resolutions on disarmament, wishes to reiterate its position that, when the time comes to send invitations to States to participate in the world disarmament conference, the phrase in question should be interpreted by strictly applying the principle of universality. In other words, *all* States would have the right to be invited to take part in the conference, and an invitation to that effect would have absolutely no juridical or political implication concerning their international status.

27. The Government of Mexico is convinced that consideration of the item inscribed under the title "World Disarmament Conference" on the provisional agenda of the twenty-seventh regular session of the General Assembly, must not and should not be adversely affected by disagreements which exist or may arise among the permanent members of the Security Council. The balanced and calm consideration of this highly important subject, leading to the unanimous adoption of the requisite resolution or resolutions, would no doubt be greatly facilitated if no State claimed to have taken the initiative with regard to the convening of the Conference and if all recognized, as is actually the case, that the initiative is being taken by the United Nations as a whole. As early as 1957 the General Assembly decided in resolution 1011 (XI) to consider the advisability of convening "a general disarmament conference"; eight years later, in 1965, the Assembly endorsed the "convening of a world disarmament conference to which all countries would be invited" (resolution 2030 (XX); and, as everyone is aware, its most recent resolution on the subject was adopted by acclamation on 16 December 1971.

28. If we wished to seek out the deep-rooted origins of the sweeping collective movement which culminated in General Assembly resolution 2833 (XXVI), we would have to look for them in the efforts of the large majority of countries generally known as the third world. First, in Belgrade in September 1961; then, in Cairo in October 1964; later, in New York, where 42 of them sponsored the draft resolution which on 29 November 1965 was to become General Assembly resolution 2030 (XX), adopted by a very eloquent majority of 112 votes in favour and none against; after that in Geneva, when in August 1970 the Conference of the Committee on Disarmament received from the delegations of three non-aligned States the draft of a comprehensive programme of disarmament, the final conclusion of which was that the feasibility of convening "a world disarmament conference of all States" should be thoroughly studied; one month later in Lusaka and, finally, at United Nations Headquarters during the twenty-sixth session of the General Assembly, when a number of non-aligned delegations successfully conducted a patient campaign of conciliation which enabled them to elaborate in its totality what was to become General Assembly resolution 2833 (XXVI). Thus little by little, thanks to their aspirations and perseverance, have been built the foundations on which it is hoped to establish the world disarmament conference as an institution that will, without delay, help to strengthen the concerted efforts of Governments to put a stop to the uncontrolled arms race, in particular in the nuclear field, which entails such incalculable risks for world peace and places so heavy an economic and social burden on all nations.

Appendix

COMPREHENSIVE PROGRAMME OF DISARMAMENT

[*For the text, see* Official Records of the General Assembly, Twenty-fifth Session, Annexes, *agenda items 27, 28, 29, 30, 31, 93 and 94, document A/8191,* or Official Records of the Disarmament Commission, Supplement for 1970, *document DC/233, annex C, sect. 42.*]

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[82] Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water (United Nations, *Treaty Series*, vol. 480, No. 6964).

26.

The Netherlands: working paper on the possibility of delimitating nerve gases within the field of organophosphorus compounds

[*CCD/383 of 1 August 1972*]
[*Original: English*]

Introduction

Both from the report of the Secretary-General of the United Nations[83] and from the report of the World Health Organization[84] 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 retardants 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.[85] 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 for which it is intended, for example, 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.[86] However, there are a number of cases where organophosphorus compounds have a high toxicity for insects and a low toxicity for mammals (for example, 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 Conference of the Committee on Disarmament[87] 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 Conference[88] 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 criterion 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

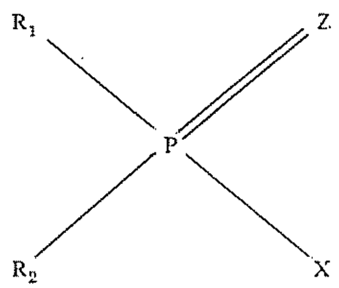
In a way the position with organophosphorus compounds is a favourable one in that we know a good deal about the mechanism of the toxicity on the molecular level: the forementioned inhibition of the enzyme acetylcholinesterase. There seems to be a reasonable relationship between toxicity and the anti-acetylcholinesterase potency.[89] 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 se* but are metabolized into potent inhibitors in the organism.

All the nerve agents mentioned in the literature[90] 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 obtain 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.[91]

$$E + I \underset{k_2}{\overset{k_1}{\rightleftharpoons}} [EI] \; n \xrightarrow{k_p} [EI]\; I$$

[83] *Chemical and Bacteriological Weapons and the Effects of their Possible Use* (United Nations publication, Sales No. E.69.I.24).

[84] *Health Aspects of Chemical and Biological Weapons* (World Health Organization, Geneva, 1970).

[85] See S. Francke, *Lehrbuch der Militärchemie*, Berlin, Deutscher Militärverlag, vol. 1, 1967, p. 21.

[86] See D. F. Heath, *Organophosphorus Poisons*, Oxford, Pergamon, Press, 1961, p. 11 and "Alternative Insecticides for Vector Control", Bulletin of the World Health Organization, 1971, vol. 44, Nos. 1, 2 and 3.

[87] See *Official Records of the Disarmament Commission, Supplement for 1970*, document DC/233, annex C, sect. 30.

[88] *Ibid., Supplement for 1971*, document DC/234, annex C, sect. 5.

[89] See K. Stade, *Pharmakologie und Klinik synthetische Gifte*, Berlin, Deutscher Militärverlag, 1964, p. 333.

[90] D. F. Heath, *loc. cit.*, pp. 317-397.

[91] See W. N. Aldridge, *Biochemical Journal*, vol. 46, 1950, p. 451.

in which E is the enzyme, I the inhibitor, $[EI]_R$ an enzyme-inhibitor complex and $[EI]_I$ 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. A. R. Main gives some data in a number of publications[92,93] 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.

$$E + I \xrightarrow{k_I} [EI]_I$$

for which the relation $k_I = k_p/K_d$ in the case of a powerful inhibitor can be shown[93] k_I is reasonably easy to determine.[94]

In the following, we will use this rate constant as a measure for antiacetylcholinsterase effects. In general, the rate of enzyme inhibition depends on a number of factors than 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.[95] Only the rate constant of the faster reacting stereoisomer has been shown.

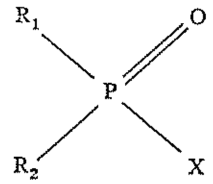
As indicated above, two factors can be distiguished: the strength of the P-X bond; and the interaction of group X with the enzyme.

(*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.[96] The few experiments we carried out with azidates ($X = N_3$, $pK_aHN_3 = 4.7$) 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).

(*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[97] 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[96] that in the case of compound 8 only the protonated (charged) form reacts with acetylcholinsterase. 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-acetylcholinsterase effect 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 aykyl 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 $X = F, N_3, CN, S\text{-}(CH_2)_n\text{-}\overset{+}{S}R_2, S\text{-}(CH_2)_n\text{-}\overset{+}{N}R_2$ and $S\text{-}(CH_2)_n\text{-}\overset{+}{N}R_3$ 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 acetylcholinsterase 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:

$(Alkyl)_2\ P{=}O$, $(Alkyl\ O)_2\ P{=}O$, and $(Alkyl\ O)\ (Alkyl)\ P{=}O$

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 for example 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

92 See *Science*, vol. 144, 1964, p. 992.

93 See A. R. Main and F. Iverson, *Biochemical Journal*, vol. 100, 1966, p. 525.

94 For the methods, see A. J. J. Ooms and H. L. Boter, *Biochemical Pharmacology*, vol. 14, 1965, p. 1839.

95 A. J. J. Ooms, Thesis, State University, Leyden, 1961, and H. L. Boter, Thesis, State University, Leyden, 1970.

96 See A. J. J. Ooms, Thesis, State University, Leyden, 1961.

97 See L. E. Tammelin, *Svensk Kemisk Tidskrift*, vol. 70, 1958, p. 157.

with ethyl groups. With larger alkyl groups the reaction rates drop off very rapidly.[96]

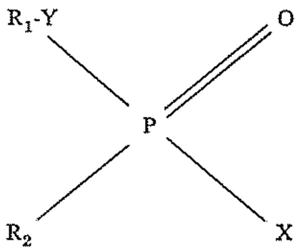
The structural requirements for the alkoxy group seem to be less stringent. There seems to be a maximum in the C_4-C_6 range. Very high rates are obtained with alkoxy groups containing a dialkylamino or a trialkylammonio group (so-called Tammelin compounds)[97] and with cycloalkyl groups. Rate constants 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.[98]

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 (for example, Tabun).[99] 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[100] 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.

[98] H. L. Boter and A. J. Ooms, *Biochemical Pharmacology*, vol, 16, 1967, p. 1563.

[99] S. Francke, op. cit., p. 347.

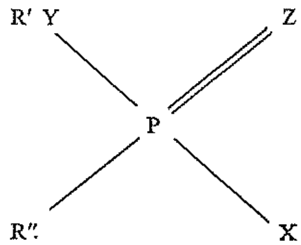
[100] See A. H. Aharoni and R. D. O'Brien, *Biochemistry*, vol. 7, 1968, p. 1538.

The influence of the P=S 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.[101] 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 bio-oxydation to the corresponding P=O compounds.[102] 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).[96] 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 criterion 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-$(CH_2)_2$-$\overset{+}{S}$ R_2 ''', S-$(CH_2)_n$-N R_2'' or S-$(CH_2)_n$-$\overset{+}{N}$ R_3'''

R' = (substituted) alkyl, cycloakyl or hydrogen

R'' = dialkylamino

R''' = alkyl

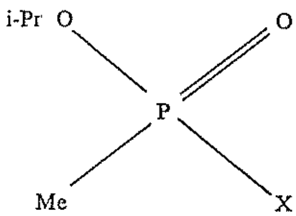
In combination with a carefully selected toxicity criterion, we consider the delimitated group of compounds to include very few compounds which are used as pesticides whereas the majority of compounds may be used as chemical warfare agents. This group could therefore be liable to an unconditional prohibition of production and stockpiling.

[101] H. L. Boter and A. J. J. Ooms, *Recueil des travaux chimiques*, vol. 85, 1966, p. 21.

[102] See for example, D. F. Heath, op. cit., p. 223.

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*	$k_1(25°, pH = 7.7)$
1)	HO-  —N Me_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

27.

Sweden: working paper on domestic legislation in Sweden regarding chemical substances

[*CCD/384 of 8 August 1972*]
[*Original: English*]

During the discussions in the Conference of the Committee on Disarmament on a chemical weapons prohibition, particular attention has hitherto been focused on the supertoxic 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, the 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, for example 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, radio-active 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, that is, 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 anthority 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 particularly 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 the 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 and 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.

28.

Mexico: working paper containing a subject index of opinions expressed on the question of the reorganization of the Conference of the Committee on Disarmament during its meetings held from 29 February to 3 August 1972

[*CCD/385 of 8 August 1972*]
[*Original: Spanish*]

I. In addition to the Secretary-General of the United Nations (545th meeting), the following delegations have referred in their statements to the question of the reorganization of the Conference of the Committee on Disarmament:[103]

Brazil	557th and 564th meetings
Bulgaria	549th meeting
Canada	546th and 571st meetings
Czechoslovakia	550th meeting
Egypt	555th meeting
Hungary	554th meeting
India	552nd meeting
Italy	547th meeting
Japan	547th and 562nd meetings
Mexico	545th meeting
Mongolia	552nd meeting
Morocco	555th meeting
Netherlands	552nd meeting
Nigeria	553rd meeting
Poland	551st meeting
Romania	550th, 559th and 574th meetings
Union of Soviet Socialist Republics	560th and 561st meetings
United Kingdom	546th meeting
United States of America	545th and 560th meetings
Yugoslavia	548th and 572nd meetings

II. The following delegations have spoken of how and when reorganization should be discussed:

United States of America	545th and 560th meetings
Mexico	545th meeting
Canada	546th and 571st meetings
United Kingdom	546th meeting
Japan	547th and 562nd meetings
Italy	547th meeting
Yugoslavia	548th and 572nd meetings
Bulgaria	549th meeting
Czechoslovakia	550th meeting
Romania	550th and 559th meetings
Poland	551st meeting
India	552nd meeting
Netherlands	552nd meeting
Mongolia	552nd meeting
Nigeria	553rd meeting
Hungary	554th meeting
Egypt	555th meeting
Morocco	555th meeting
Brazil	557th and 564th meetings
Union of Soviet Socialist Republics	560th meeting

III. Specific changes suggested:

A. *Procedure*

1. Replacement of the system of co-chairmanship by the annual election of a chairman or monthly rotation of the chair:

Mexico	545th meeting
Yugoslavia	548th meeting
Brazil	557th meeting

2. Annual election of officers in accordance with the system of rotation used in the United Nations:

Romania	550th meeting

3. Annual election of two vice-chairmen, one from each of the two main military alliances:

Brazil	557th meeting

4. Election of a rapporteur:

Yugoslavia	548th meeting

5. Preparation of an annual programme of work:

Yugoslavia	548th meeting
Romania	550th meeting

6. Adoption of a calendar for each session:

Nigeria	553rd meeting

7. Participation of the Secretariat in the preparation of the annual report:

Mexico	545th meeting
Yugoslavia	548th meeting

8. Permission to non-member countries to express views and make proposals in the Conference:

Yugoslavia	548th meeting

9. More frequent informal meetings:

Japan	547th meeting

10. Use of working groups:

Italy	547th meeting
Yugoslavia	548th meeting
Romania	550th meeting
Brazil	557th meeting

B. *Enlargement*

1. This should be done in such a way as to secure, without detriment to the smooth working of the Conference, the participation of France and of:

(*a*) All the nuclear Powers:

United States of America	545th meeting
Canada	546th and 571st meetings
Japan	547th and 562nd meetings
Yugoslavia	548th and 572nd meetings
Bulgaria	549th meetings
Czechoslovakia	550th meeting
Romania	550th meeting
Poland	551st meeting
Nigeria	553rd meeting
Hungary	554th meeting
Morocco	555th meeting
Brazil	557th and 564st meetings
Union of Soviet Socialist Republics	560th and 561st meetings

[103] Delegations are listed here in alphabetical order; elsewhere in the document always in chronological order.

(*b*) The great Powers:

Netherlands . . . 552nd meeting

(*c*) The major military and economic Powers:

United States of America . . . 545th meeting

(*d*) Countries of military importance:

Canada	546th meeting
United Kingdom	546th meeting
Italy	547th meeting
Yugoslavia	548th meeting
Poland	551st meeting
Mongolia	552nd meeting
Nigeria	553rd meeting
Hungary	554th meeting
Union of Soviet Socialist Republics	560th and 561st meetings

(*e*) China:

Mexico	545th meeting
Canada	546th and 571st meetings
United Kingdom	546th meeting
Japan	547th and 562nd meetings
Italy	547th meeting
Yugoslavia	548th and 572nd meetings
Bulgaria	549th meeting
Poland	551st meeting
India	552nd meeting
Netherlands	552nd meeting
Mongolia	552nd meeting
Nigeria	553rd meeting
Hungary	554th meeting
Morocco	555th meeting
Union of Soviet Socialist Republics	560th meeting
Brazil	564th meeting

(*f*) Germany:

United Kingdom	546th meeting
Netherlands	552nd meeting

(*g*) The Federal Republic of Germany and the German Democratic Republic:

Czechoslovakia	550th meeting
Poland	551st meeting
Mongolia	552nd meeting
Hungary	554th meeting

2. The enlargement, like that of 1969, should be submitted to the General Assembly for approval:

Mexico . . . 545th meeting

3. In the enlargement a reasonable balance should be maintained between the three groups making up the Conference:

Nigeria . . . 553rd meeting

IV. Main objectives of a reorganization, explicitly mentioned:

A. To make the Conference a more effective organ, with the participation of China and France:

Mexico	545th meeting
Canada	546th meeting
United Kingdom	546th meeting
Japan	547th meeting
Italy	547th meeting
Yugoslavia	548th meeting
Bulgaria	549th meeting
Romania	550th, 559th and 574th meetings
India	552nd meeting
Mongolia	552nd meeting
Nigeria	553rd meeting
Hungary	554th meeting
Brazil	557th meeting

B. Better observance of the principle of the sovereign equality of States:

Mexico	545th meeting
Yugoslavia	548th meeting
Romania	550th and 574th meetings

C. To ensure that the Conference reflects changes in the international political situation:

United Kingdom	546th meeting
Italy	547th meeting
Yugoslavia	548th meeting
Bulgaria	549th meeting
Romania	550th, 559th and 574th meetings
Egypt	555th meeting

D. To enhance the authority and credibility of the Conference as a negotiating body for disarmament:

Bulgaria	549th meeting
Netherlands	552nd meeting
Romania	574th meeting

E. To enable the Conference to participate in the preparatory work for the world conference on disarmament:

Mexico	545th meeting
Italy	547th meeting
Yugoslavia	548th and 572nd meetings
Bulgaria	549th meeting
Poland	551st meeting
Union of Soviet Socialist Republics	560th meeting

F. To enable the Conference to become the permanent negotiating body which may result from the world disarmament conference:

Mexico . . . 545th meeting

29.

United Kingdom of Great Britain and Northern Ireland: working paper on seismic data handling and analysis for a comprehensive test ban

[*CCD/386 of 22 August 1972*]
[*Original: English*]

Introduction

In September 1965 the United Kingdom tabled a working paper (ENDC/155)[104] which outlined a scheme for monitoring underground explosions by means of a network of between 20 and 25 seismograph arrays. The system was described in more detail in document CCD 296 of 28 July 1970[105] when the detection and discrimination capacity of a world-wide network of 26 arrays on named sites was presented.

Both papers referred to the need for processing the recorded data so that the full potential of the arrays could be used. In particular, the second paper recommended the installation at each station of a small computer to assist with the handling and processing of these data. Backed by the results of the research and development programme which began in 1960, the United Kingdom was in a position to make detailed specifications of the design of the array and of site and engineering requirements, for a given detection and discrimination threshold, and to provide an estimate of the capital and running costs for a network having a discrimination threshold for explosions giving average magnitudes of m_b 4½. Following the arguments presented in the United Kingdom working paper CCD/363/Rev.1 of 25 April 1972 (see sect. 6 above), this threshold can now be better expressed in terms of M_s. Direct measurements of Rayleigh wave amplitudes show that the threshold of the network advocated in document CCD/296 is M_s 2½. Reference to the observations summarized in appendices A and B of document CCD/363/Rev.1 indicates a yield equivalence of roughly 5 k'ton referred to consolidated rock (or about 40 k'ton to unconsolidated rock).

However, the requirements and design of the computer-aided system for processing the recorded data had not been studied in detail at the time document CCD/296 was presented in 1970, and the purpose of the present working paper is to expand on the reasons why a good deal of data processing would

[104] See *Official Records of the Disarmament Commission, Supplement for January to December 1965*, document DC/227, annex I, sect. C.

[105] *Ibid., Supplement for 1970*, document DC/233, annex C, sect. 25.

be best carried out at the recording stations, to outline the kind of system which would do the task and to review costs in the light of other new studies which have been undertaken by the United Kingdom since the working paper was completed two years ago.

Last year the United Kingdom pointed out[106] that the introduction of tape recording required by the Canadian improvements to standard stations (CCD/327 of 29 June 1971)[107] would involve some degree of electronic processing before measurements could be made on the improved seismograms. The advantages of an array of seismometers over a standard station are to increase the amplitude of the signal relative to background noise (signal-to-noise ratio), to separate overlapping signals, and independently, if not very accurately, to locate events.

However the complexity and speed of processing required to exploit these advantages are much greater than are required for improved standard stations (for which no more than straightforward filtering processes are needed) and require computer processing. Examples of the procedure necessary before an analyst can make best use of the recorded data from an array are illustrated in the annex to this paper. The examples are derived from processing carried out in a laboratory with the aid of an analog computer; but for operational purposes at an array station a fast digital computer is essential (see description below of the Seismic Array Station Processor which has been designed for this purpose).

For the United Kingdom Research and Development programme, the processing and analysing of array recordings has always been done at a data centre; the recording stations are provided only with visible recordings, similar to those of a standard station. If arrays of this type are to be used to monitor a comprehensive test ban the question that must be answered is how and where are all the recorded data to be processed, displayed and analysed.

In document CCD/296, the United Kingdom advocated that the full power of each array should be made available by suitable processing at the station, thereby giving analysts at each station the full benefit of the array. The consequences of this decision would be reflected in a reduction of long distance communications loads, and of routine processing at data centres of huge quantities of unnecessary data. This is because the overwhelming proportion of the recorded data is background noise and earthquake signals, which if transmitted to regional or international data centres would add significantly to the running costs of each station. Other factors in favour of this approach are that the basic measurements whether of standard recordings, improved standard recordings, or of processed array recordings are equally simple to make by competent analysts, and that such facilities would give greater independence to national systems of verification.

These points were briefly made in the United Kingdom working paper CCD/296, but the way in which the task might be accomplished had not been studied in detail. Since then, one of the principal efforts of the United Kingdom research programme has been devoted to the detailed design of a Seismic Array Station Processor (SASP). A SASP is now under construction and it should be operational by the end of 1973. A first report on its performance should be available early in 1974. In the philosophy and design of SASP the United Kingdom researchers have benefited from the pioneer work on the same problem by colleagues in Australia and Canada. The rest of this working paper contains a brief recapitulation of the problem, the method proposed to solve it, and an updated version of the costs estimated in document CCD/296.

The Seismic Array Station Processor

At an average array site the analyst would be expected to deal with some 5,000 events each year (although this number might easily be doubled in great earthquake years) and the analyst should spend his time looking only at the signals from these events. But these signals will occupy only about 400 hours out of a total year's recording of 8,760 hours. How does one quickly and reliably eliminate over 8,000 hours (over 95 per cent) of non-essential data each year? It can be done with the assistance of a specially programmed computer, and once accomplished, and the improved seismogram displayed, the analyst takes over as described in the appendix.

The computer can be used basically in two ways. One way is to feed the signals from the seismometers directly into the computer and arrange for signals to be processed and displayed as they are recorded. The analyst would make measurements on each signal while waiting for the next event to be recorded. This is the so-called "real-time" or "on-line" method, and it would entail manning the station throughout the 24-hour day. It would also result in gross misuse of the small but fast computers which are nowadays available for the task. The alternative method which we have decided to use is to scan the previous 24 hours of magnetic tape recordings "off-line" as fast as present day computers would allow, and thereby complete the whole detection and editing procedure within the first hour or two of the following working day, leaving time for analysis, for dealing with interrogations from data centres or other stations, for special studies of "difficult" events, and for maintenance of the equipment. To begin with, a speed-up factor of eight times over the original recording speed will be used. At this speed, sets of beams will search (sweep) for signal arrivals using all the short-period (narrow band) seismometer outputs within the array. With further experience of the system and with even faster computers now being marketed a day's worth of recordings may be scanned in less than one hour. When an event is detected, the rough onset time and approximate epicentre is noted and the unfiltered ("raw") array data for a period of about two minutes before and after the event will be transferred to a "library" tape. In this way the long sections of noise, which form the bulk of the previous 24 hours recording, are eliminated and only those sections that contain recognizable signals are stored on the library tape. Though this fast detection-editing process takes advantage of filters for maximum detection capacity, as illustrated in figure 1 of the annex, the event library tape contains unfiltered array data, thereby retaining any differences in source characteristics which may be present in the original data.

The two main considerations in the design of SASP are speed—the faster the many hours of background noise between each event can be eliminated the more time will remain for analysis of events—and the fact that the short-period (P-wave) arrays are more sensitive than those of long-period (R-wave) in detecting underground explosions. Working paper CCD/296 drew attention to this point when assessing the practical limits to discrimination, and advantage has been taken of the half-magnitude gap between detection and discrimination to reduce the complexity and cost of the processor by accepting a reduction in the automatic detection threshold of SASP of m_b 0.2 relative to the optimum capacity of the array. Any events not detected because of this relaxation will still be available on the primary recordings for special searches on interrogation by other stations or data centres. The processing has also been simplified and costs reduced by taking advantage of the line symmetry of the United Kingdom type arrays. The full resolving power of the array will of course be used when the analyst comes to process the library tape of events which have taken place during the previous 24 hours. A much denser (high resolution) pattern of beams will then be formed round the original detection beam, and the parameters estimated from the maximum resolution of each event will be typed out, and the best (maximum resolution) seismogram displayed visually for the analyst.

The long-period signals will be processed in a similar fashion, the onset times having been predicted during the processing of the event library tape, and finally the basic data on the event will be punched onto paper tape for transmission, with the analyst's assessment, to other stations or to regional or international data centers whenever called for.

[106] *Ibid., Supplement for 1971*, document DC/234, annex C, sect. 32.
[107] *Ibid.*, sect. 9.

The United Kingdom recording system is economical of magnetic tape, and there would be no practical difficulty in retaining the magnetic tapes for the arrays and the event library for a period of two years. This allows ample time for reviews of data in the context of a comprehensive test ban and for seismological research. The data are particularly valuable for the latter activity and the two year data bank currently stored by the United Kingdom is much sought after.

Costs

The cost (1972) of SASP is estimated to be £30,000, including additional facilities (for research and development and for testing criteria) which will not be incorporated in an operational recording station. This is a quarter of the estimates which were included in the over-all figure of £15 million reported in document CCD/296. The United Kingdom researchers have also reviewed the design of the 16-element long period arrays and reached the conclusion that vertical component seismometers would suffice in place of the three component instruments recommended in 1970. The over-all effect at 1972 prices would be to reduce the cost of the United Kingdom proposals in document CCD/296 to about £10 million.

Appendix

Examples of Data Processing and Analysis

The upper traces of figures 1 and 2 are the records of a single seismometer selected from an array of 20. They are equivalent to the vertical component recording of a standard station. The second trace of figure 1 is the result of beaming (tuning) the whole array at GBA (S India) for optimum reception of seismic energy arriving from eastern Kazakhstan. To the practised eye this record now reveals a small signal of short duration but of higher frequency than the background noise about 65 seconds after the beginning of the recording, and it is the sudden change of frequency at this point which draws the analyst's attention to it. Advantage is now taken of this change of frequency by passing the recording through a suitable filter which has the effect of diminishing the amplitude of the lower frequency noise, while passing the higher frequency signal. The result, illustrated in the third trace of figure 1, is a signal on which the analyst can now make an accurate measurement of amplitude, and after applying the normalizing factor appropriate for the approximate distance between eastern Kazakhstan and Gauribidanur, an estimate of the magnitude (m_b) of the event. In doing so he makes the reasonable assumption that the signal is the P-wave or first arrival of a seismic event. The analyst is also able now to measure the onset time of the signal, and thereby infer the expected arrival time of the lower velocity R-waves. He will then search the station recordings for signs of the surface waves around this time.

In this particular case the amplitude (M_s) of the R-wave was small even after suitable processing, and the measurements, perhaps also the recordings themselves must now be transferred to a centre for more detailed processing and collation with those of other stations before a decision on the source of the event can be made. Nevertheless, given the suitably processed array data the station analyst was able to detect signals which otherwise would be difficult or impossible to see in the background noise, and from simple measurements to estimate onset times, rough locations, and magnitudes m_b (and M_s if R-waves detected). The lower trace in figure 1 is the result of a processing method which measures the energy of the signal. It is useful for assessing the complexity of seismic events, and is a more efficient way of detecting them, but no amplitude (m_b) measurements can be made on this trace.

Figure 1 illustrates the effect of processing an array on the detection of small signals. In figure 2 on the other hand the signal on the "standard" recording is clearly defined; the onset time and magnitude can be measured without processing. A second arrival which follows the onset some 80 seconds later could well be associated with the train of signals initiated by one event. In fact, as the next two traces show, the array beams have revealed that these two signals originated at two quite different places. Signals from an event in Nevada have overlapped with the wave train initiated by an event in the Pacific Ocean. The surface-wave magnitudes of the first event puts it in the earthquake population on the $m_b : M_s$ criterion. The well marked burst of energy which arrives some 20 seconds after the P onset of this event would be earmarked by the analyst as a possible surface reflected P wave indicating a source of about 90 kms in depth.

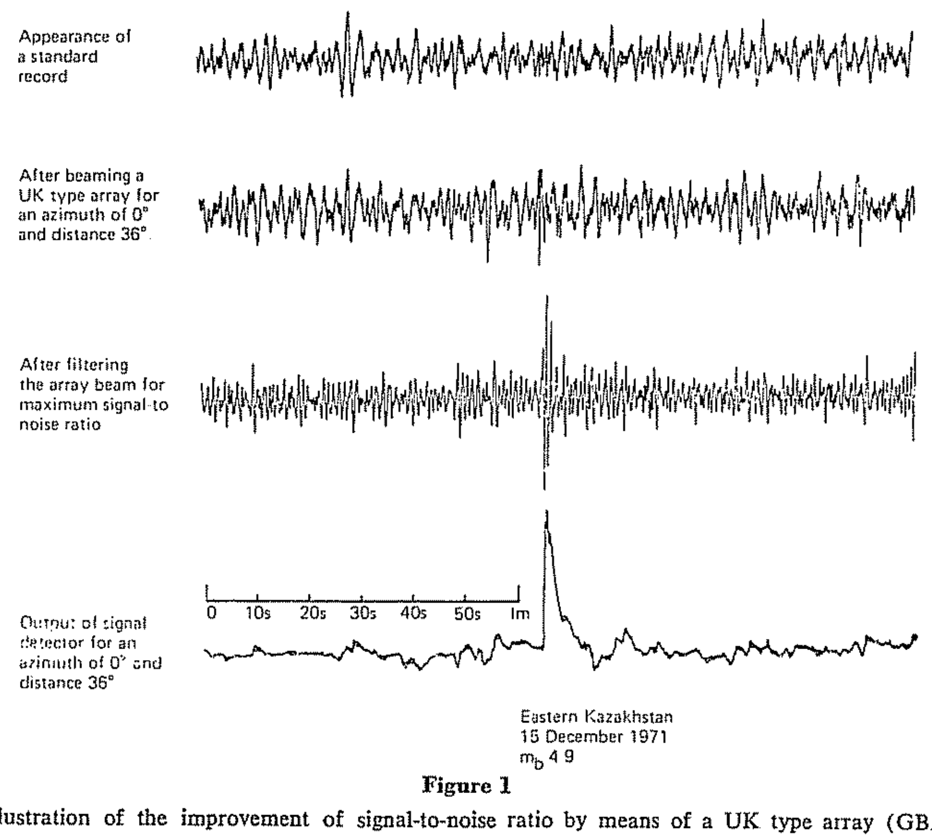


Figure 1

Illustration of the improvement of signal-to-noise ratio by means of a UK type array (GBA)

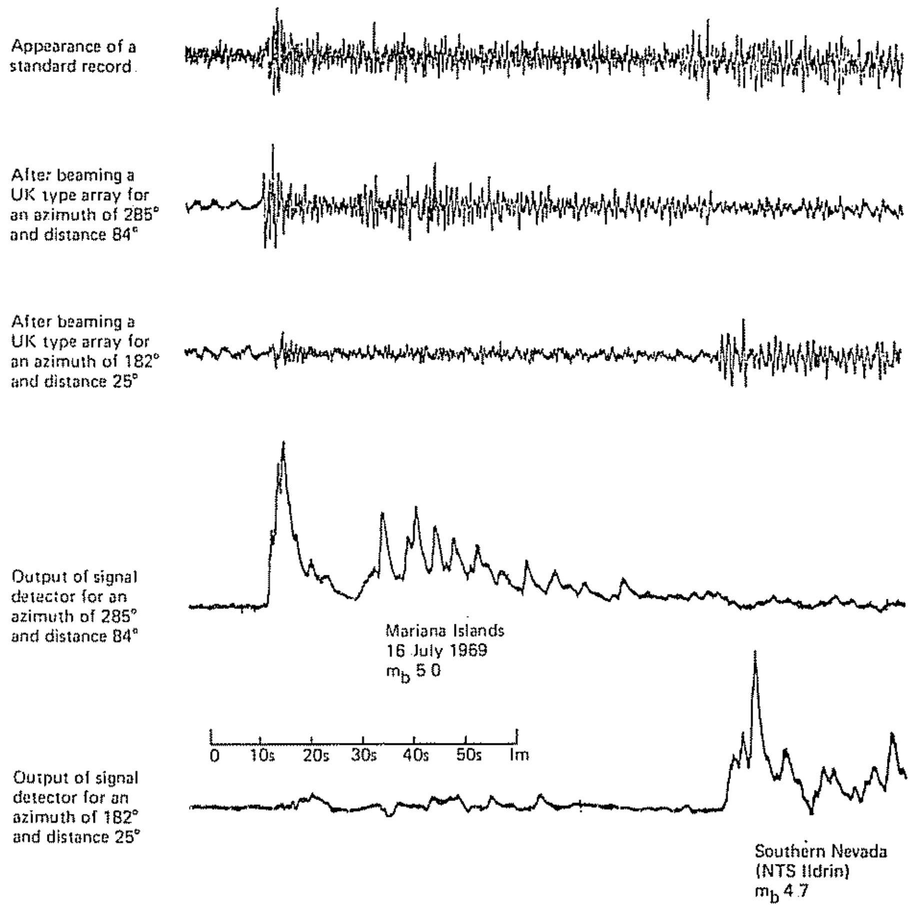


Figure 2

Detection and separation of two mixed P-wave signals by means of a UK type array (YKA)

GLOSSARY OF TERMS USED IN THIS WORKING PAPER

On-line computer	A computer used to process data as it is recorded with little or no time delay.
Off-line computer	A computer used to process data previously recorded onto a magnetic tape. Delay between recording and processing can range up to many years.
Real time processing	Equivalent to using an on-line computer: the processing is carried out as the seismic data is recorded.
Beam-forming	The process of combining the outputs from the seismometers of an array to look for signals arriving from a given direction and distance. Usually a number of beams are formed covering a range of directions and distances. When a signal (which is large enough to detect) arrives at the array this signal will appear with largest amplitude on the beam that is looking towards the source of the signal; this output is called the best beam. So not only is the signal detected but the epicentre of its source can be determined from a knowledge of the direction in which the best beam is pointing. Beam-forming is also something called beam-steering or the process is referred to as phasing or tuning the array.
Seismic spectrum	Seismic events generate vibrations with a very wide range of frequencies. A large earthquake for example produces vibrations ranging from several vibrations (cycles) per second down to one vibration in about an hour: The whole range of seismic frequencies is called the seismic spectrum.
Short-period (SP) recording systems	Conventionally systems that record only that part of the seismic spectrum around 1 cycle/second (i.e. periods of vibration of 1 second).
Long-period (LP) recording systems	Long-period (LP) recording systems
Very-long-period (VLP) recording systems	Currently used to describe systems that record only that part of the seismic spectrum around 0.025 cycles/sec (i.e. periods of vibration of 40 seconds).

Narrow band recording systems — Systems that record only a small range of frequencies out of the total seismic spectrum. SP, LP, and VLP systems are narrow band.

Filtering — The process of operating on any signal to select particular frequencies of vibration and suppress others.

30.

Canada: working paper on toxicity of chemical substances, methods of estimation and applications to a chemical control agent

[*CCD/387 of 24 August 1972*]
[*Original: English*]

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 Conference of the Committee on Disarmament (Japan CCD/301[108] and 344;[109] Netherlands CCD/320;[110] etc.) 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 its paper CCD/360 of 20 March 1972 (see sect. 4 above) 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.

108 *Ibid., Supplement for 1970*, document DC/233, annex C, sect. 30.
109 *Ibid., Supplement for 1971*, document DC/234, annex C, sect. 36.
110 *Ibid.*, sect. 3.

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 1. 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 chemical warfare 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.

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.

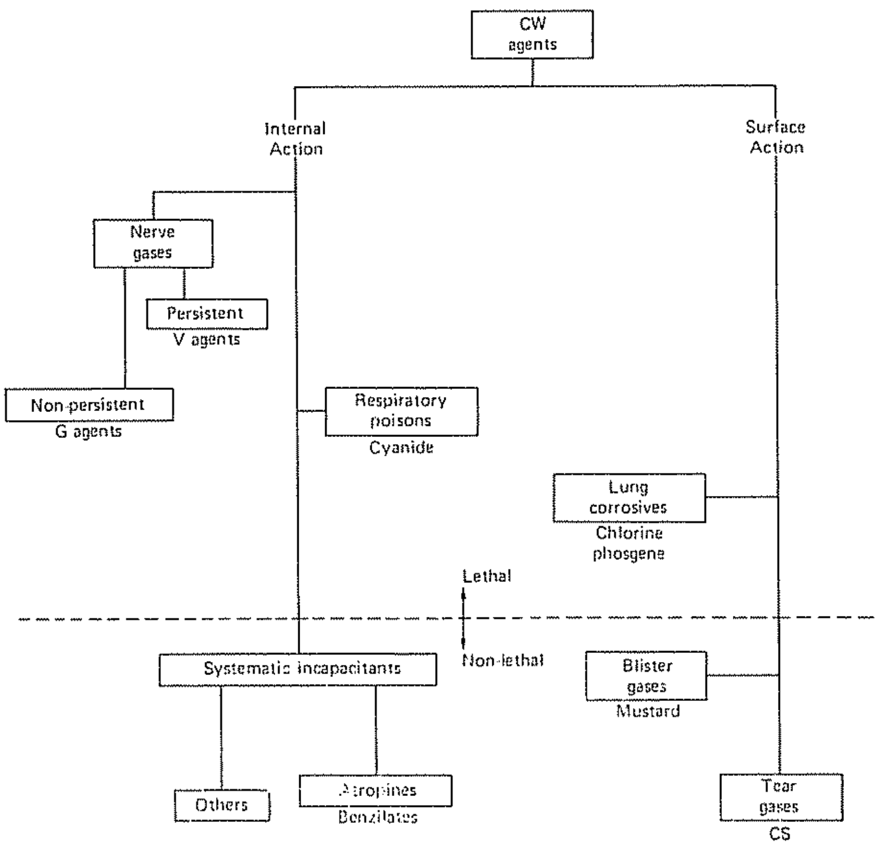


Figure 1

Classes of chemical warfare agents defined by primary mode of action

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 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 "supertoxic" 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 destroy 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 simplicity 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.[111] 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 intravenous 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 intraperitoneal injection is recommended.

If deaths appear in groups of 10 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.[112]

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 intraperitoneal and 0.001 ml/g for intramuscular. 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 1.

Table 1

CHEMICAL WEAPON 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 chemical warfare agents (for example, $LD_{50}<1$ 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 in-

[111] D. E. S. Campbell and W. Richter, "an observational Method for Estimating Toxicity and Drug Actions in Mice supplied to 68 Reference Drugs", *Acta Pharmalogica Toxicologia*, vol. 25, 1967, p. 345.

[112] C. I. Bliss, "The Calculation of the Dose Mortality Curve", *Annals of Applied Biology*, vol. 22, 1935, p. 307 and D. J. Finney, *Profit Analysis*, 2nd ed. Cambridge University Press, Cambridge, 1952.

clude 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, for example, as illustrated in table 2.

Table 2

PRACTICAL ROUTES OF ENTRY IN MAN V. 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—intraocular
	—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 10 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 chemical warfare agent. These procedures are summarized graphically in figure 2. 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 Conference of the Committee on Disarmament have suggested (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 chemical warfare 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.

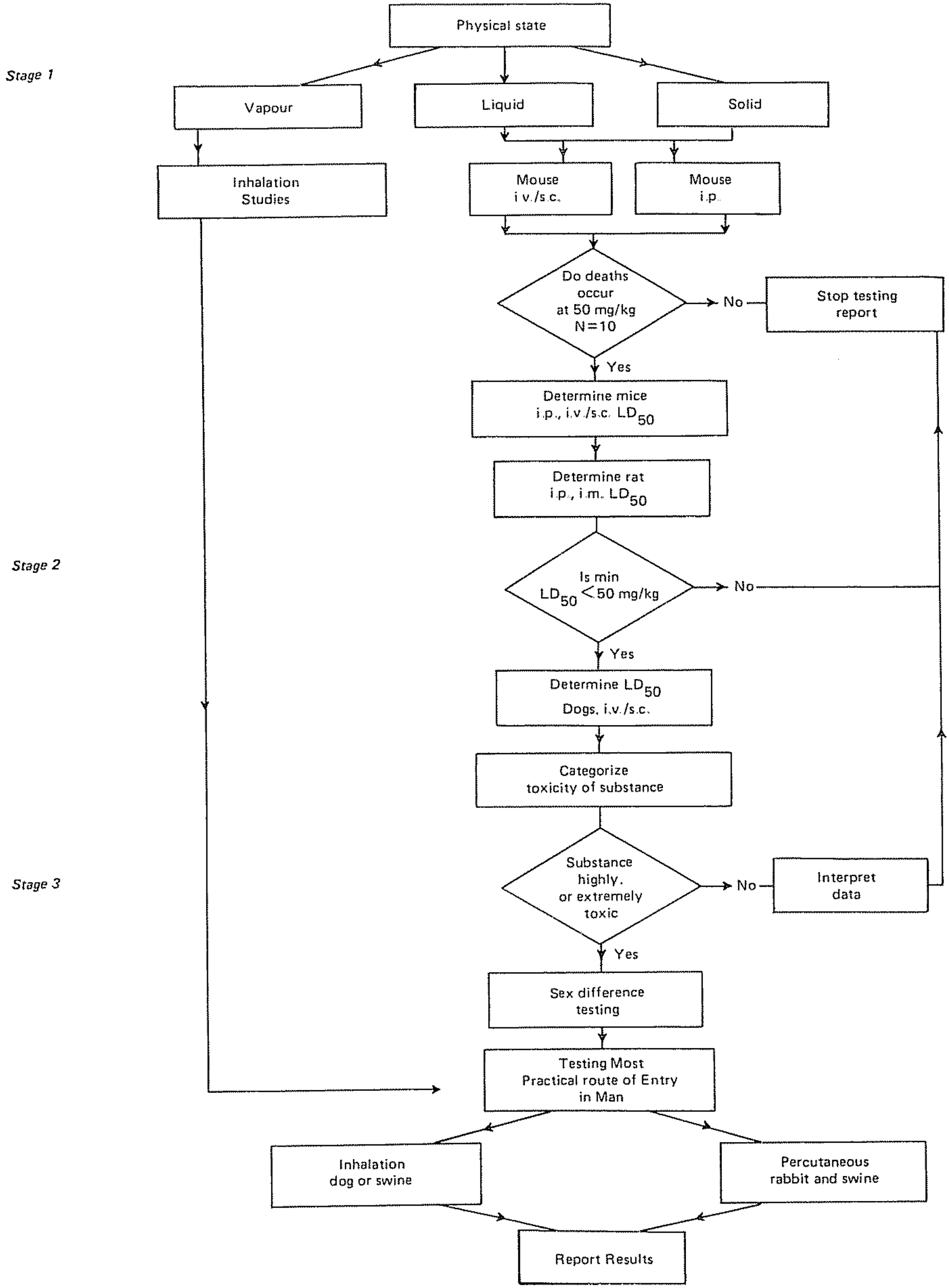


Figure 2

Chemical agent lethality testing—general procedures

Failure to meet a number of these factors could prevent a highly toxic substance becoming a chemical warfare 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 chemical warfare 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 chemical warfare 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.

31.

United States of America: a review of current progress and problems in seismic verification

[*CCD/388 of 24 August 1972*]
[*Original: English*]

Introduction

The scope of the ongoing United States program, Project VELA, devoted to research into seismic verification of an underground test ban has been previously reported to the Conference in a working paper of June 1971, CCD/330.[113] The present paper reviews the progress towards attaining the research objectives outlined at that time, and discusses certain residual problems presently preventing seismic verification down to low magnitudes. It also outlines some directions that are currently being pursued in seismic instrumentation, seismic systems, and deployments to assist in the solution of these problems.

I. Recent progress in seismic verification research

The United States Large Array Program is now halfway through its two-year evaluation programme. Available data indicate the capability of these arrays as research tools and their potential for seismic monitoring systems. In the companion Very-Long-Period Experiment, seven stations have been in operation during the past year and three others are nearing completion. The results of this experiment indicate the value of careful emplacement of instruments to ensure that the residual noise is in fact earth noise and pose some interesting questions as to the emplacement and seismometer bandwidth of future installations. This section is a review of progress to date in these programmes and indications for future research.

[113] *Official Records of the Disarmament Commission, Supplement for 1971*, document DC/234, annex C, sect. 12.

Signal detection capabilities of large arrays

Research has continued on the detection capabilities of the three large seismic arrays developed under the United States research programmes. These are the Large Aperture Seismic Array (LASA) in Montana, the large Research Array in Norway (NORSAR), and the Alaskan Long-Period Array (ALPA). During the past year, two significant developments have occurred. First, there has been an important improvement in the techniques for automatically detecting events at LASA, bringing the automatic seismic event detection threshold close to the limit for this array. Secondly, high-quality data from the full NORSAR array have provided a means to estimate the ultimate P-wave detection threshold for that array and the development of automatic detection methods is now well under way. Turning to the long-period arrays, sufficient data have now been obtained to estimate their detection thresholds for seismic events. Summaries of both short-period and long-period detection thresholds are described below. High-quality data from all three arrays have become available for the initial studies of capabilities and limitations of identification criteria at low magnitude.

Capability to detect short-period P-waves

P-wave detection thresholds of short-period arrays are ultimately limited by:

(*a*) The amplitude and variability of the ambient noise which exists in the earth at the detection site.

(*b*) The improvement in effective signal-to-noise ratio which can be achieved by combining the outputs of all the sensors of the array, and

(*c*) The reducton in amplitude of seismic signals of interest caused by filtering and combining signals from the array's sensors. These parameters are measurable, and may be used to determine the ultimate threshold of an array. The first two parameters, measured in the frequency band of the P-wave signals of interest, define the irreducible noise at the output of the array, and hence the amplitude of the minimum detectable P-wave signal. The third parameter is then used to define the P-wave earth motion input required to produce the minimum detectable signal at the array output. This earth motion may then be interpreted in terms of earthquake magnitude.

The limiting threshold for LASA has been established for several years, and reported in several publications of Lincoln Laboratory[114] and the Seismic Data Laboratory.[115] These studies indicate that the ultimate teleseismic detection threshold of the LASA array is about m_b 3.9 (LASA magnitude) at the 90 per cent confidence level. Based on recently acquired data from NORSAR, we may now estimate that the ultimate teleseismic detection threshold is about 4.1 (NORSAR magnitude) for that station at the 90 per cent confidence level. Details of these estimates are given in table 1.

Developing the capability to approach these ultimate detection thresholds by automatic means has been one of the goals of the United States seismic research programme. It was reported in document CCD/330 to the Conference of the Committee on Disarmament that equipment for automatic event detection had achieved a threshold $m_b = 4.2$ at the 90 per cent confidence level for LASA. Since then, improvements in the computer logic for recognizing earthquake signals have lowered this threshold to $m_b = 3.9$.

This threshold was verified by counting the number of earthquakes detected in small magnitude increments and observing the magnitude level at which the number of detected events no longer increase as expected. Figure 1 shows the

[114] See R. M. Sheppard, Jr., "Determination of LASA Detection and Location Ability Using Kurile Island Events", Technical Note 1968-23, 1 October 1968, Lincoln Laboratory, Massachusetts Institute of Technology.

[115] See E. F. Chiburis and R. A. Hartenberger, "Signal-to-Noise Ratio Improvement by Time-Shifting and Summing LASA Seismograms", S.D.L. 164, 30 September 1966, Teledyne Geotech, Alexandria, Virginia.

Table 1

ULTIMATE SHORT-PERIOD THRESHOLDS FOR LASA AND NORSAR BASED ON MEASURED EARTH NOISE AND OBSERVED SIGNAL LOSSES

	LASA (345 sensors)	NORSAR (132 sensors)
Earth noise input, single sensor 90 per cent probability that input noise in the 0.4-3 Hz passband will be equal to or less than this amplitude	2.6mμ (rms)*	4.5mμ (rms)
Array noise output, optimum real time processing 90 per cent probability that array output noise in the 0.4-3 Hz passband will be equal to or less than this amplitude	0.3mμ (rms)	0.45mμ (rms)
Minimum detectable signal on array output 90 per cent confidence 3 × rms of 90 per cent array output noise	0.9mμ(o-p)**	1.35mμ (o-p)
Minimum detectable input signal, 90 per cent confidence Input signal required to produce minimum detectable output signal at 90 per cent confidence in presence of array output noise. Based on 3 db loss caused by filtering and intersensor incoherence	1.3mμ (o-p)	1.9mμ (o-p)
Teleseismic detection threshold, 90 per cent confidence Average teleseismic magnitude (30°-80°) derived from minimum detectable input signal, based on $\overline{m} = 3.8 + \log A/T$	$m_b = 3.9$	$m_b = 4.1$

* rms = root mean square, .707 × maximum amplitude
** o-p = peak amplitude measured from the base or zero line

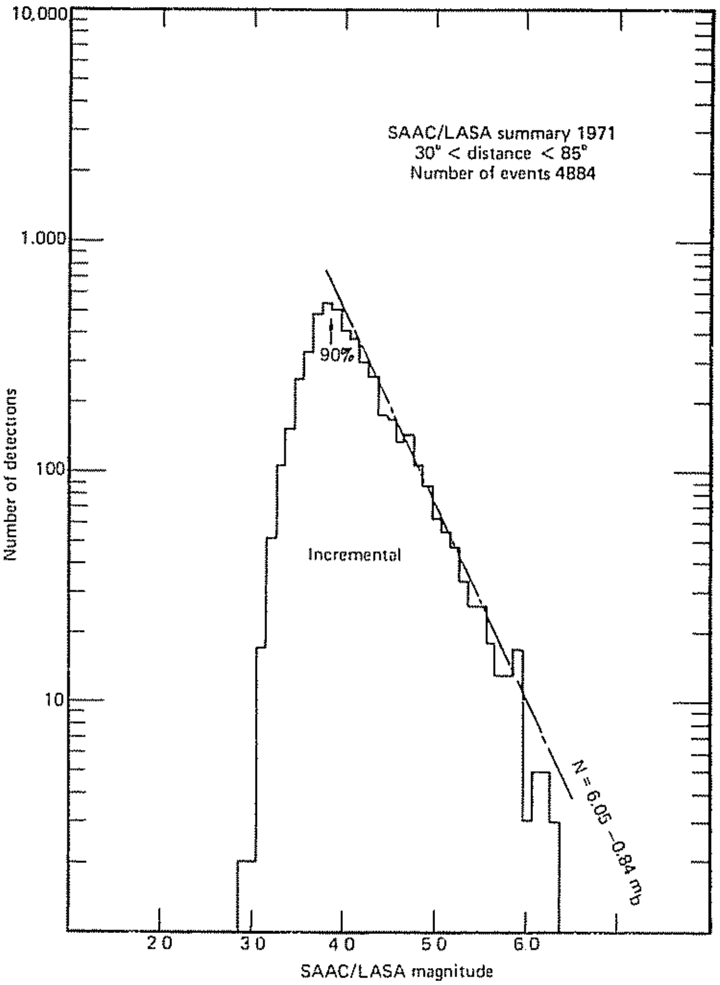


Figure 1

Number of detected events versus LASA body-wave magnitudes

incremental histograms of 4,884 seismic events automatically detected by LASA at distances between 30° and 85°. The body-wave magnitudes are those determined directly by LASA, which agree closely with magnitudes reported by the United States National Oceanic and Atmospheric Administration. The general trend of increasing numbers of events detected as the magnitude decreases continues from magnitude 6 down to magnitude 4. The rate of increase drops sharply just below magnitude 4 as increasing numbers of earthquakes which are known from other evidence to occur are no longer detected by LASA. The incremental histogram implies that 90 per cent of the expected number of $m_b = 3.9$ earthquakes are detected, confirming that this is the current threshold for automatic event detection at LASA.

Automatic event detection methods at NORSAR have not yet been fully developed to take advantage of signal and noise characteristics at that site. Accordingly, the lowest possible automatic event detection threshold at that station has not yet been achieved. Preliminary data similar to that given for LASA in figure 1 suggest that the current automatic event detection threshold of NORSAR is near $m_b = 4.4$ (90 per cent incremental). Although NORSAR's ultimate short-period threshold will not quite equal that of LASA, its long-period characteristics are equally as good. Furthermore, NORSAR and LASA are now providing crucial data needed for research on events in regions of common coverage.

Capability to detect long-period waves

An intial evaluation of the long-period detection capabilities of NORSAR, LASA and ALPA has recently been completed. The earthquake source region chosen for the study was the Kurile-Kamchatka area which is about 60° from NORSAR and LASA and 30° from ALPA. The processing used was filtering and beam-forming of vertical seismometers augmented by matched filtering when required. It appears that this is very close to optimum processing for those arrays. A preliminary estimate of the 90 per cent incremental detection thresholds for Rayleigh waves, in the absence of interfering events (which are discussed separately later), were determined to be $M_s = 3.0$ for NORSAR, 3.1 for LASA, and 2.6 for ALPA. These values were obtained from histograms of numbers of earthquakes versus magnitude in a manner similar to that discussed previously for short-period detection thresholds. A simple correction to normalize these magnitude values to a common distance indicates that all three arrays can detect surface waves down to a magnitude of M_s 2.5-2.6 at 30°. Further data may modify these estimates.

To determine the utility of the large long-period arrays for the discrimination problem, it is also necessary to know the threshold of these arrays in terms of body-wave magnitude. That is, for an event of given m_b we want to know the probability of detecting Rayleigh waves to be used in criteria such as that based upon $M_s : m_b$. The correlation of body-wave and surface-wave magnitude is complicated by the fact that surface-wave magnitudes are dependent upon the depth of the seismic event and a determination of the depth of focus is important to this correlation. We are currently investigating this problem, particularly in a comprehensive study of world-wide data (see sect. III below), with a view to defining the body-wave magnitude of shallow focus earthquakes corresponding to the surface-wave magnitude thresholds of the large arrays for various seismic areas of the world.

Very-Long-Period Experiment

The Very-Long-Period Experiment has two principal objectives. The first is to demonstrate that high-gain instruments can be installed such that their performance is limited only by earth noise and to demonstrate that careful siting of the instruments can markedly reduce the amount of earth noise. The second is to exploit the fact that the instrument response was designed to be at a maximum where the earth noise level is at a minimum between 30 and 50 seconds (figure 2). It was anticipated that this favorable "window" for viewing surface waves from earthquakes and explosions would reveal new characteristics that might supplement our previous experience at periods in the vicinity of 20 seconds. Of particular importance was the hypothesis that there might be a greater separation of the earthquake and explosion population on the $M_s : m_b$ plot than exists at 20 seconds.

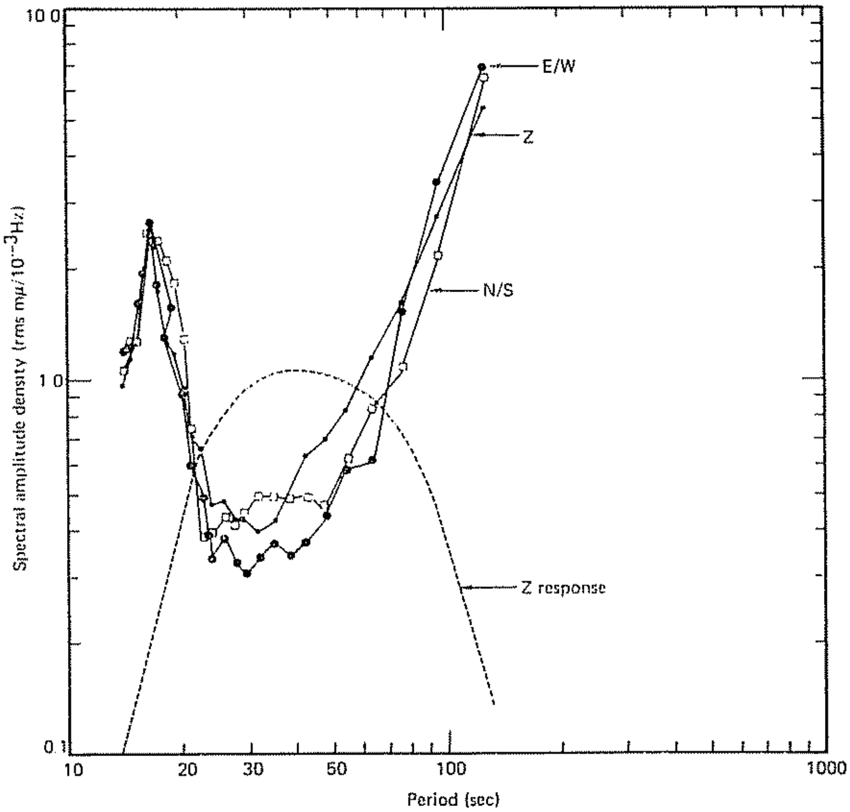


Figure 2

The three-component, vertical, North-South, and East-West noise spectra at Ogdensburg, New Jersey, compared with the vertical component instrument response curve

Table 2

STATION LOCATIONS, GEOLOGIC SETTINGS

Station	*Latitude*	*Longitude*	*Elevation (m)*	*Bedrock*	*Depth of overburden (m)*
Fairbanks (Alaska)	64°53'N	148°00'W	330	Precambrian Birch Creek schist	20
Charters Towers (Australia)	20°05'S	146°15'E	357	Devonian Ravenswood granodiorite	30
Eilat (Israel)	29°33'N	34°57'E	200	Precambrian granite-porphyry	200
Ogdensburg (New Jersey)	41°04'N	74°37'W	—373	Franklin limestone	543
Chiang Mai (Thailand)	18°47'N	98°58'E	416	Triassic granite	0
Toledo (Spain)	39°51'N	4°00'E	465	Precambrian granite	20
Konigsburg (Norway)	59°38'N	9°35'E	216	Precambrian cystalline-like slate and granite	340

Seven stations have been used extensively in recent studies. The seven existing stations are listed in table 2, together with their geological settings. The base noise levels for the vertical, North-South, and East-West horizontal components at 20 seconds and 40 seconds with a passband of 0.013 Hz are shown in table 3. During particularly noisy periods, however, the noise levels can be an order of magnitude greater than the base levels at 20 seconds due to microseismic storms. Base levels, therefore, represent the quietest conditions at the stations recorded to date. The locations of the stations and their 30° area of coverage are shown in figure 3.

The results indicate that careful design of seismometer, instrument container, and vault has resulted in an instrument which is sufficiently insulated from the environment that we can have confidence that it is recording only ground movement. This is an important achievement because full utilization has been made of the instrument gain, as much as 100,000, at periods of 35 to 40 seconds. The equivalent earthquake m_b detection capability of the first four stations built for various seismic areas of the world is shown in figure 4. This figure indicates that these four stations give an m_b 4.3-4.4 in the Kurile-Kamchatka region and an m_b 4.5 or less capability in most areas investigated. An enhanced capability could be achieved by more stations, possibly as small arrays, and by digital data processing.

The stability of the noise level at 40 seconds is apparently greater than that at 20 seconds. This stems from the origin of the noise components at two periods, that at 20 seconds being from microseisms and that at 40 seconds from local atmospheric perturbations. At depth these different origins might have greater significance than at the surface since the microseisms do not decrease significantly with depth but the atmospheric-induced component does, particularly with respect to the horizontal signals due to earth tilt. These horizontal components are especially important for the detection of Love waves.

Based on results from a large number of earthquakes and a relatively small number of explosions it appears that no increase in the average separation between earthquakes and presumed explosions will be obtained by using $M_s(40) : m_b$ instead of $M_s(20) : m_b$ although the spread in $M_s(40)$ values at a given m_b appears to be less. Azimuthally-dependent spectral criteria have still to be investigated in detail. By the utilization of deep boreholes advantage might possibly be taken of the suppression of atmospheric-induced noise with depth. This is an approach which will be pursued further. Analysis of data obtained under the Very-Long-Period Experiment programme has supported the concept of the general utility of the $M_s : m_b$ criterion to earthquakes, always keeping in mind the existence of anomalous events. We have seen that the capabilities attained at the prototype station are attainable at other sites. We are only now attaining the technical capability to analyse fully and effectively the Very-Long-Period Experiment data.

II. Important remaining problems

Some detailed studies over the past year have attempted to provide quantitative information on several problems which were discussed previously but for which no precise data have been available. For instance, it was suggested in the United States working paper last year that the $M_s : m_b$ criterion for seismic discrimination might fail occasionally, for reasons unknown. Such events, sometimes referred to as false alarms, appear in the explosion population on the $M_s : m_b$ plot. Another question unanswered previously was the extent and severity of the mixed event problem at low magnitudes. This phenomenon has been investigated further and is reported in this section. Finally, of continuing concern is the possibility of evasion. The current United States research into possible clandestine testing techniques and research into ways of deterring such testing is reviewed briefly.

Anomalous events

A number of effective discriminant criteria may be successfully employed for distinguishing between signals from earthquakes and explosions. One of those in extensive use is a comparison of amplitudes of long-period surface waves and amplitudes of short-period body waves; that is, the so-called $M_s : m_b$ criterion. It is intended to be applied to shallow focus (depth less than 60 kilometres) events. It has been found that in mose cases such earthquakes have much higher M_s values for a given m_b value than do explosions.

Table 3

RMS base noise levels at 20- and 40-second period with 0.013 Hz band width at both periods

(*At least 8-hour samples*)

Station	20 Seconds			40 Seconds		
	Vertical	North-south	East-west	Vertical	North-south	East-west
Fairbanks Alaska (United States of America)	9	5	3	7.3	7	7
Charters Towers (Australia)	4.6	3.5	5.2	3.6	11*	11
Eilat (Israel)	3	**	3.2	2	**	3
Ogdensburg New Jersey (United States of America)	8	8.6	8	3.2	7	7
Chiang Mai (Thailand)	10	10	10	3.1	12	12
Toledo (Spain)	4.3	4.3	13	3.7	11.5	16
Konigsberg (Norway)	3.6	4	4.5	1.6	3	2.7
90 per cent Confidence Level, 2.2 db Spread						

* Daytime average level—night-time level is 3.6 $m\mu$.
** Instrument malfunction.

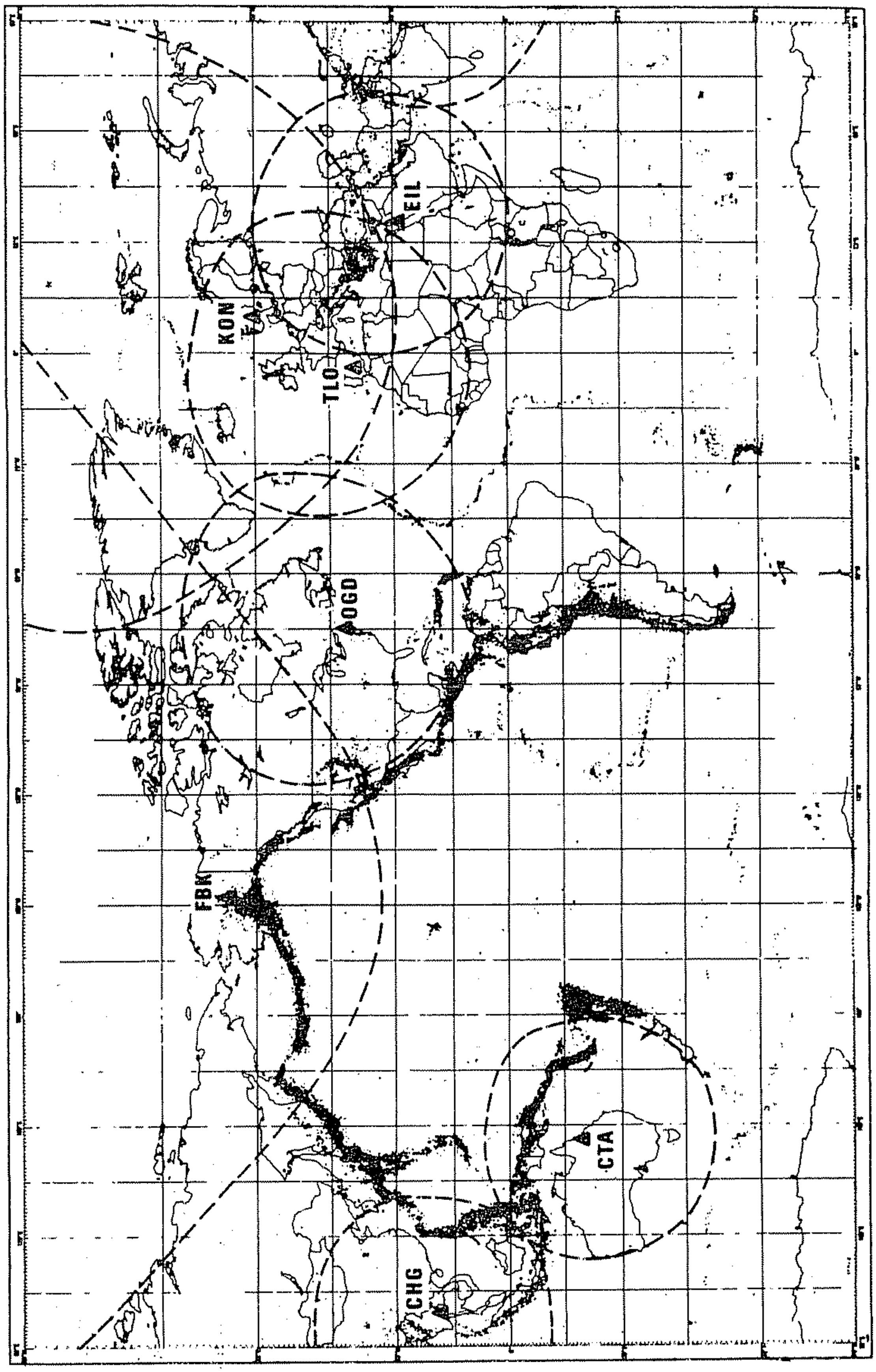


Figure 3

The distribution of the Very-Long-Period Experiment sites and their 30° coverage area. World seismicity during 1961-1969 is also shown

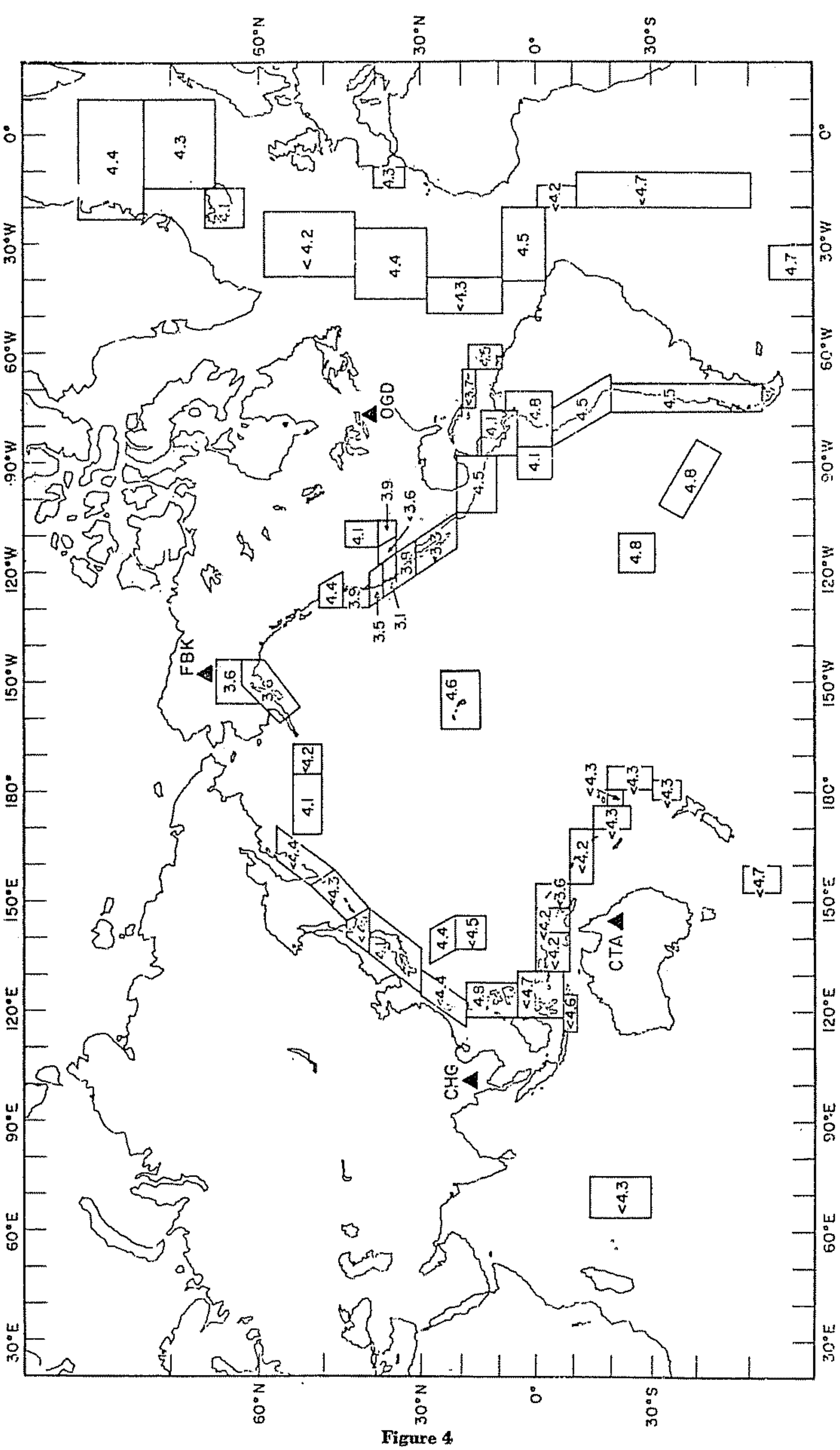


Figure 4

The seismic capability, in terms of m_b equivalent, of the Very-Long-Period Experiment stations for some of the seismic areas of the world. The m_b values are those for single station detections

For reasons not thoroughly understood at this time, some earthquakes are inefficient generators of Rayleigh waves. These events, most of which appear to be of shallow focus on the basis of the Preliminary Determination of Epicenters by NOAA, give surface-wave magnitudes that are so low that they are statistically indistinguishable from explosions by the $M_s : m_b$ criterion. Although these events occur occasionally at magnitudes slightly above m_b 5, their numbers increase substantially at low magnitudes; this is largely because there are more seismic events at low magnitude.

To document this phenomenon, a study was made of $M_s : m_b$ characteristics of earthquakes in a region comprising the eastern Himalayas and parts of Assam and Tibet. This region was chosen because there had been previous indications that anomalous Rayleigh wave energy was associated with some seismic sources in the area.

Fifty-three earthquakes occurring between 1963 and 1970 within the region bounded by lattitudes 27°N and 34°N and longitudes 92°E and 100°E, were selected for study. Epicentral characteristics are listed in table 4. Stations whose data contributed to the analysis were Shillong, Poona, and New Delhi, India; Kabul, Afghanistan; Quetta and Lahore, Pakistan; and Chiang Mai, Thailand. It was decided not to obtain Rayleigh wave data from more distant stations although the proximity to the seismic zone of the stations used could introduce some bias. All individual station magnitudes were

Table 4

LIST OF EVENTS

Date	*Origin Time*	*Co-ordinates*		*Depth*			*Geographical region*
Mo. Day Yr.		*North Latitude*	*East Longitude*	*Km*	M_b	M_s**	
07 05 63	7 19 15.8	27.7	92.1	*	4.2	3.90	Assam, India
10 08 63	2 51 6.0	28.6	95.1	24	5.4	4.33	Assam, India
11 16 63	11 39 37.8	28.1	95.1	37	4.7	3.93	Assam, India
01 07 64	4 50 37.0	29.8	98.7	46	5.0	4.38	Eastern Tibet
01 27 64	5 29 27.0	29.2	97.2	*	4.9	3.87	Southern Tibet
04 30 65	7 13 23.1	28.3	96.0	*	4.4	3.96	India-China Border
06 04 65	15 56 56.0	31.7	95.2	*	5.0	3.87	Tibet
07 31 65	16 36 53.8	32.7	93.2	*	4.9	4.27	Tibet
07 31 65	17 7 52.6	32.7	93.1	*	4.7	4.81	Tibet
07 31 65	19 1 9.4	32.8	93.0	*	4.4	4.40	Tibet
07 31 65	21 44 47.8	32.7	93.1	21	4.9	4.60	Tibet
08 01 65	14 14 1.7	32.6	93.6	*	5.5	3.94	Tibet
08 01 65	20 9 17.9	32.6	93.3	32	5.3	4.78	Tibet
08 02 65	17 49 47.0	32.8	93.3	*	4.8	4.35	Tibet
10 06 65	8 3 3.2	29.2	96.1	27	5.4	4.10	India-China Border
12 09 65	20 26 4.0	27.5	92.5	22	5.3	4.47	India-China Border
01 31 66	2 35 5.8	27.9	99.6	*	5.6	4.87	Yunnan Prov., China
03 14 66	4 42 50.0	32.4	97.4	*	4.9	4.46	Tibet
05 27 66	14 35 5.0	27.4	96.5	51	4.8	4.34	Burma-India Border
09 11 66	15 55 20.0	27.0	95.8	37	5.0	3.77	Burma-India Border
09 26 66	5 10 58.1	27.5	92.6	*	5.6	5.26	India-China Border
09 26 66	6 3 48.0	27.6	92.7	*	4.2	3.59	India-China Border
03 11 67	16 56 48.7	28.4	94.4	7	5.3	4.69	India-China Border
03 14 67	6 58 4.6	28.4	94.3	24	5.9	5.54	India-China Border
07 07 67	22 56 30.8	27.8	92.2	*	4.9	3.71	India-China Border
08 15 67	9 21 2.3	31.1	93.7	*	5.7	5.07	Tibet
02 16 68	5 37 54.2	33.7	95.1	*	4.8	4.51	Tsinghai Province, China
06 28 68	20 34 55.3	30.1	95.1	44	4.8	3.58	Tibet
06 30 68	5 4 10.0	30.2	94.8	42	4.8	3.40	Tibet
07 01 68	3 11 10.0	30.3	94.5	28	4.3	3.00	Tibet
07 04 68	6 45 58.0	30.3	94.9	*	4.7	3.46	Tibet
07 13 68	6 5 54.2	30.3	94.6	*	5.0	3.46	Tibet
07 14 68	18 12 41.0	30.3	94.8	22	4.9	3.54	Tibet
07 15 68	5 9 5.9	30.3	95.0	22	4.8	3.39	Tibet
07 16 68	22 23 7.0	30.3	94.8	40	4.8	3.45	Tibet
07 23 68	20 51 47.9	30.3	94.9	30	4.9	3.43	Tibet
07 26 68	12 44 3.0	29.4	95.0	*	4.9	3.45	India-China Border
08 23 68	12 1 16.5	30.3	94.9	*	4.8	3.46	Tibet
08 24 68	14 26 7.4	30.0	95.1	56	4.6	3.35	Tibet
08 25 68	17 55 5.3	30.4	94.8	19	4.8	3.28	Tibet
08 29 68	19 51 24.6	30.2	95.1	*	5.0	3.48	Tibet
09 01 68	5 59 26.6	30.3	94.8	20	5.0	3.59	Tibet
09 03 68	17 45 54.1	30.2	94.8	53	4.9	3.43	Tibet
09 04 68	1 40 4.0	33.5	97.5	*	4.8	4.05	Tsinghai Province, China
09 11 68	3 7 32.0	30.3	94.9	38	4.3	3.52	Tibet
08 15 69	7 15 37.0	30.2	95.0	*	5.2	3.57	Tibet
11 24 69	2 1 9.3	30.6	98.9	12	4.6	4.00	Tibet
02 08 70	19 7 30.0	31.1	93.5	*	4.5	4.05	Tibet
05 08 70	11 8 8.4	32.8	95.2	35	4.5	3.55	Tibet
06 24 70	0 43 1.9	28.9	95.6	*	4.8	4.53	India-China Border

* Depth constrained to 33 km.

** Calculated according to the formula of Marshall and Basham (1971) including depth correction. For those events with constrained depths, the depth correction was applied as if they were at 33 km.

normalized to the mean values from the network on large events to minimize possibilities of bias when signals were detected at only a few stations.

Surface-wave magnitudes were computed by three methods, using the Prague, Marshall and Basham, and von Seggern formulae with only slight differences in the results. The data presented in this paper are based solely on the method of Marshall and Basham (including depth corrections) since this technique is gaining wide acceptance.

The plot of $M_s : m_b$ is given in figure 5 for all events whose depth is estimated to be less than 60 km. The shaded area encloses all explosion data for Central Asia (Eastern Kazakhstan and Sinkiang) shown by Marshall and Basham.[116]

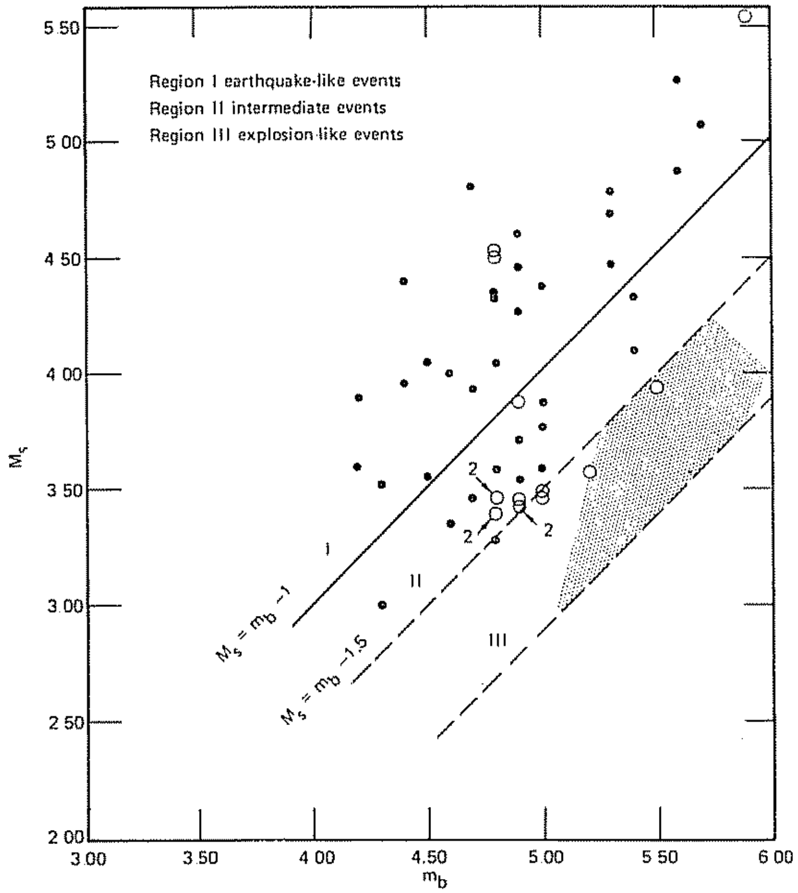


Figure 5

The m_b values are from NOAA. The M_s values are calculated according to the Marshall and Basham method with depth corrections included. Earthquakes have calculated depths 60 km or less or have had depth constrained to 33 km. Stippled area contains Marshall and Basham's observations of explosions in eastern Kazakh and Sinkiang.

The $M_s : m_b$ plane in figure 5 is divided into three parts by the lines

$$M_s = m_b - 1.0$$
$$M_s = m_b - 1.5$$

It will be observed that the M_s and m_b values of the Marshall and Basham explosion population lie below the line $M_s = m_b - 1.5$. It should be understood that the points which are plotted are subject to normal statistical error. Accordingly, an event with mean M_s and m_b values which plots somewhat above the explosion zone may, nevertheless, be statistically indistinguishable from an explosion by this criterion. Region 1, above $M_s = m_b - 1$, can be safely characterized as containing only earthquakes. It is clear from figure 5 that the values of M_s:m_b for numerous earthquakes in this area below about m_b 5.0 cannot be distinguished with confidence from explosions. The conclusion of this study is that for events of this area, the $M_s : m_b$ criterion by itself is not a positive identifier of explosions smaller than m_b 5.0, although it should be pointed out that an event as high as m_b 5.5 was observed to lie within the explosion population. While the examples of anomalous events given here are derived from a particular region, such events have been noted on some occasions to occur in some other regions as well.[117]

The cause and geographical distribution of anomalous earthquakes are an important field of research because they may assist in defining the extent of the problem. Figure 6 shows each event plotted and symbolized to indicate to which of the three populations in figure 5 it belongs. A striking feature of the distribution is the concentration of explosion-like $M_s : m_b$ values centred at about 30°N and 95°E. Futhermore, the events in question occurred mainly in one sequence which occurred from June to September 1968. Two other clear regions characterized by low M_s values relative to m_b values can be dis-

[116] P. D. Marshall and P. W. Basham, "Discrimination between Earthquakes and Underground Explosions Using an Improved M_s Scale", *Geophysical Journal*, Royal Astronomical Society, 1972.

[117] See T. Landers, "Some Interesting Central Asian Events on the $M_s : m_b$ Diagram", *Seismic Discrimination Semi-Annual Technical Summary Report to the Advanced Research Projects Agency*, 30 June 1972, Lincoln Laboratory, Massachusetts Institute of Technology.

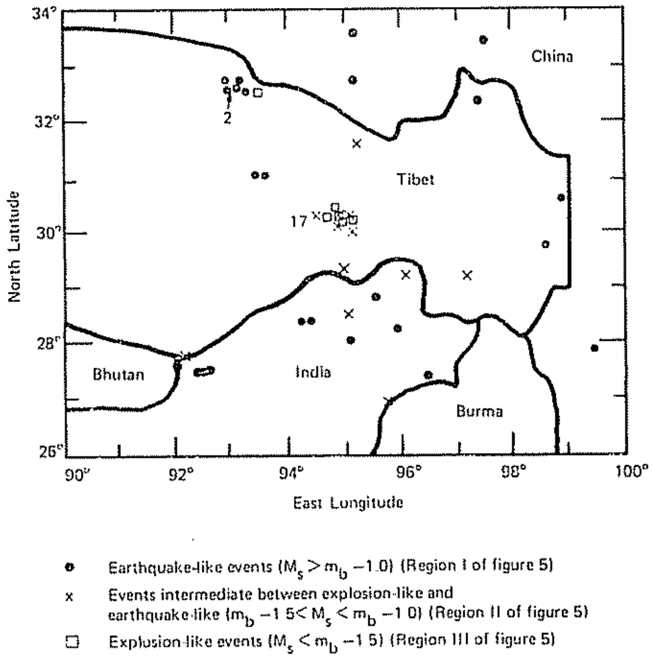


Figure 6

Geographical distribution of various M_s—m_b types. M_s—m_b values were corrected for mean station magnitude differences prior to averaging. Marshall and Basham's method was used in the M_s calculations

tinguished. One is the frontal region of the Himalayas, also described by Marshall and Basham, which shows such anomalous events intermingled with normal earthquakes. The other occupies the eastern end of Assam and the north-south trending mountain ranges which join the Himalayas and extend south toward Burma. The observed magnitude characteristics would thus appear to correlate with geological features.

Perhaps continuing research will permit us to understand the causative mechanisms of such events and place limits on where they may occur in the future. The importance of other criteria for achieving proper classification of anomalous events is clearly indicated. Perhaps the most promising of those under development for events of m_b 5 and smaller involves the determination of focal depth with greater accuracy and more confidence than has heretofore been possible. These methods are basically refinements of the classical ones which use surface reflections, calibrated travel times of P waves and calibrated travel times of other phases (especially S where suitable stations exist or can be established within a few degrees of the source). Research on these and other methods may hopefully find a variety of solutions to the problem posed by events which are inefficient generators of surface waves.

Interfering long-period signals or mixed events

Because of their relatively long time duration, a number of surface-wave trains from different seismic events will overlap. In some cases the resulting interference will be so severe as to make any extraction of useful information relating to the later arrival impossible. In other cases, and with certain techniques, the problem is more tractable and allows the interfering wave trains to be separated. It should be pointed out that many earthquakes with mixed surface waves can be identified as earthquakes by a variety of other techniques, among which are establishing depth of focus and location by use of short-period data.

There are three distinct circumstances in which interference may occur, each causing different degrees of difficulty in effecting separation of the component events. The first is when signals from two events of approximately the same magnitude from different locations arrive simultaneously at a seismic station. The second is when signals originate from two discrete but nearly co-located events having roughly the same origin time, and the third is when a small event is mixed in the coda of a much larger earthquake.

As an illustration of the extent of the problem, table 5 shows the percentage of mixed events at six single stations providing data for the Very-Long-Period Experiment. Expected signal arrival times at the stations for Eurasian events were calculated from origin times and locations given by a combined list of NOAA (including the World-Wide Standard Seismological Network (WWSSN)), LASA, and NORSAR epicentres. The data were collected between 1 January 1972 and 20 February 1972. A total of 155 signal sources within Eurasia are the data base for the study. On the average, about 16 per cent of the total possible single station observations showed interfering signals. An interfering signal in this context is taken to be one which, from visual inspection of actual seismic records, lies within the wave train of an event preceding it in time on the record to such an extent that no reliable information on amplitude or spectral content may be obtained from the combined waveform. Proximity to seismic areas causes some variation in this percentage. For example, Chiang Mai and Charters Towers both had a higher than average number of mixed events.

Table 5

PERCENTAGE OF MIXED EVENTS AT SINGLE STATIONS OF THE VERY-LONG-PERIOD EXPERIMENT

	Number of events recorded during study	*Percent mixed at single station*
Charters Towers (Australia)	154	19
Fairbanks, Alaska (United States)	133*	14
Konigsberg (Norway)	154	14
Ogdensberg, New Jersey (United States)	154	16
Toledo (Spain)	133*	12
Chiang Mai (Thailand)	77*	22

* In operation during only part of the period of the study.

The effect of a group of Very-Long-Period Experiment stations acting as a network is shown in table 6. Since all the stations were not operable over the entire period of the study, results are given when four, five or six of the stations were taken together as a network.

The tabulation shows that only in 92 out of 155 events was there no interference at all, but that the number of mixed events for which signals were obscured at all stations of the network was reduced as the number of stations in the detecting network was increased. Distribution of the totally mixed events as a function of magnitude was as follows:

Table 7

Magnitude	$m_b<4.0$	m_b 4.0 to 5.0	$m_b>5.0$
Number of events for which all stations in network recorded mixed signals	3	3	2
Number of events in population	41	99	15

Table 6

SUMMARY OF INTERFERING (OR MIXED) EVENT OBSERVATIONS FOR SELECTED VLPE NETWORKS

Network	Number of days operational	Number of events analysed	Events not mixed	Number of events mixed at: 1	2	3	4	5	6 Stations
Charters Towers (Australia); Fairbanks, Alaska (United States); Ogdensburg, New Jersey (United States); Konigsberg, Norway	5	44	26	18	11	7	4		
Charters Towers (Australia); Fairbanks, Alaska (United States); Ogdensburg, New Jersey (United States); Konigsberg, Norway; Toledo, Spain	27	70	48	22	12	9	7	1	
Charters Towers (Australia); Fairbanks, Alaska (United States); Ogdensburg, New Jersey (United States); Konigsberg, Norway; Toledo, Spain; Chiang Mai (Thailand)	25	41	18	23	11	9	6	4	3

The largest of eight mixed events noted above occurred simultaneously with an m_b 5.0 event some 600-700 km away, so that the arrival times of the two were nearly the same at all stations. The signals from three intermediate magnitude events were mixed with large signals from $m_b > 5.5$ events not occurring within Eurasia. Signals from the three low magnitude events were masked by either the signal or the coda from events outside Eurasia of magnitudes greater than m_b 4.5.

The above discussion centred upon the reduction of the mixed event population by the use of a geographically distributed network. Beam-forming capabilities of an array can also be used as an effective means of separating mixed events. In particular, the frequency-wave number analysis technique has proved most effective.

Frequency-wave number (f-k) analysis is fundamentally beam-forming in the frequency domain. The method takes advantage of the fact that signal-to-noise ratio is frequency dependent; therefore, beam-forming is performed frequency by frequency. Since frequency-domain array analysis procedures are computationally faster than their time-domain equivalents, many beams can be examined rapidly. In practice this means that the azimuth and velocity of a signal need not be assumed; one merely accepts the beam with the maximum power. The position of this maximum in the wave number domain defines the azimuth and velocity of the signal, its amplitude being a function of ground motion amplitude and hence related to the seismic magnitude. A typical representation of a wavenumber spectrum at a period of 18.3 seconds is shown in figure 7 (A). A large coherent signal from the north-east causes a power peak in the wavenumber plane at a point corresponding to its azimuth and velocity, the velocity being inversely proportional to the distance from the origin of the wavenumber co-ordinates. The same wavenumber spectrum is shown in relief in figure 7 (B).

The capability of f-k analysis to separate interfering signals is illustrated by comparing figures 7 and 8. In figures 7 (A) and 7 (B), a suspected small signal coming from the south is completely dominated by the large signal. However, the f-k technique allows us to remove the main peak along with its associated sidelobe and, thereby, bring out the smaller signal as shown in figures 8 (A) and 8 (B). The analysis is, of course, done entirely by the computer and these illustrations merely give a visual representation of the results of the data processing.

The technique will allow the measurement of the magnitude of interfering events provided that the signals are less than a seismic magnitude apart in energy and the azimuthal separation is greater than 20°. Since the analysis is done in the frequency domain, in principle the spectral content can be preserved and spectral discriminants still utilized. In practice, however, some degradation of spectral information will probably occur. This is a subject of current research.

The utility of the f-k analysis technique for the separation of mixed events was tested in two recent studies. In the first, conducted from 1 May 1971 to 23 January 1972, signals from earthquake sources in the Kurile Islands were recorded at LASA (77 events) and NORSAR (74 events). In the second, 94 events were recorded at LASA, NORSAR, and ALPA from 20 February 1972 to 1 March 1972. The number of events mixed before f-k processing was applied, and after it had been applied, are shown for each array in table 8. Also shown is the effective reduction by the use of more than one array as a network in a similar fashion to the Very-Long-Period Experiment study. Array processing brings the mixed event population down to about 20 per cent and f-k analysis techniques improve the situation to just below 10 per cent. The use of multiple arrays reduces the number still further to about 6 per cent. The residual mixed events are due to nearby co-located events or very large events with long codas.

The problem of a small seismic event being mixed in the coda of a very large earthquake might be alleviated by the use of a network of high sensitivity broadband instruments close to the seismic zones. While the coda energy from a large earthquake tends to be omni-directional, it also tends to be concentrated at periods of 18-20 seconds and longer. By contrast, the signals from a nearby event tend to still retain shorter

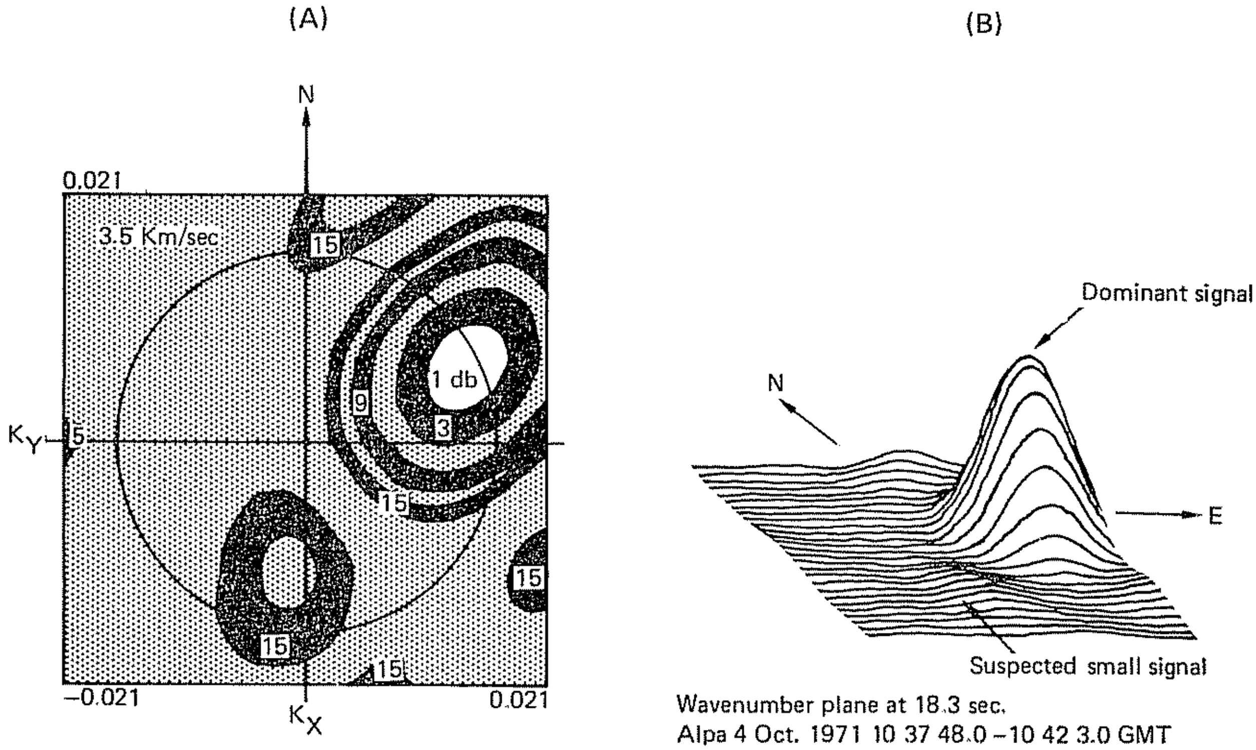


Figure 7

Frequency wavenumber representation of two interfering signals. The wavenumber plane is shown on the left and a relief version is shown on the right

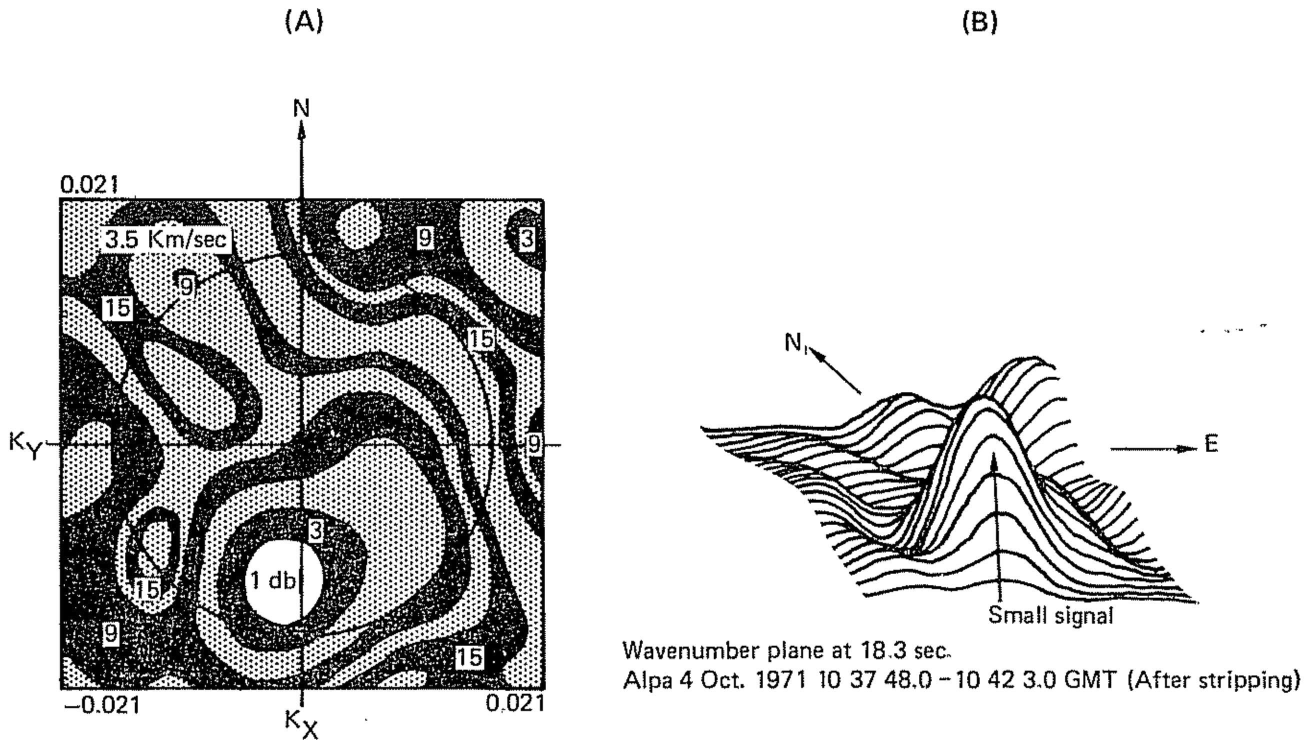


Figure 8

Case shown above with dominant signal removed thereby enhancing the small signal. The right-hand illustration is a relief version of the wavenumber plane shown on the left periods around the 12-14 second range. Broadband instrumentation coupled with digital equipment, both to utilize the inherent dynamic range and to perform adaptive filtering, might be useful in separating signals in the frequency domain.

Some possibilities open up, therefore, for mitigating the mixed event problem by a combination of small high-quality long-period arrays for array processing separation and high gain broadband instruments close to seismic zones. Although it might be anticipated that this approach to a network will reduce the residual long-period non-detections, it is conceded that the separation of residual mixed events, particularly from co-located or very large events, remains a significant problem which may impose a limitation on long-period seismic detection in areas of interest for monitoring a test ban.

Table 8

THE EFFECT OF F-K SPACE ANALYSIS ON THE SEPARATION OF MIXED EVENTS IN TWO RECENT STUDIES OF EVENTS IN THE KURILE ISLANDS AND EURASIA

Study	*Region studied*	*Duration of study*	*Number of events studied*	*Mixed at a single array*		*Mixed with multiple arrays after f-k analysis*	
				Before f-k analysis	*After f-k analysis*	*2 arrays*	*3 arrays*
Using NORSAR and LASA	Kurile Islands	1 May 71 to 23 Jan 72	74 77	16 17	6 6	5	—
Using ALPA NORSAR LASA	Eurasia	20 Feb 72 to 20 Mar 72	81 95 102	19 18 18	10 8 8	—	6

Evasion

There are inherent limitations to verification systems which mean that nuclear testing at some level can be carried out without seismic detection and identification. Recent work described in the previous two sections highlighted some of these problems. Even though further research may reduce the number of anomalous events, there are likely to be some events each year whose source identity cannot be determined by teleseismic means. We have also seen that there is always likely to be some residuum of overlapping events whose signals interfere to such an extent that they cannot be separated and identified teleseismically. There may even be a few occasions per year when the world's seismometers, both long-period and short-period, may be rendered largely useless for verification purposes by a very large earthquake. These inescapable occurrences of natural phenomena continue to be a cause of concern because they could conceivably offer a potential violator of a comprehensive test ban additional opportunities to test without detection, let alone identification. It should be pointed out that the extent to which clandestine testing might be possible depends on the capability of the monitoring facilities available.

Our programme of evasion research is oriented to understanding the potential techniques that could be used for clandestine testing in order to develop approaches that can improve the deterrence against such testing. Most United States research to date on this problem has focused on obtaining a better understanding of seismic coupling, yield/magnitude relationships as a function of rock type, and methods which might be used to decouple seismic energy. We have also been conducting theoretical studies concerned with the so-called "multiple explosion" technique. In our studies, the simulated explosions are sequenced so that in the composite seismogram the short-period body waves are reduced (depressing m_b) and the long-period surface waves are reinforced (increasing M_s). The result is an earthquake-like signal, both in general appearance and in $M_s : m_b$ ratio. Thus far, "identification" of the "event" as a multiple explosion using accepted diagnostic aids and discriminants has not been possible.

Another series of studies are under way to evaluate the likelihood of detecting and identifying the seismic signal from an explosion hidden in the signal from either a nearby earthquake or a distant large earthquake and its aftershocks. The detection problem is, in effect, simliar to that already discussed for mixed events, and the present inability to separate certain events makes this evasion technique a subject for particular attention.

The emphasis of our current research is being directed towards determining the capabilities and limitations of seismic techniques that may be used to foil the earthquake-simulation and hide-in-earthquake evasion technique.

Table 9 summarizes current information on evasion potential. It suggests estimated yield limits for various evasion techniques which are considered technically feasible. Despite known constraints on the tester, including yield limitations, high cost, and the possibility of detection, we cannot be confident that they will suffice to deter a potential evader. It therefore seems important to improve the seismic means for detecting such tests.

III. FUTURE RESEARCH

The problems discussed in section II suggest some promising avenues of further inquiry that should assist in their solution. For example, our inadequate data base for events of low magnitude for many of the seismic areas of the world can be rectified by the deployment of higher quality seismic stations with higher gains in quiet sites. Additionally, as more low-magnitude events become detectable, the problem of handling more high-quality digital data will present a task of major proportions in data processing and system management. Finally, increased knowledge about evasion techniques may suggest ways to deter clandestine testing; countermeasures to evasion should be actively pursued. This section seeks to outline some

Table 9

Evasion techniques	*Estimated yield limit to avoid detection**	*Constraints on tester*
Tamped shot in low coupling media	1-2**	Low yields; relatively few areas of low coupling media, most in undeveloped regions, evader would probably test in seismic region.
Decoupling cavity	50 kt	Large volume of rock or salt required; long preparation time; expensive.
Detonate following nearby earthquake	50 kt	Device must be pre-positioned; local earthquakes must be about one seismic magnitude larger than explosion; decision to test must be made very quickly.
Detonate following large distant earthquake	100 kt	Device must be pre-positioned; evader would probably have to test in seismic regions; 1 opportunity every 1-2 years to conduct several simultaneous events in a series; decision to test must be made quickly.
Multiple shot simulation of earthquake signal	100 kt	Requires multiple emplacement holes; evader would have to test in seismic regions. Requires considerable testing experience.

* Estimates based on detection capabilities of stations remote from event.

** Could be as high as 10 kt dependent upon the availability of sufficiently deep low coupling media.

of the new approaches to research suggested by the unresolved problems in seismic verification.

A multi-national seismic co-operation study

At the present time we do not know with any degree of confidence how many seismic events there are in every area of the world above magnitude 4.0. To address this problem a co-operative multi-national project has recently been undertaken under the aegis of the Lincoln Laboratory of the Massachusetts Institute of Technology. It utilizes the detection logs, rather than the more conservative seismic bulletins of the participating groups, and will seek to answer a number of scientific and operational questions related to detection and discrimination by using all available seismic data.

Data recorded for a period of one month, 20 February to 19 March 1972, has been selected for this extensive study with participating groups in Canada, Sweden, Norway, the United Kingdom and the United States. In addition, the analogue records of all other groups submitting data to the United States National Oceanic and Atmospheric Administration have been incorporated in the data base. Finally, a list of events from non-seismic regions, or which for some reason cause difficulties with some discriminants, and other recent special events of particular interest, is being compiled for study by the various groups. The number of potential events being considered is about 5,000 although the process of event authentication promises to reduce this figure to under 1,500. Event authentication means that detection of an event is made by at least three WWSSN stations or one detection at a local standard station corroborating the same detection by an array.

Although the work is only in its initial phase, it is hoped that the final bulletin will contain very nearly all events in the Northern Hemisphere of m_b 4.0 and greater and that by using modern data acquisition systems and computer techniques for data integration and manipulation such a capability might be achieved routinely. Of course, some events smaller than m_b 4.0 will be detected too but not with sufficient reliability to be useful. Another parameter which requires evaluation is a more precise estimate of the number of times small events are masked by occasional very large events.

Data already compiled have included bulletins from the United States National Oceanic and Atmospheric Administration, NORSAR and LASA; detection logs from NORSAR, LASA, Yellowknife, Hagfors, and Warramunga; arrival times and amplitude measurements for Warramunga, Guaribidinaur, Canadian network stations, and other measurements reported to NOAA. Film records of selected WWSSN stations will also be utilized and every attempt will be made to reprocess array data for possible events not originally reported by the arrays. For the first time we will be in a position to accumulate a single list of events which will form a common and agreed data base for comparative studies, almost an impossibility up to this time.

It is anticipated that the work will be completed by October, 1972 at which time the results will be distributed by Lincoln Laboratory to all participants and other interested workers.

Future communications systems and data analysis

One of the important issues which was mentioned in our earlier paper (CCD/330) was that optimum verification system performance requires a good deal of operating experience before it is actually achieved, and is crucially dependent on the quality of system management. Preliminary results of the multi-national co-operative experiment is revealing that there are likely to be as many as 20,000 events above m_b 4.0 per year. This will pose a data management and processing problem of major proportions.

The approach to this problem which the United States is now undertaking will have three facets. First, each high quality station or array will have a comprehensive signal processing system including techniques for maximizing signal-to-noise ratios for various wave types, azimuths, and frequency bands; automatic event detection; signal editing and storage; and a means of reprocessing data on request.

Secondly there should be regular but not necessarily real time transmission of processed data from the individual station to an analysis centre or centres. Modern satellite communication systems, already in existence and commercially available at economic rates, have made communications on a world-wide basis simple in principle. A map of current ground stations and the three COMSAT satellites is shown in figure 9. They possess the unique advantage in a world-wide seismic

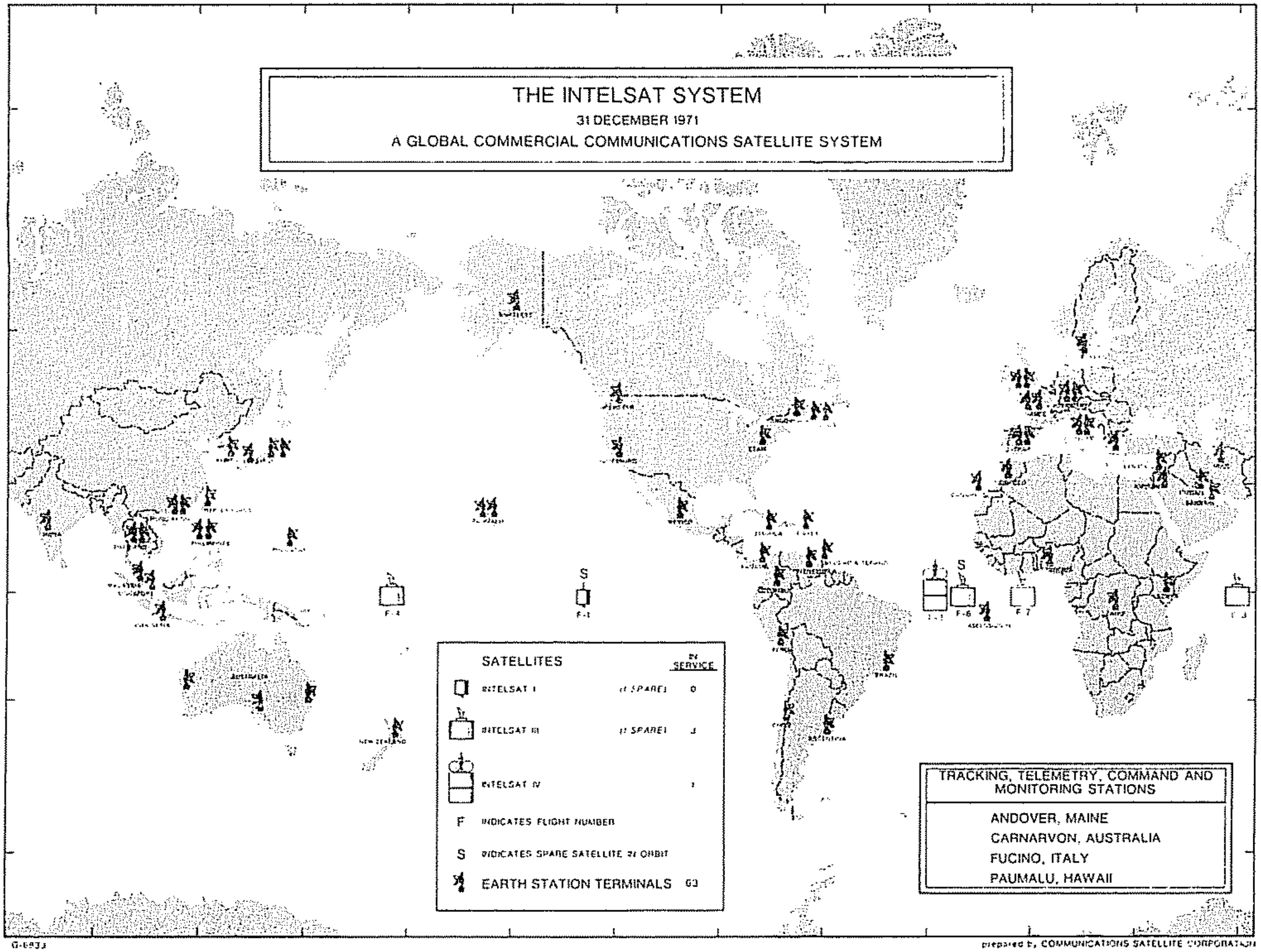


Figure 9

The Intelsat System

monitoring context that the data would be available to all who would wish to use it, the only requirement being a link to a satellite communications ground station. Simple though the concepts may be, many details must be investigated. These include data format; the means of interfacing with the satellite link; data rate, including trade-offs between continuous low rate and short bursts of high rate transmission of accumulated data; and sufficient two-way transmission to permit data to be extracted from as well as deposited in the data bank.

Thirdly, consideration will have to be given to the functions of the data bank and central data analysis centres. The important seismic parameters for an operating system will have to be specified, such as location, time of origin, depth, magnitudes, spectral data and other possible discriminant material, and improved means for computing them will have to be developed to handle the great numbers of events which occur world wide. The development of the recently operational network of interacting computers—called the ARPANET—encourages us to explore these possibilities without being limited by computers. This net provides high quality remote access to a number of large special and general purpose computers in the United States. The Seismic Array Analysis Center (SAAC) in Alexandria, Virginia, is linked to this net, and this provides the Center with the capability of utilizing the largest and most sophisticated computing facilities available. A further development which promises to be more valuable from the point of view of a data bank is a mass storage device having a capacity of approximately 10^{12} bits of data. This is adequate to store the unedited data from 25 nine-element long-period arrays operating for approximately three years.

Seismic instrumentation

The results of recent research make it important to review our current thinking on seismic instrumentation. The results obtained from the Very-Long-Period Experiment seem to indicate that rather than restricting analysis to periods of 20 or 40 seconds, it seems much more profitable to use as broadband data as possible. An extension of the pass band of long-period instruments is indicated by the fact that earthquakes occurring within 20° have a richer frequency spectrum in the region of 12-14 seconds than at greater distances. There is a prospect, therefore, of seeing relatively short-range earthquakes against the background of the coda from a large earthquake whose dominant period is likely to be of the order of 20 seconds. These facts combine to suggest that in future research we should record broadband from about 10 to 50 seconds.

Recent research has been devoted to develop a reliable broadband instrument. Hitherto, analogue recording has precluded the realization of the potential of the broadband instrument since instrument band passes were designed to eliminate seismic noise, specifically at the 6-second and 18-second microseismic peaks. With the introduction of digital recording, the large dynamic range can be exploited and the prewhitening of the noise by analogue filtering avoided.

An instrument with a good response curve from periods of one second to d.c. has been constructed. This essentially means that this instrument, with digital recording, and perhaps notched filtering to remove the 6-second microseismic peak, has the potential of obtaining data presently obtained by both long-period and short-period instruments. The instrument can be packaged in a way that it contains its own temperature and pressure environment and, in addition, is small enough for use in a 7-inch diameter borehole. This latter feature is of considerable importance because it opens up the attractive possibility of economically deploying instruments below the zone of locally-generated atmospherically-induced earth noise. The horizontal components of the long period ($t > 20$ seconds) earth noise are particularly sensitive to deep burial, and it is the noise in these components which at surface sites severely inhibits the detection of potentially useful Love waves. The noise is not only high in these components at the surface but is highly unstable due to storms and diurnal changes due to atmospheric loading causing earth tilt. Love waves have been less investigated for this reason.

The instrument and other similar new developments are currently being evaluated at the Tonto Forest Observatory alongside more conventional long-period instruments in surface vaults. A borehole experiment will be undertaken to establish the advantages to be gained operationally from the deployment of this seismometer at depths up to 5,000 feet, particularly to explore the utility of Love wave data as a factor in seismic discrimination.

Improved seismic research networks

Studies of identification criteria which have been conducted to date reveal deficiencies in the data base available for research. For example, the previously described events in Asia having low $M_s : m_b$ ratios are so remote from the large arrays and from all but one of the stations of the Very-Long-Period Experiment that only limited information can be obtained from these stations. In addition, some other promising criteria which might identify these events (for example, Wadati's method for determining focal depth using S-P[118]) require high-quality data recorded within several degrees of the source. Valuable as they are for most general seismological studies, data from standard WWSSN stations are inadequate to support the desired research. In particular, the stations do not have sufficient effective gain to record data from the low magnitude events of interest, and the photographic recordings are not suitable for the necessary computer analyses.

As a consequence of these considerations, and as an adjunct to the communications study and other studies related to the consideration of monitoring a test ban, the United States is planning a programme for selectively upgrading selected WWSSN stations. Sites would be chosen at locations where they can be expected to produce data needed for important investigations. Small arrays may be needed at a few locations to attain necessary defection thresholds and to assist in mixed event separation. Digital recorders will be needed for high dynamic range and efficient analysis. As currently envisioned, about 20 stations of the WWSSN might be improved with advantage. Planning is, at present, in the preliminary stages and hence cannot be reported to the Conference at this time.

Counter-evasion research

The principal objective of the research programme into evasion techniques is to devise measures which can be incorporated into seismic verification schemes to detect, and thereby deter, possible attempts to test clandestinely. It is important to determine the quantity and character of seismic data which will sufficiently deter such testing and to design a seismic verification system which meets those specifications.

A number of new approaches to the evasion problem are being examined using spectral analysis of both long-period and short-period data as well as broadband signals. Further research on coda suppressions as a means of limiting testing opportunities is required. Performance comparisons need to be made for various beam-forming techniques, filters, and spectral processors as a means of separating and identifying events. Continued work on short-period discriminants is required since this may prove to be the only useful positive counter-evasion approach at low magnitude levels. Network characteristics, particularly station location, may be able to reduce the likelihood of successful evasion by simulating an earthquake or hiding the explosion signal in the coda of a natural event. Research on these subjects is continuing.

32.

Italy: working paper on the problem of reorganization of the negotiating structures in the disarmament field

[*CCD/389 of 28 August 1972*]
[*Original: English*]

During the informal meeting held on 16 August 1972 at the request of the delegation of Mexico, the delegation of Italy

118 See K. Wadati, "On the Travel Time of Earthquake Waves, Part II", *Geophysical Magazine*, vol. 7, 1933, p. 101.

submitted to the Committee some views on the problem of the reorganization of the negotiating structures in the disarmament field.

These views are set forth in the present working paper for further consideration by the Committee.

1. The Italian delegation believes that the present structure of the Conference of the Committee on Disarmament, which *inter alia* makes the participation of China and France more difficult, may not fully meet the requirements of the multilateral negotiating body of the future in the disarmament field. Structural changes, whether in the composition of the Conference or in its rules of procedure, are, therefore, essential if we are to breathe new life into the multilateral negotiations.

It is not therefore a question of whether there should be reorganization, but rather of how and when. To find the right answer to these questions, which relate to the real practical aspects of our problem, we must start from a premise which seems to us unquestionable: that the multilateral organ for disarmament negotiations cannot fulfil its task unless it includes among its members all the politically and militarily important Powers and, in particular, all the nuclear Powers. Any reorganization of structures and procedures must therefore be conceived with a view to securing, as a first and essential requirement, the participation of China and France in such a multilateral organ. Now, the fact must be faced that not only is there no tangible indication of any readiness on the part of those two Powers to participate in the work of the Conference, but these is no evidence to suggest that any reorganization of the Conference would induce them, at least today, to review their position. In fact, we can hardly see how the structural and procedural changes on which we might try, at this stage, to reach a consensus in our Committee could, by themselves alone, make China and France change their attitude to the Conference. Therefore, if changes in its organization are undertaken without any evidence as to what would be the attitude of these two Powers there is a risk that such a reorganization would fail in its most important objective, which is to bring them into the multilateral disarmament negotiations and, at the same time, that it might weaken the efficiency of the present negotiating body.

2. This does not mean that the problem of reorganizing the negotiating structures in the disarmament field should be shelved. The problem exists and needs a solution. In our opinion, such a solution could be sought in connexion with the forthcoming discussions on the proposal of convening a world disarmament conference.

We believe that with adequate preparation a world disarmament conference could, at the appropriate time, promote positive developments in the action for disarmament; and we consider that, for sound operational reasons, the task of preparing such a conference should be entrusted to a qualified committee of restricted membership. The very establishment of this committee could give us the key not only for the fruitful preparation of a world disarmament conference but also for the structural reorganization of the multilateral negotiating body.

In our opinion, the preparatory committee would best be able to carry out its tasks to the full only if its membership does not exceed 30 or, at the very most, 35 States; if it includes all the nuclear Powers, and if it is based not so much on simple criteria of geographical distribution, which do not always correspond to the peculiar nature of disarmament problems, but rather on the criteria of realistic political and military balance on which the composition of the Conference itself is based. To our mind, the most practical solution would be for the preparatory committee to comprise all those States now participating in the works of the Conference, which could thus contribute their knowledge and experience of multilateral disarmament negotiations, as well as China and France and any other countries which it might be felt necessary to include, in order to take account of new developments in the international community.

If in its present composition the Conference of the Committee on Disarmament does not meet the necessary requirements to become the preparatory committee of a world disarmament conference, on the other hand, the establishment of a new body might create a replica or a rival of the Conference, and, in any case, would raise the problem of the relationship between two multilateral organs both operating in the disarmament field: namely, the Conference of the Committee on Disarmament and the preparatory committee of a world disarmament conference.

If we go to the heart of this problem we cannot help recognizing that the coexistence of two multilateral restricted bodies in the disarmament field would not be a realistic solution. Once an organ that includes all the nuclear Powers is constituted for the purpose of preparing the ground for a world disarmament conference which will have to deal with all the major problems of disarmament and formulate the essential guidelines for their solutions, such an organ will inevitably deprive the Conference of the Committee on Disarmament of its political importance and thereby impair its practical effectiveness as a negotiating body. To put it more clearly, we believe there can be no coexistence of two organs without one becoming overshadowed and, sooner or later, being eliminated by the other.

Accordingly, if a realistic solution is to be found it will mean, in our view, a choice between two options: either the Conference of the Committee on Disarmament becomes the preparatory committee of the World Disarmament conference—but this may not solve the crucial problem of securing the participation of China and France in the preparation for the world disarmament conference; or the new preparatory committee of the world disarmament conference, established on the basis of the criteria we have suggested and including therefore all the nuclear Powers, assumes also the functions of the multilateral negotiating body: in which case the preparatory organ of the world disarmament conference would itself become a new Conference of the Committee on Disarmament, not duplicating but replacing our present Committee. In our opinion, this latter option offers the most practical approach to the problem of the reorganization of the negotiating structures in the light of today's political realities.

In other words, we believe that the problem of establishing a preparatory committee for a world disarmament conference, along the lines suggested above, and the problem of reorganizing a negotiating body in the disarmament field would thus be merged into one.

3. Of course, this approach does not rule out the possibility of making, in the meantime, some pragmatic improvement in our procedure as, for instance, the establishment of *ad hoc* groups to study specific issues, thus making for a more efficient and flexible working method, along the lines indicated in the statement of the representative of Italy of 7 March 1972 (CCD/PV/547).

33.

Mexico: working paper containing a list of statements dealing with reorganization of the Conference of the Committee on Disarmament which were made at formal meetings of the Conference between 29 February and 24 August 1972

[*CCD/390 of 28 August 1972*]
[*Original: Spanish*]

	Date	*Record of meeting*
The Secretary-General	29 February	CCD/PV.545, p. 11
Brazil	18 April	CCD/PV.557, pp. 15 and 16
	29 June	CCD/PV.564, pp. 8 and 9
Bulgaria	14 March	CCD/PV.549, pp. 17 and 18
Canada	2 March	CCD/PV.546, pp. 6 and 13
	25 July	CCD/PV.571, pp. 12 and 13

	Date	Record of meeting
Czechoslovakia	16 March	CCD/PV.550, p. 5
Egypt	11 April	CCD/PV.555, p. 6
Hungary	6 April	CCD/PV.554, pp. 7, 17 and 18
India	23 March	CCD/PV.552, p. 8
Italy	7 March	CCD/PV.547, pp. 15, 16 and 19
Japan	7 March	CCD/PV.547, pp. 6 and 7
	22 June	CCD/PV.562, pp. 7, 8 and 18
Mexico	29 February	CCD/PV.545, pp. 31-34
	8 August	CCD/PV.575, pp. 20-23
	24 August	CCD/PV.580, pp. 6, 10 and 11
Mongolia	23 March	CCD/PV.552, p. 23
Morocco	11 April	CCD/PV.555, p. 16
Netherlands	23 March	CCD/PV.552, pp. 12 and 13
Nigeria	28 March	CCD/PV.553, pp. 13 and 14

	Date	Record of meeting
Poland	21 March	CCD/PV.551, p. 32
Romania	16 March	CCD/PV.550, pp. 13, 21 and 22
	25 April	CCD/PV.559, p. 21
	3 August	CCD/PV.574, p. 15
Union of Soviet Socialist Republics	27 April	CCD/PV.560, pp. 19 and 20
	20 June	CCD/PV.561, pp. 10 and 11
United Kingdom	2 March	CCD/PV.546, pp. 17 and 18
United States of America	29 February	CCD/PV.545, pp. 17 and 18
	27 April	CCD/PV.560, p. 16
Yugoslavia	9 March	CCD/PV.548, pp. 8-10
	27 July	CCD/PV.572, pp. 29, 34 and 35

ANNEX C

List of verbatim records of the meetings of the Conference of the Committee on Disarmament

CCD/PV.545-560 (29 February to 27 April 1972): records of the 545th to 560th meetings.

CCD/PV.561-584 (20 June to 7 September 1972): records of the 561st to 584th meetings.

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