1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons

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OTHER ACTIVITIES RELEVANT TO ARTICLE III

Background paper prepared by the United Nations Secretariat

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I. INTRODUCTION

1. At its second session, held from 17 to 21 January 1994, the Preparatory Committee for the 1995 Review and Extension Conference of the Parties to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) invited the Secretary-General of the United Nations to prepare for the Committee at its third session, to be held from 12 to 16 September 1994, a number of background papers regarding the implementation of various articles of the Treaty (General Assembly resolution 2373 (XXII), annex). Pursuant to that request, the United Nations Secretariat submitted those background papers to the Preparatory Committee at its third session. In reviewing the papers, the States parties expressed general appreciation for the work done and requested the Secretariat to update and revise, as appropriate, the background papers, taking into account various specific observations and suggestions made on that occasion. In that connection, the Secretariat was specifically requested to cover also the issue of export control regimes, which had not been dealt with in the pertinent background papers as initially submitted.

2. In the course of the fourth session of the Preparatory Committee, the Secretariat informed the States parties of its intention, in the context of updating and revising the background papers, to provide them also with factual information on export-control regimes as part II of the background paper dealing with article III of the Treaty. At its meeting on 27 January 1995, the Committee took note of that information. The present paper is submitted accordingly.

II. BACKGROUND

A. General

3. The regulation of nuclear exports became an issue of international concern with the beginning of the nuclear era itself. Over the years, various ideas have been expressed and specific proposals advanced with the objective of promoting international cooperation in the broad field of peaceful uses of nuclear energy for the benefit of all States, while at the same time preventing nuclear proliferation. Over that period, policies on nuclear exports were elaborated in various national and international contexts. In the 1960s, consideration of the issue received additional impetus from growing expectations of the benefits of nuclear energy and was also given greater urgency by the apprehensions about the potential proliferation of nuclear-weapon technology. These two aspects - peaceful benefits and the threat of nuclear proliferation - prompted the international community, irrespective of the political and ideological differences that existed in international relations at the time, to try to develop a common approach.

4. The Treaty on the Non-Proliferation of Nuclear Weapons of 1968 represented the first successful global multilateral effort to lay down basic rules regarding nuclear exports, facilitating their peaceful application while precluding their diversion to nuclear explosive uses. Article IV, paragraph 1, of the Treaty made clear that it did not affect the inalienable right of its

parties to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I and II. 1/ Paragraph 2 further committed the parties to facilitate, and granted them the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for such purposes. The Treaty also commits parties in a position to do so to cooperate in further development of nuclear energy for peaceful purposes, especially in the territories of the non-nuclear-weapon States parties to the Treaty and with due consideration for the needs of the developing areas of the world. 2/

5. In that connection, article I of the Treaty requires nuclear-weapon States not "in any way to assist, encourage, or induce any non-nuclear-weapon State to manufacture or otherwise acquire nuclear weapons or other nuclear explosive devices". In addition, paragraph 1 of article III spells out the safeguards requirements that non-nuclear-weapon States parties must meet to benefit from the peaceful uses of nuclear energy. Each such State wishing to benefit from the peaceful uses undertakes to accept the safeguards of the International Atomic Energy Agency (IAEA) "for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty" 3/ (see NPT/CONF.1995/7/Part I).

6. Paragraph 2 of article III, however, stipulates specific obligations of all States parties, both nuclear and non-nuclear-weapon States "not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this article". 4/

7. The Treaty did not, however, provide a definition of what was meant by the terms "source or special fissionable material" or "equipment or material especially designed or prepared for the processing, use or production of special fissionable material". Clarifications of these terms was pursued by an informal group of nuclear suppliers shortly after the Treaty entered into force in 1970. The interpretations and specifications that resulted from that effort were first published in 1974 and are commonly referred to as the "Zangger Guidelines" (after the first Chairman of the Group, Mr. Claude Zangger). Subsequently another group, open also to non-party suppliers, published additional guidelines in 1978.

8. Some of the export guidelines subsequently led to differences in position between various developing recipient States and suppliers. One criticism expressed by developing recipient States was related to the manner in which suppliers handled the matter. Developing States argued that those matters should not be considered in informal groups outside the framework of the mechanism of the Treaty itself nor, more importantly, without their involvement in working out the export guidelines. For their part, the supplier countries, who on the whole were also major recipients, have maintained that the main purpose of their policies was to give all States confidence that nuclear cooperation would take place in a manner consistent with the Treaty's principles by (a) facilitating such cooperation, and (b) enhancing global and regional

stability by assuring, through adequate safeguards, that supplies would be used only for peaceful purposes.

B. NPT Exporters' Committee (Zangger Committee)

9. Following the entry into force of the Treaty, in 1970, a group of States began holding informal and, at the time, confidential meetings at Vienna to discuss how to implement their obligations under article III, paragraph 2. The group met under the formal name of the "NPT Exporters' Committee", but became better known as the "Zangger Committee". The group decided that its status should be informal and that its decisions would not be legally binding upon its members but would serve as a basis for harmonized national policies. As suppliers or potential suppliers of nuclear material and equipment, the States members of the Committee set as their objective to reach a common understanding regarding the definition of items listed under article III, paragraph 2 (a) and (b), and the conditions and procedures that would govern the export of such items. One guiding principle of the Committee was that the regulations to be applied should not disturb fair international commercial competition and that each item on its list should meet the criterion of the Treaty, namely, be "especially designed or prepared for the processing, use or production of nuclear material".

10. After a series of meetings held between March 1971 and August 1974, the Committee reached consensus on basic understandings that were described in two separate memoranda. The export of items included in these memoranda triggers a request by the supplier that the conditions of supply set out in those memoranda should apply. Those conditions are designed to ensure that items on the "trigger list" cannot be exported or re-exported to a non-nuclear-weapon State not party to the NPT unless they are covered by a non-explosive-use assurance, IAEA safeguards and re-export provisions, that is, such recipients of an exported item are not to re-export it without requiring the same conditions. The trigger list was accompanied by an annex, which provided more detailed clarifications and definitions of the items contained in memorandum B.

11. Those documents were made public on 14 August 1974. The understandings were formally accepted by individual members of the Committee by an exchange of notes among themselves, which committed them to give effect to the understandings through respective domestic export-control legislation. In parallel with that procedure, most members wrote identical letters to the Director General of IAEA informing him of their decision to act in conformity with the conditions set out in the understandings. The content of the letters was communicated to all States members of the Agency on 3 September 1974 and issued as IAEA document INFCIRC/209 (see annex I).

12. Memorandum A dealt with the export of commodities described in article III, paragraph 2 (a), of the NPT (source or special fissionable material). It states that the definition of that term will be that contained in article XX of the IAEA statute. Memorandum B covered export of commodities referred to in article III, paragraph 2 (b) (equipment or material especially designed or prepared for the processing, use or production of special fissionable material). As published in 1974, it defines plants, equipment and material in the following

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categories: reactors and equipment therefor; non-nuclear materials for reactors; plants for the reprocessing of irradiated fuel elements and equipment especially designed or prepared therefor; plants for the fabrication of fuel elements; and equipment, other than analytical instruments, especially designed or prepared for the separation of isotopes of uranium.

13. At the time the trigger list was first agreed upon, the supplier States considered that limiting the application of safeguards to entire facilities in the nuclear-fuel cycle would be sufficient to hinder any diversion from legitimate uses of nuclear technology. With further rapid technological advances in the field, the members of the Committee felt, however, that it was necessary to make adjustments accordingly. Consequently, in subsequent years, both the memoranda and their annex were regularly reviewed by the Committee and clarified in order to take into account technological developments and to add greater precision and clarity to items on the list to be controlled. Those reviews and consequential clarifications were conducted on the basis of consensus, using the same procedure followed in the adoption of the original understandings. In the period up to the 1990 NPT Review Conference, the following clarifications had been made, all of which were published as modifications of the original document (INFCIRC/209):

(a) In December 1978, memorandum B was amended to include new headings, "plants for the production of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor", and to alter the section already in it on zirconium tubes (INFCIRC/209/Mod.1). The inclusion of the first item was prompted by the London Group (see para. 18) on the grounds that since the export of heavy water was already covered by the trigger list, it was only logical that plants for the production of that material should be subject to safeguards as well;

(b) In February 1984, additions concerning gas centrifuge enrichment equipment were made to the annex to the trigger list in order to clarify the items covered by the list heading in Memorandum B on "Equipment, other than analytical instruments, especially designed or prepared for the separation of isotopes" (INFCIRC/209/Mod.2), a technological development that had taken place in the course of the preceding decade.

(c) In August 1985, additions concerning fuel-reprocessing plants were made to the annex in order to clarify the item covered by the trigger list heading in memorandum B, "Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor" (INFCIRC/209/Mod.3);

(d) In February 1990, additions concerning gaseous diffusion enrichment equipment were made in order to clarify the items covered by the trigger list heading in memorandum B, on "Equipment, other than analytical instruments, especially designed or prepared for the separation of isotopes" (INFCIRC/209/Mod.4).

14. Unlike non-nuclear-weapon States parties to the NPT, which under article II, have already renounced nuclear weapons or other nuclear explosive devices, and under Article III, paragraph 1, have accepted safeguards on all

their peaceful nuclear activities, and under Article III, paragraph 2, have accepted the obligation not to export the items specified therein without requiring safeguards on them, States not-parties to the NPT were not under such an obligation. The Committee therefore included, among the understandings governing their exports to non-nuclear-weapon States not party to the Treaty, the following basic conditions of supply:

(a) Source or special fissionable material, either directly transferred or produced, processed or used in the facility for which the transferred item is intended, shall not be diverted to nuclear weapons or other nuclear explosive devices;

(b) Source or special fissionable material, as well as equipment and non-nuclear material, shall be exported only to a non-nuclear-weapon State not party to the Treaty if subject to safeguards under an agreement with IAEA;

(c) Source or special fissionable material, as well as equipment and non-nuclear material, shall not be re-exported to a non-nuclear-weapon State not party to the Treaty unless the recipient State accepts safeguards on the re-exported item.

C. The London Group

15. Following India's detonation of a nuclear device in 1974, several major supplier States decided to undertake a new review of the guidelines regulating nuclear exports. Their objective was to ensure that the controls of major suppliers, even if not parties to the NPT, were harmonized and to improve non-proliferation controls, particularly with respect to transfers to States not parties to the Treaty. The Group, because of the venue of its meetings, became initially known as the "London Group".

16. By 1978, following a series of meetings, the Group had reached agreement on a set of guidelines regarding export of items related to peaceful uses of nuclear energy. In the process, the Group was further expanded.

17. These original "London Guidelines" were published by IAEA in February 1978 (INFCIRC/254) upon request of the Group. The guidelines, by and large, incorporated the work of the Zangger Committee, but in some respects went beyond it in several areas. Thus, as regards the conditions of supply, besides the three formulated by the Zangger Committee - non-explosive use assurance, safeguards, transfer approval rights (see para. 14) - the London Guidelines identified two more criteria to be met by a recipient State: (a) to apply physical protection measures on nuclear material on the basis of the recommendations in IAEA document INFCIRC/225; and (b) to accept that any facility that was built on the basis of the know-how of certain supplied technology (the "know-how" clause) would be put under safeguards.

18. The items subject to the conditions of supply set out in the guidelines were those previously identified by the work of the Zangger Committee, but with the addition of one new item to the trigger list ("Plants for the production of heavy water, deuterium, and deuterium compounds and equipment especially

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designed therefor") and a clarification of the items covered by trigger list heading "Equipment, other than analytical instruments, especially designed or prepared for the separation of isotopes" ("separation plant equipment") (see para. 13 above).

19. Finally, the guidelines introduced some entirely new requirements with respect to sensitive facilities, technology and weapons-usable materials. These essentially required suppliers to exercise special care in the export of such items, for example reprocessing and isotope separation facilities.

20. Following the publication of the London Guidelines in February 1978, the Group did not meet until after the 1990 Review Conference. Its members felt that they would not at that stage be able to add much to what had already been accomplished and which could not be done within the framework of the Zangger Committee, whose members continued to meet regularly in order to review its trigger list and to clarify it as necessary.

D. Review Conferences, the Zangger Committee and the London Group

21. The four Review Conferences held up to 1990 dealt in one way or the other with the work of the Zangger Committee and the London Group. The attitude towards the two was markedly different, however. This followed the perception, held largely by the developing countries, that the Zangger trigger list clarified the conditions of supply established by the NPT, while the London Guidelines went beyond the legal framework of Article III, paragraph 2. This became even more the case when the re-established Nuclear Suppliers Group in 1991 introduced a second area of nuclear items to be subject to export controls, the "nuclear-related dual-use items", an area which in the opinion of the developing countries was not properly defined.

22. As regards the Zangger Committee, the first three conferences recognized and, in fact, endorsed its work, without explicitly referring to the Zangger Committee. Thus, the Final Declaration of the first Review Conference in 1975, adopted by consensus, contained the following language: 5/

> "With regard to the implementation of Article III, paragraph 2, of the Treaty, the Conference notes that a number of States suppliers of material or equipment have adopted certain minimum standard requirements for IAEA safeguards in connection with their exports of certain such items to non-nuclear-weapon States not party to the Treaty (IAEA document INFCIRC/209 and addenda). The Conference attaches particular importance to the condition, established by those States, of an undertaking of non-diversion to nuclear weapons or other nuclear explosive devices, as included in the said requirements."

The Declaration went on to urge that "common export requirements relating to safeguards be strengthened, in particular by extending the application of safeguards to all peaceful nuclear activities in importing States not Party to the Treaty". 6/

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23. The second Review Conference, held in 1980, was unable to agree on a final declaration, owing to disagreements pertaining to the implementation of Article VI of the Treaty and whether full-scope safeguards should be a condition of supply. While from the outset recognizing the need to clarify Article III, paragraph 2, of the Treaty, and subsequently accepting the Zangger trigger list not necessarily as a preferable option but still as a generally acceptable mechanism for promoting export for the purpose of peaceful uses of nuclear energy, the reaction of non-nuclear-weapon States to the London Guidelines was negative.

24. These countries believed that the London Group had exaggerated the threat of the potential misuse of peaceful uses of nuclear energy and, consequently, introduced the restrictions on exports of nuclear material, which made it more difficult for those countries to acquire the technology needed to help them take full advantage of nuclear power for their economic development. In the opinion of the developing countries the mere publication of the Guidelines was not sufficient. They continued to reiterate the longstanding request that they be actively involved in this work as well. An attempt to do so was made after the Second NPT Review Conference in 1980 through the establishment of an IAEA Board of Governors Committee known as the Committee on Assurances of Supply, which still exists but is no longer active. The proponents of the Guidelines, on the other hand, saw them as largely designed to broaden safeguard coverage in non-parties and to harmonize all suppliers' approaches, both to ensure that non-proliferation objectives would be met as well as to remove non-proliferation from the area of commercial competition.

25. At the time the third Review Conference was held in 1985, this had changed. While many of the misgivings related to export-control regimes remained, they were increasingly related to political principles, such as the equality of all States parties, rather than primarily to their potentially negative effect on the economic development of developing States. There was also a growing fear in the international community of the possible proliferation of nuclear-weapon technology to non-nuclear-weapon States, both party and non-party to the NPT. All of these developments, in various degrees, made it possible for the Review Conference to adopt unanimously a Final Declaration, which in its relevant parts, once again, expressed support for the work of the Zangger Committee, but without naming it explicitly. The Declaration stated: 7/

> "The Conference believes that further improvement of the list of materials and equipment which, in accordance with Article III, paragraph 2, of the Treaty, calls for its application of IAEA safeguards should take account of advances in technology."

The Declaration went even further as regards full-scope safeguards by recommending that nuclear suppliers take effective steps towards achieving such a commitment by their customers. All the views and recommendations expressed by the Review Conference were subsequently reflected in the work of the Zangger Committee (see paras. 35 and 36).

26. The developments that facilitated the adoption of the Final Declaration by consensus at the 1985 Review Conference came into even sharper focus at the Fourth NPT Review Conference in 1990. Many countries, including the United

States of America and most European States, had placed, or experienced, temporary moratoriums on the construction of new nuclear power plants in response to the spiralling costs involved in building them and the lingering question of their safety prompted by the Chernobyl reactor accident in 1986. The concerns related to suspicions that some "threshold States", both party and non-party to the Treaty, might be involved in acquiring nuclear weapons technology, and that some might already have done so, not only by clandestine activities but also by taking advantage of certain loopholes in the export regimes, have provided a strong impetus to convergence of views on some aspects of the export controls and safeguard mechanisms. They have, however, also led subsequently to divergence of views between supplier and developing countries in their approach to the whole issue, in particular regarding further elaboration of the conditions of supply for nuclear items following revitalization of the London Group as the Nuclear Suppliers Group in 1991 and the introduction of the "nuclear-related dual-use regime" (see para. 31).

27. Although the Review Conference was unable in 1990, as in 1980, to agree on a final declaration, owing once again to disagreements regarding Article VI of the Treaty, its deliberations provided a significant foundation for better understanding of the concerns of the parties. In accordance with established practice, the issues pertaining to article III were dealt with in Main Committee II. The report of the Committee on its work contained several important references to those issues which were clearly the result of a carefully balanced compromise. Thus, the report stated that the "non-proliferation and safeguards principles in the Treaty are essential for peaceful nuclear commerce and cooperation". Further, the document referred to the Zangger Committee by name for the first time and provided a brief description of its aims and practices, recommending that its trigger list be reviewed periodically, and urged all States to adopt the Zangger Committee's requirements for any nuclear cooperation with a non-nuclear-weapon State not party to the NPT. However, in response to developing countries' concerns, the document also emphasized that the export requirements should not hamper the development of nuclear energy for peaceful purposes. The relevant part of the report containing various recommendations with regard to the work of the Zangger Committee read as follows: 8/

> "The Conference notes that a number of States parties engaged in the supply of nuclear material and equipment have met regularly as an informal group which has become known as the Zangger Committee in order to coordinate their implementation of article III, paragraph 2. To this end, these States have adopted certain requirements, including a list of items triggering IAEA safeguards, for their export to non-nuclear-weapon States not party to the treaty, as set forth in IAEA document INFCIRC/209 as revised. The Conference urges all States to adopt these requirements in connection with any nuclear cooperation with non-nuclear-weapon States not party to the Treaty. The Conference recommends that the list of items triggering IAEA safeguards and procedures for implementation be reviewed from time to time to take into account advances in technology and changes in procurement practices. The Conference recommends the States parties to consider further ways to improve the measures to prevent diversion of nuclear technology for nuclear weapons, other nuclear explosive purposes or nuclear weapon capabilities. While recognizing the efforts of the Zangger

items included in the 'trigger list' are essential in the development of nuclear energy programmes for peaceful uses. In this regard, the Conference requests that the Zangger Committee should continue to take appropriate measures to ensure that the export requirements laid down by it do not hamper the acquisition of such items by States parties for the development of nuclear energy for peaceful uses."

28. In other sections the report of Main Committee II made two further recommendations: in the first recommendation, it urged all non-nuclear-weapon States "to make an internationally, legally binding commitment not to acquire nuclear weapons or other nuclear explosive devices and to accept IAEA safeguards on their peaceful nuclear activities, both current and future, to verify that commitment". At the same time, as a complementary measure, the report urged all the nuclear supplier States "to require as a necessary condition for the transfer of relevant nuclear supplies to non-nuclear-weapon States under new supply arrangements, such a commitment and acceptance of such safeguards"; and in a second recommendation, it "recognized that there are items of equipment and materials, including tritium not identified in NPT Article III, paragraph 2, that are relevant to the proliferation of nuclear weapons and therefore to the NPT as a whole". 9/ The report went on to say:

"Without prejudice to existing principles guiding international cooperation in the peaceful uses of nuclear energy, especially article IV of the NPT, the Conference in this regard calls for early consultations among States to ensure that their supply and export controls are appropriately coordinated."

III. MAIN DEVELOPMENTS SINCE THE FOURTH NUCLEAR PROLIFERATION TREATY REVIEW CONFERENCE

29. Following the 1990 Review Conference, a number of steps were taken by States parties that reflected their desire to take into account new developments in international relations, which had heightened concerns about possible diversion of nuclear technology to non-peaceful purposes. Iraq's breach of its commitments under the Treaty was particularly alarming and significantly galvanized the resolve of the international community to close the loopholes in the system of export control regimes. All these events had a direct impact on the work of both the Zangger Committee and the Nuclear Suppliers Group.

30. At the invitation of the Netherlands, the Nuclear Suppliers Group resumed regular meetings in March 1991. Since then, the Group, which had meanwhile expanded its membership to 30 States, met three more times, at Warsaw in 1992, Lucerne in 1993 and Madrid in 1994. The next meeting is scheduled to take place at Helsinki in April 1995. 10/

31. The meeting at Warsaw agreed on a new set of Guidelines for Transfers of Nuclear-Related Dual-Use Equipment, Material and Related Technology, along with an annex listing such items. This was published in July 1992 as INFCIRC/254/Rev.1/Part 2 (see annex III), while the original Guidelines on Nuclear Transfers were simultaneously reissued as INFCIRC/254/Rev.1/Part 1 but

in a new format and incorporating all the clarifications to the Zangger Committee trigger list that had been made up till then (see annex II).

32. The meeting of the Nuclear Suppliers Group at Warsaw also agreed that the Guidelines on Nuclear Transfers should be amended to make full-scope safeguards a condition of supply. This was formally achieved at the Group's Lucerne meeting and the Guidelines were then reissued in July 1993 in appropriately amended form as INFCIRC/254/Rev.1/Part 1/Mod.1. Subsequently some further changes were made to the Group's nuclear trigger list, two reflecting similar changes to the Zangger Committee's and a further one unique to the Nuclear Suppliers Group list. These changes were published in April 1994 as INFCIRC/254/Rev.1/Part 1/Mod.2.

33. At its meeting at Madrid, the Nuclear Suppliers Group also decided to amend its nuclear Guidelines, to prevent non-Group members from importing items from Group members and then re-exporting them to non-nuclear-weapon States without requiring full-scope safeguards; and to insert a new guideline to the effect that:

> "Notwithstanding other provisions of these Guidelines, suppliers should authorize transfer of items identified in the trigger list only when they are satisfied that the transfers would not contribute to the proliferation of nuclear weapons or other nuclear explosive devices."

These changes to the Guidelines are incorporated in INFCIRC/254/Rev.1/Part 1/Mod.3, published in November 1994.

34. Currently, part 1 of the Nuclear Suppliers Group Guidelines consist of the following documents: (a) the Guidelines proper; (b) the trigger list (annex A); (c) the clarifications to the trigger list (annex B); and (d) the criteria for levels of physical protection (annex C).

35. For its part, the Zangger Committee, which has never ceased its work since 1971, continued to hold its meetings at Vienna twice a year. 11/ The Committee has agreed on two more clarifying amendments, which were made public in the usual manner as modifications to IAEA document INFCIRC/209 (see annex I):

(a) In May 1992, an amendment was introduced further to clarify plants for the production of heavy water, deuterium and deuterium compounds, and associated equipment (INFCIRC/209/Rev.1/Mod.1);

(b) In October 1993, agreement was reached over the interpretation of paragraph 6 of Memorandum A attached to INFCIRC/209/Rev.1, to ensure that safeguards would be applied to export of bulk quantities of source material intended for non-nuclear use;

(c) Finally, in April 1994, further clarifications to the enrichment section were made and a modification of the entry on "Primary coolant pumps" to include water pumps was introduced (INFCIRC/209/Rev.1/Mod.2).

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36. The Zangger Committee has focused its attention in recent years on the question of whether or not facilities for the conversion of uranium fall under the definition of article III, paragraph 2. The matter is under review.

37. Thus, over the years, two groups of suppliers - the Zangger Committee and the Nuclear Suppliers Group - although generally dealing with the same subject-matter of nuclear export controls, have emphasized different aspects of the issue. The Zangger Committee, which derives its existence from the NPT, is concerned with the interpretation of supplier commitments under article III, paragraph 2, while the Nuclear Suppliers Group, in addition to the development of a trigger list largely identical to that of the Zangger Committee, has in recent years focused also on the proliferation impact of dual-use equipment and technology. The two groups, with almost identical membership, continue to work along those lines.

38. As noted earlier, since the inception of the export-control regimes, developing countries have expressed, to varying degrees, their concerns and, at times, strong objections to what they perceived as even more stringent conditions of supply of nuclear materials, which, they felt, were harmful to their economic development, in general, and discriminatory in nature, in particular. They voiced their concerns on numerous occasions and in different forums. The recurrent theme in the statements was the demand for the respect of the principle of long-term assurance of supply. In this connection, these countries have repeatedly recalled paragraph 5 of the Final Declaration of the 1985 Review Conference, adopted by consensus, which in conjunction with the review of article IV and preambular paragraphs 6 and 7 of the Treaty, stated the position of the States parties as follows:

> "The Conference recognizes the need for more predictable long-term supply assurances with effective assurances of non-proliferation." 12/

This principle was also part of the terms of reference of the Committee on Assurances of Supply mentioned in paragraph 24. Apart from the substantive aspects of the issue, developing countries have continued to express misgivings regarding the form and procedure under which the supplier States pursue their work. They consider that greater transparency and involvement of recipient States in this work is necessary.

39. Developing countries parties to the Treaty also object to what they consider insufficient differentiation on the part of suppliers between recipient States parties and non-parties to the Treaty. In this context reference is made to the draft of the Final Declaration of the Fourth Non-Proliferation-Treaty Review Conference with respect to the implementation of article IV, which recalls that "in all activities designed to promote the peaceful uses of nuclear energy, preferential treatment [should] be given to the non-nuclear-weapon States parties to the Treaty which have concluded the required safeguards agreement with IAEA, taking the needs of developing countries particularly into account". 13/

40. The most recent occasion on which these views were expressed by a large group of States was the Eleventh Ministerial Conference of the Movement of the Non-Aligned Countries, held at Cairo from 31 May to 3 June 1994. 14/ In the

section on disarmament and international security of the Final Document of the Conference, the non-aligned developing States made the following reference to the NPT and the question of export-control regimes: 15/

> "The Ministers expressed their objection to the continued functioning of ad hoc export-control groups on the pretext of non-proliferation of armaments, since they could impede the economic and social development of developing countries. They reiterated the need for multilaterally negotiated, universal, comprehensive and non-discriminatory disarmament agreements to address proliferation problems."

41. On the other hand, supplier States point out that the requirement for export controls is well established and their benefits are widely recognized. For example, in addition to the various recommendations of NPT Review Conferences, in 1992 the members of the United Nations Security Council, meeting at the level of Heads of State and Government issued a statement that, inter alia, said: 16/

> "On nuclear non-proliferation, they note the importance of the decision of many countries to adhere to the Non-Proliferation Treaty and emphasize the integral role in the implementation of that Treaty of fully effective IAEA safeguards, as well as the importance of effective export controls."

42. These States also point out that the General Assembly, at its forty-ninth session, adopted resolution 49/65 by a vote of 161 to none with 6 abstentions, the third preambular paragraph of which recognized "the importance of the work of the Agency in promoting the further application of nuclear energy for peaceful purposes, as envisaged in its statute and in accordance with the inalienable right of State parties to the Treaty on the Non-Proliferation of Nuclear Weapons and other relevant internationally legally binding agreements that have concluded relevant safeguards agreements with the Agency to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I and II of the Treaty, other relevant articles and with the object and purposes of the Treaty."

Notes

1/ Article IV, paragraph 1, reads as follows:

"1. Nothing in this Treaty shall be interpreted as affecting the inalienable right of all the Parties to the Treaty to develop research, production and use of nuclear energy for peaceful purposes without discrimination and in conformity with articles I and II of this Treaty."

2/ Article IV, paragraph 2, reads as follows:

"2. All the Parties to the Treaty undertake to facilitate, and have the right to participate in, the fullest possible exchange of equipment, materials and scientific and technological information for the peaceful uses of nuclear energy. Parties to the Treaty in a position to do so shall also cooperate in contributing alone or together with other States or international organizations to the further development of the application of nuclear energy for peaceful purposes, especially in the territories of non-nuclear-weapons States Party to the Treaty, with due consideration for the needs of the developing areas of the world."

3/ Article III, paragraph 1, reads as follows:

"1. Each non-nuclear-weapon State Party to the Treaty undertakes to accept safeguards, as set forth in an agreement to be negotiated and concluded with the International Atomic Energy Agency in accordance with the Statute of the International Atomic Energy Agency and the Agency's safeguards system, for the exclusive purpose of verification of the fulfilment of its obligations assumed under this Treaty with a view to preventing diversion of nuclear energy from peaceful uses to nuclear weapons of other nuclear explosive devices. Procedures for the safeguards required by this article shall be followed with respect to source or special fissionable material whether it is being produced, processed or used in any principal nuclear facility or is outside any such facility. The safeguards required by this article shall be applied on all source or special fissionable material in all peaceful nuclear activities within the territory of such State, under its jurisdiction, or carried out under its control anywhere."

4/ Article III, paragraph 2, reads as follows:

"2. Each State Party to the Treaty undertakes not to provide (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use of production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source of special fissionable material shall be subject to the safeguards required by this article."

5/ NPT/CONF.I/35/1, annex I, p. 3.

6/ Ibid.

7/ NPT/CONF.III/64/I, annex I, p. 5, para. 13.

8/ NPT/CONF.IV/DC/I/Add.3 (a), p. 5, para. 27.

9/ Ibid., p. 3, para. 18.

10/ Currently, the Nuclear Suppliers Group consists of the following members: Argentina, Australia, Austria, Belgium, Bulgaria, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovak Republic, South Africa, Spain, Sweden, Switzerland, United Kingdom and United States.

11/ With the exception of Argentina and New Zealand, which is presently a member of the Nuclear Suppliers Group, but not the Zangger Committee, and the Republic of Korea, which has been invited to observe the work of the Committee, the membership of the two forums - the Nuclear Suppliers Group and the Zangger Committee - is the same.

12/ NPT/CONF.III/64/I.

13/ NPT/CONF.IV/DC/1/Add.3.

14/ A/49/287-S/1994/894 and Corr.1.

15/ Ibid., para. 66.

16/ S/23500. The membership of the Security Council in January 1992 was as follows: Austria, Belgium, Cape Verde, China, Ecuador, France, Hungary, India, Japan, Morocco, Russian Federation, United Kingdom of Great Britain and Northern Ireland, United States of America, Venezuela and Zimbabwe.

Annex I

INF

International Atomic Energy Agency

INFORMATION CIRCULAR

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COMMUNICATIONS RECEIVED FROM MEMBERS REGARDING THE EXPORT OF NUCLEAR MATERIAL AND OF CERTAIN CATEGORIES OF EQUIPMENT AND OTHER MATERIAL

1. The Director General has received letters dated 3 September 1990 from the Resident Representatives to the Agency of Australia, Canada, Czechoslovakia, Denmark, Finland, the German Democratic Republic, the Federal Republic of Germany, Greece, Hungary, Ireland, Japan, Luxembourg, the Netherlands, Norway, Poland, Sweden, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America concerning the commitments of these Member States under Article III, paragraph 2, of the Treaty on the Non-Proliferation of Nuclear Weapons.

2. The purpose of the letters is to consolidate and clarify the information contained in documents INFCIRC/209/Mod.1,2,3 and 4 into a single document and to provide information on the functioning of the "Zangger Committee", also known as the "Nuclear Exporters' Committee", with regard to the commitments of the Committee's members under Article III, paragraph 2, of the Treaty.

3. In the light of the wish expressed at the end of each letter, the text of the letters is annexed hereto.

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LETTER

I have the honour to refer to [relevant previous communication] in which the Government of [Member State] informed you that it had decided to act in accordance with certain procedures in relation to exports of nuclear material and certain categories of equipment and other material which you circulated to all Member States of the Agency as document INFCIRC/209, and to [relevant subsequent communications] informing you of its desire to clarify certain items described in the Annex "Clarification of Items on the Trigger List" to Memorandum B and circulated as documents INFCIRC/209/Mods.1,2,3 and 4.

In the interests of clarity it has become desirable, in the view of my Government, to consolidate these communications, without change in their substance, in a single document a copy of which is attached hereto.

As hitherto, my Government reserves to itself the right to exercise discretion with regard to the interpretation and implementation of the procedures set out and the right to control, if it wishes, the export of relevant items other than those specified in the aforementioned attachment to this letter.

I should be grateful if you would circulate the text of this letter and its attachment, together with the appended background paper, to all Member States for their information.

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CONSOLIDATED TRIGGER LIST
MEMORANDUM A

1. INTRODUCTION

The Government has had under consideration procedures in relation to exports of nuclear materials in the light of its commitment not to provide source or special fissionable material to any non-nuclear-weapon State for peaceful purposes unless the source or special fissionable material is subject to safeguards under an agreement with the International Atomic Energy Agency.

2. DEFINITION OF SOURCE AND SPECIAL FISSIONABLE MATERIAL

The definition of source and special fissionable material adopted by the Government shall be that contained in Article XX of the Agency's Statute:

(a) "SOURCE MATERIAL"

The term "source material" means uranium containing the mixture of isotopes occurring in nature: uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine.

(b) "SPECIAL FISSIONABLE MATERIAL"

i) The term "special fissionable material" means plutonium-239, uranium-233, uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing; and such other fissionable material as the Board of Governors shall from time to time determine; but the term "special fissionable material" does not include source material.

ii) The term "uranium enriched in the isotopes 235 or 233" means uranium containing the isotopes 235 or 233 or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is greater than the ratio of the isotope 235 to the isotope 238 occurring in nature.

3. THE APPLICATION OF SAFEGUARDS

The Government is solely concerned with ensuring, where relevant, the application of safeguards in non-nuclear-weapon States not party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT)* with a view to preventing diversion of the safeguarded nuclear material from peaceful purposes to nuclear weapons or other nuclear explosive devices. If the Government wishes to supply source or special fissionable material for peaceful purposes to such a State, it will:

(a) Specify to the recipient State, as a condition of supply, that the source or special fissionable material, or special fissionable material produced in or by the use thereof, shall not be diverted to nuclear weapons or other nuclear explosive devices; and

(b) Satisfy itself that safeguards to that end, under an agreement with the Agency and in accordance with its safeguards system, will be applied to the source or special fissionable material in question.

4. DIRECT EXPORTS

In the case of direct exports of source or special fissionable material to non-nuclear-weapon States not party to the NPT, the Government will satisfy itself, before authorizing the export of the material in question, that such material will be subject to a safeguards agreement with the Agency, as soon as the

* reproduced in INFCIRC/140

recipient State takes over responsibility for the material, but no later than the time the material reaches its destination.

5. RETRANSFERS

The Government, when exporting source or special fissionable material to a nuclear-weapon State not party to the NPT, will require satisfactory assurances that the material will not be re-exported to a non-nuclear-weapon State not party to the NPT unless arrangements corresponding to those referred to above are made for the acceptance of safeguards by the State receiving such re-export.

6. MISCELLANEOUS

Exports of the items specified in sub-paragraph (a) below, and exports of source or special fissionable material to a given country, within a period of 12 months, below the limits specified in sub-paragraph (b) below, shall be disregarded for the purpose of the procedures described above:

(a) Plutonium with an isotopic concentration of plutonium-238 exceeding 80%;
Special fissionable material when used in gram quantities or less as a sensing component in instruments; and
Source material which the Government is satisfied is to be used only in non-nuclear activities, such as the production of alloys or ceramics;

(b)

Special fissionable material	50	effective grams;
Natural uranium	500	kilograms;
Depleted uranium	1000	kilograms; and
Thorium	1000	kilograms.

MEMORANDUM B

1. INTRODUCTION

The Government has had under consideration procedures in relation to exports of certain categories of equipment and material, in the light of its commitment not to provide equipment or material especially designed or prepared for the processing, use or production of special fissionable material to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material produced, processed or used in the equipment or material in question is subject to safeguards under an agreement with the International Atomic Energy Agency.

2. THE DESIGNATION OF EQUIPMENT OR MATERIAL ESPECIALLY DESIGNED OR PREPARED FOR THE PROCESSING, USE OR PRODUCTION OF SPECIAL FISSIONABLE MATERIAL

The designation of items of equipment or material especially designed or prepared for the processing, use or production of special fissionable material (hereinafter referred to as the "Trigger List") adopted by the Government is as follows (quantities below the levels indicated in the Annex being regarded as insignificant for practical purposes):

2.1. **Reactors and equipment therefor (see Annex, section 1.);**

2.2. **Non-nuclear materials for reactors (see Annex, section 2.);**

2.3. **Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor (see Annex, section 3.);**

2.4. **Plants for the fabrication of fuel elements (see Annex, section 4.);**

/...

2.5. Plants for the separation of isotopes of uranium and equipment, other than analytical instruments, especially designed or prepared therefor (see Annex, section 5.);

2.6. Plants for the production of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor (see Annex, section 6.).

3. THE APPLICATION OF SAFEGUARDS

The Government is solely concerned with ensuring, where relevant, the application of safeguards in non-nuclear-weapon States not party to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) with a view to preventing diversion of the safeguarded nuclear material from peaceful purposes to nuclear weapons or other nuclear explosive devices. If the Government wishes to supply Trigger List items for peaceful purposes to such a State, it will:

(a) Specify to the recipient State, as a condition of supply, that the source or special fissionable material produced, processed or used in the facility for which the item is supplied shall not be diverted to nuclear weapons or other nuclear explosive devices; and

(b) Satisfy itself that safeguards to that end, under an agreement with the Agency and in accordance with its safeguards system, will be applied to the source or special fissionable material in question.

4. DIRECT EXPORTS

In the case of direct exports to non-nuclear-weapon States not party to the NPT, the Government will satisfy itself, before authorizing the export of the equipment or material in question, that such equipment or material will fall under a safeguards agreement with the Agency.

5. RETRANSFERS

The Government, when exporting Trigger List items, will require satisfactory assurances that the items will not be re-exported to a non-nuclear-weapon State not party to the NPT unless arrangements corresponding to those referred to above are made for the acceptance of safeguards by the State receiving such re-export.

6. MISCELLANEOUS

The Government reserves to itself discretion as to interpretation and implementation of its commitment referred to in paragraph 1 above and the right to require, if it wishes, safeguards as above in relation to items it exports in addition to those items specified in paragraph 2 above.

ANNEX
CLARIFICATION OF ITEMS ON THE TRIGGER LIST
(as designated in Section 2 of Memorandum B)

1. Reactors and equipment therefor

1.1. Complete nuclear reactors

Nuclear reactors capable of operation so as to maintain a controlled self-sustaining fission chain reaction, excluding zero energy reactors, the latter being defined as reactors with a designed maximum rate of production of plutonium not exceeding 100 grams per year.

EXPLANATORY NOTE

A "nuclear reactor" basically includes the items within or attached directly to the reactor vessel, the equipment which controls the level of power in the core, and the components which normally contain or come in direct contact with or control the primary coolant of the reactor core.

It is not intended to exclude reactors which could reasonably be capable of modification to produce significantly more than 100 grams of plutonium per year. Reactors designed for sustained operation at significant power levels, regardless of their capacity for plutonium production, are not considered as "zero energy reactors".

EXPORTS

The export of the whole set of major items within this boundary will take place only in accordance with the procedures of the Memorandum. Those individual items within this functionally defined boundary which will be exported only in accordance with the procedures of the Memorandum are listed in paragraphs 1.2. to 1.7. Pursuant to paragraph 6 of the Memorandum, the Government reserves to itself the right to apply the procedures of the Memorandum to other items within the functionally defined boundary.

1.2. Reactor pressure vessels

Metal vessels, as complete units or as major shop-fabricated parts therefor, which are especially designed or prepared to contain the core of a nuclear reactor as defined in paragraph 1.1. above and are capable of withstanding the operating pressure of the primary coolant.

EXPLANATORY NOTE

A top plate for a reactor pressure vessel is covered by item 1.2. as a major shop-fabricated part of a pressure vessel.

Reactor internals (e.g. support columns and plates for the core and other vessel internals, control rod guide tubes, thermal shields, baffles, core grid plates, diffuser plates, etc.) are normally supplied by the reactor supplier. In some cases, certain internal support components are included in the fabrication of the pressure vessel. These items are sufficiently critical to the safety and reliability of the operation of the reactor (and, therefore, to the guarantees and liability of the reactor supplier), so that their supply, outside the basic supply arrangement for the reactor itself, would not be common practice. Therefore, although the separate supply of these unique, especially designed and prepared, critical, large and expensive items would not necessarily be considered as falling outside the area of concern, such a mode of supply is considered unlikely.

1.3. Reactor fuel charging and discharging machines

Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor as defined in paragraph 1.1. above capable of on-load operation or employing technically sophisticated positioning or alignment features to allow complex off-load fuelling operations such as those in which direct viewing of or access to the fuel is not normally available.

1.4. Reactor control rods

Rods especially designed or prepared for the control of the reaction rate in a nuclear reactor as defined in paragraph 1.1. above.

EXPLANATORY NOTE

This item includes, in addition to the neutron absorbing part, the support or suspension structures therefor if supplied separately.

1.5. Reactor pressure tubes

Tubes which are especially designed or prepared to contain fuel elements and the primary coolant in a reactor as defined in paragraph 1.1. above at an operating pressure in excess of 50 atmospheres.

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1.6. Zirconium tubes

Zirconium metal and alloys in the form of tubes or assemblies of tubes, and in quantities exceeding 500 kg in any period of 12 months, especially designed or prepared for use in a reactor as defined in paragraph 1.1. above, and in which the relation of hafnium to zirconium is less than 1:500 parts by weight.

1.7. Primary coolant pumps

Pumps especially designed or prepared for circulating liquid metal as primary coolant for nuclear reactors as defined in paragraph 1.1. above.

2. Non-nuclear materials for reactors

2.1. Deuterium and heavy water

Deuterium, heavy water (deuterium oxide) and any other deuterium compound in which the ratio of deuterium to hydrogen atoms exceeds 1:5000 for use in a nuclear reactor as defined in paragraph 1.1. above in quantities exceeding 200 kg of deuterium atoms for any one recipient country in any period of 12 months.

2.2. Nuclear grade graphite

Graphite having a purity level better than 5 parts per million boron equivalent and with a density greater than 1.50 g/cm^3 in quantities exceeding $3 \cdot 10^4$ kg (30 metric tons) for any one recipient country in any period of 12 months.

3. Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor

INTRODUCTORY NOTE

Reprocessing irradiated nuclear fuel separates plutonium and uranium from intensely radioactive fission products and other transuranic elements. Different technical processes can accomplish this separation. However, over the years Purex has become the most commonly used and accepted process. Purex involves the dissolution of irradiated nuclear fuel in nitric acid, followed by separation of the uranium, plutonium, and fission products by solvent extraction using a mixture of tributyl phosphate in an organic diluent.

Purex facilities have process functions similar to each other, including: irradiated fuel element chopping, fuel dissolution, solvent extraction, and process liquor storage. There may also be equipment for thermal denitration of uranium nitrate, conversion of plutonium nitrate to oxide or metal, and treatment of fission product waste liquor to a form suitable for long term storage or disposal. However, the specific type and configuration of the equipment performing these functions may differ between Purex facilities for several reasons, including the type and quantity of irradiated nuclear fuel to be reprocessed and the intended disposition of the recovered materials, and the safety and maintenance philosophy incorporated into the design of the facility.

A "plant for the reprocessing of irradiated fuel elements", includes the equipment and components which normally come in direct contact with and directly control the irradiated fuel and the major nuclear material and fission product processing streams.

These processes, including the complete systems for plutonium conversion and plutonium metal production, may be identified by the measures taken to avoid criticality (eg by geometry), radiation exposure (eg by shielding), and toxicity hazards (eg by containment).

EXPORTS

The export of the whole set of major items within this boundary will take place only in accordance with the procedures of the Memorandum.

Items of equipment that are considered to fall within the meaning of the phrase "and equipment especially designed or prepared" for the reprocessing of irradiated fuel elements include:

3.1. Irradiated fuel element chopping machines

INTRODUCTORY NOTE

This equipment breaches the cladding of the fuel to expose the irradiated nuclear material to dissolution. Especially designed metal cutting shears are the most commonly employed, although advanced equipment, such as lasers, may be used.

Remotely operated equipment especially designed or prepared for use in a reprocessing plant as identified above and intended to cut, chop or shear irradiated nuclear fuel assemblies, bundles or rods.

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3.2. Dissolvers

INTRODUCTORY NOTE

Dissolvers normally receive the chopped-up spent fuel. In these critically safe vessels, the irradiated nuclear material is dissolved in nitric acid and the remaining hulls removed from the process stream.

Critically safe tanks (eg small diameter, annular or slab tanks) especially designed or prepared for use in a reprocessing plant as identified above, intended for dissolution of irradiated nuclear fuel and which are capable of withstanding hot, highly corrosive liquid, and which can be remotely loaded and maintained.

3.3. Solvent extractors and solvent extraction equipment

INTRODUCTORY NOTE

Solvent extractors both receive the solution of irradiated fuel from the dissolvers and the organic solution which separates the uranium, plutonium, and fission products. Solvent extraction equipment is normally designed to meet strict operating parameters, such as long operating lifetimes with no maintenance requirements or adaptability to easy replacement, simplicity of operation and control, and flexibility for variations in process conditions.

Especially designed or prepared solvent extractors such as packed or pulse columns, mixer settlers or centrifugal contactors for use in a plant for the reprocessing of irradiated fuel. Solvent extractors must be resistant to the corrosive effect of nitric acid. Solvent extractors are normally fabricated to extremely high standards (including special welding and inspection and quality assurance and quality control techniques) out of low carbon stainless steels, titanium, zirconium, or other high quality materials.

3.4. Chemical holding or storage vessels

INTRODUCTORY NOTE

Three main process liquor streams result from the solvent extraction step. Holding or storage vessels are used in the further processing of all three streams, as follows:

(a) The pure uranium nitrate solution is concentrated by evaporation and passed to a denitration process where it is converted to uranium oxide. This oxide is re-used in the nuclear fuel cycle.

(b) The intensely radioactive fission products solution is normally concentrated by evaporation and stored as a liquor concentrate. This concentrate may be subsequently evaporated and converted to a form suitable for storage or disposal.

(c) The pure plutonium nitrate solution is concentrated and stored pending its transfer to further process steps. In particular, holding or storage vessels for plutonium solutions are designed to avoid criticality problems resulting from changes in concentration and form of this stream.

Especially designed or prepared holding or storage vessels for use in a plant for the reprocessing of irradiated fuel. The holding or storage vessels must be resistant to the corrosive effect of nitric acid. The holding or storage vessels are normally fabricated of materials such as low carbon stainless steels, titanium or zirconium, or other high quality materials. Holding or storage vessels may be designed for remote operation and maintenance and may have the following features for control of nuclear criticality:

(1) walls or internal structures with a boron equivalent of at least two per cent, or
(2) a maximum diameter of 175 mm (7 in) for cylindrical vessels, or
(3) a maximum width of 75 mm (3 in) for either a slab or annular vessel.

3.5. Plutonium nitrate to oxide conversion system

INTRODUCTORY NOTE

In most reprocessing facilities, this final process involves the conversion of the plutonium nitrate solution to plutonium dioxide. The main functions involved in this process are:
process feed storage and adjustment, precipitation and solid/liquor separation, calcination, product handling, ventilation, waste management, and process control.

Complete systems especially designed or prepared for the conversion of plutonium nitrate to plutonium oxide, in particular adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards.

3.6. Plutonium oxide to metal production system

INTRODUCTORY NOTE

This process, which could be related to a reprocessing facility, involves the fluorination of plutonium dioxide, normally with highly corrosive hydrogen fluoride, to produce plutonium fluoride which is subsequently reduced using high purity calcium metal to produce metallic plutonium and a calcium fluoride slag. The main functions involved in this process are: fluorination (eg involving equipment fabricated or lined with a precious metal), metal reduction (eg employing ceramic crucibles), slag recovery, product handling, ventilation, waste management and process control.

Complete systems especially designed or prepared for the production of plutonium metal, in particular adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards.

EXPORTS

Pursuant to paragraph 6 of the Memorandum B, the Government reserves to itself the right to apply the procedures of the Memorandum to other items within the functionally defined boundary.

4. Plants for the fabrication of fuel elements

A "plant for the fabrication of fuel elements" includes the equipment:

(a) Which normally comes in direct contact with, or directly processes, or controls, the production flow of nuclear material, or

(b) Which seals the nuclear material within the cladding.

EXPORTS

The export of the whole set of items for the foregoing operations will take place only in accordance with the procedures of the Memorandum. The Government will also give consideration to application of the procedures of the Memorandum to individual items intended for any of the foregoing operations, as well as for other fuel fabrication operations such as checking the integrity of the cladding or the seal, and the finish treatment to the sealed fuel.

5. Plants for the separation of isotopes of uranium and equipment, other than analytical instruments, especially designed or prepared therefor

Items of equipment that are considered to fall within the meaning of the phrase "equipment, other than analytical instruments, especially designed or prepared" for the separation of isotopes of uranium include:

5.1. Gas centrifuges and assemblies and components especially designed or prepared for use in gas centrifuges

INTRODUCTORY NOTE

The gas centrifuge normally consists of a thin-walled cylinder(s) of between 75 mm (3 in) and 400 mm (16 in) diameter contained in a vacuum environment and spun at high peripheral speed of the order of 300 m/s or more with its central axis vertical. In order to achieve high speed the materials of construction for the rotating components have to be of a high strength to density ratio and the rotor assembly, and hence its individual components, have to be manufactured to very close tolerances in order to minimize the unbalance. In contrast to other centrifuges, the gas centrifuge for uranium enrichment is characterized by having within the rotor chamber a rotating disc-shaped baffle(s) and a stationary tube arrangement for feeding and extracting the UF_6 gas and featuring at least 3 separate channels, of which 2 are connected to scoops extending from the rotor axis towards the periphery of the rotor chamber. Also contained within the vacuum environment are a number of critical items which do not rotate and which although they are especially designed are not difficult to fabricate nor are they fabricated out of unique materials. A centrifuge facility however requires a large number of these components, so that quantities can provide an important indication of end use.

5.1.1. Rotating components

(a) Complete rotor assemblies:

Thin-walled cylinders, or a number of interconnected thin-walled cylinders, manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section;

If interconnected, the cylinders are joined together by flexible bellows or rings as described in section 5.1.1.(c) following. The rotor is fitted with an internal baffle(s) and end caps, as described in section 5.1.1.(d) and (e) following, if in final form. However the complete assembly may be delivered only partly assembled.

(b) Rotor tubes:

Especially designed or prepared thin-walled cylinders with thickness of 12 mm (0.5 in) or less, a diameter of between 75 mm (3 in) and 400 mm (16 in), and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

(c) Rings or Bellows:

Components especially designed or prepared to give localized support to the rotor tube or to join together a number of rotor tubes. The bellows is a short cylinder of wall thickness 3 mm (0.12 in) or less, a diameter of between 75 mm (3 in) and 400 mm (16 in), having a convolute, and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

(d) **Baffles:**
Disc-shaped components of between 75 mm (3 in) and 400 mm (16 in) diameter especially designed or prepared to be mounted inside the centrifuge rotor tube, in order to isolate the take-off chamber from the main separation chamber and, in some cases, to assist the UF_6 gas circulation within the main separation chamber of the rotor tube, and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

(e) Top caps/Bottom caps:
Disc-shaped components of between 75 mm (3 in) and 400 mm (16 in) diameter especially designed or prepared to fit to the ends of the rotor tube, and so contain the UF_6 within the rotor tube, and in some cases to support, retain or contain as an integrated part an element of the upper bearing (top cap) or to carry the rotating elements of the motor and lower bearing (bottom cap), and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

EXPLANATORY NOTE

The materials used for centrifuge rotating components are:
(a) Maraging steel capable of an ultimate tensile strength of $2.05 \cdot 10^9$ N/m^2 (300,000 psi) or more;
(b) Aluminium alloys capable of an ultimate tensile strength of $0.46 \cdot 10^9$ N/m^2 (67,000 psi) or more;
(c) Filamentary materials suitable for use in composite structures and having a specific modulus of $12.3 \cdot 10^6$ m or greater and a specific ultimate tensile strength of $0.3 \cdot 10^6$ m or greater ('Specific Modulus' is the Young's Modulus in N/m^2 divided by the specific weight in N/m^3; 'Specific Ultimate Tensile Strength' is the ultimate tensile strength in N/m^2 divided by the specific weight in N/m^3).

5.1.2. Static components

(a) Magnetic suspension bearings:
Especially designed or prepared bearing assemblies consisting of an annular magnet suspended within a housing containing a damping medium. The housing will be manufactured from a UF_6-resistant material (see EXPLANATORY NOTE to Section 5.2.). The magnet couples with a pole piece or a second magnet fitted to the top cap described in Section 5.1.1.(e). The magnet may be ring-shaped with a relation between outer and inner diameter smaller or equal to 1.6 : 1. The magnet may be in a form having an initial permeability of 0.15 H/m (120,000 in CGS units) or more, or a remanence of 98.5% or more, or an energy product of greater than 80 kJ/m^3 (10^7 gauss-oersteds). In addition to the usual material properties, it is a prerequisite that the deviation of the magnetic axes from the geometrical axes is limited to very small tolerances (lower than 0.1 mm) or that homogeneity of the material of the magnet is specially called for.

(b) Bearings/Dampers:
Especially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper. The pivot is normally a hardened steel shaft polished into a hemisphere at one end with a means of attachment to the bottom cap described in section 5.1.1.(e) at the other. The shaft may however have a hydrodynamic bearing attached. The cup is pellet-shaped with a hemispherical indentation in one surface. These components are often supplied separately to the damper.

(c) Molecular pumps:
Especially designed or prepared cylinders having internally machined or extruded helical grooves and internally machined bores. Typical dimensions are as follows: 75 mm (3 in) to 400 mm (16 in) internal diameter, 10 mm (0.4 in) or more wall thickness, 1 to 1 length to diameter ratio. The grooves are typically rectangular in cross-section and 2 mm (0.08 in) or more in depth.

(d) Motor stators:
Especially designed or prepared ring-shaped stators for high speed multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuum in the frequency range of 600-2000 Hz and a power range of 50-1000 VA. The stators consist of multi-phase windings on a laminated low loss iron core comprised of thin layers typically 2.0 mm (0.08 in) thick or less.

5.2. Especially designed or prepared auxiliary systems, equipment and components for gas centrifuge enrichment plants

INTRODUCTORY NOTE

The auxiliary systems, equipment and components for a gas centrifuge enrichment plant are the systems of plant needed to feed UF_6 to the centrifuges, to link the individual centrifuges to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the 'product' and 'tails' UF_6 from the centrifuges, together with the equipment required to drive the centrifuges or to control the plant.

/...

Normally UF_6 is evaporated from the solid using heated autoclaves and is distributed in gaseous form to the centrifuges by way of cascade header pipework. The 'product' and 'tails' UF_6 gaseous streams flowing from the centrifuges are also passed by way of cascade header pipework to cold traps (operating at about 203 K (-70°C)) where they are condensed prior to onward transfer into suitable containers for transportation or storage. Because an enrichment plant consists of many thousands of centrifuges arranged in cascades there are many kilometers of cascade header pipework, incorporating thousands of welds with a substantial amount of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.

5.2.1. Feed systems/product and tails withdrawal systems

Especially designed or prepared process systems including:

Feed autoclaves (or stations), used for passing UF_6 to the centrifuge cascades at up to 100 kN/m² (15 psi) and at a rate of 1 kg/h or more;

Desublimers (or cold traps) used to remove UF_6 from the cascades at up to 3 kN/m² (0.5 lb/in²) pressure. The desublimers are capable of being chilled to 203 K (-70°C) and heated to 343 K (70°C);

'Product' and 'Tails' stations used for trapping UF_6 into containers.

This plant, equipment and pipework is wholly made of or lined with UF_6-resistant materials (see EXPLANATORY NOTE to this section) and is fabricated to very high vacuum and cleanliness standards.

5.2.2. Machine header piping systems

Especially designed or prepared piping systems and header systems for handling UF_6 within the centrifuge cascades. The piping network is normally of the 'triple' header system with each centrifuge connected to each of the headers. There is thus a substantial amount of repetition in its form. It is wholly made of UF_6-resistant materials (see EXPLANATORY NOTE to this section) and is fabricated to very high vacuum and cleanliness standards.

5.2.3. UF_6 mass spectrometers/ion sources

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking 'on-line' samples of feed, product or tails, from UF_6 gas streams and having all of the following characteristics:

1. Unit resolution for mass greater than 320;
2. Ion sources constructed of or lined with nichrome or monel or nickel plated;
3. Electron bombardment ionization sources;
4. Having a collector system suitable for isotopic analysis.

5.2.4. Frequency changers

Frequency changers (also known as converters or invertors) especially designed or prepared to supply motor stators as defined under 5.1.2.(d), or parts, components and sub-assemblies of such frequency changers having all of the following characteristics:

1. **A multiphase output of 600 to 2000 Hz;**
2. **High stability (with frequency control better than 0.1%);**
3. **Low harmonic distortion (less than 2%); and**
4. **An efficiency of greater than 80%.**

EXPLANATORY NOTE

The items listed above either come into direct contact with the UF_6 process gas or directly control the centrifuges and the passage of the gas from centrifuge to centrifuge and cascade to cascade.

Materials resistant to corrosion by UF_6 include stainless steel, aluminium, aluminium alloys, nickel or alloys containing 60% or more nickel.

5.3. Especially designed or prepared assemblies and components for use in gaseous diffusion enrichment

INTRODUCTORY NOTE

In the gaseous diffusion method of uranium isotope separation, the main technological assembly is a special porous gaseous diffusion barrier, heat exchanger for cooling the gas (which is heated by the process of compression), seal valves and control valves, and pipelines. Inasmuch as gaseous diffusion technology uses uranium hexafluoride (UF_6), all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that remain stable in contact with UF_6. A gaseous diffusion facility requires a number of these assemblies, so that quantities can provide an important indication of end use.

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5.3.1. Gaseous diffusion barriers

(a) Especially designed or prepared thin, porous filters, with a pore size of 100-1,000 Å (angstroms), a thickness of 5 mm or less, and for tubular forms, a diameter of 25 mm or less, made of metallic, polymer or ceramic materials resistant to corrosion by UF_6, and

(b) especially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60 per cent or more nickel, aluminium oxide, or UF_6-resistant fully fluorinated hydrocarbon polymers having a purity of 99.9 per cent or more, a particle size less than 10 microns, and a high degree of particle size uniformity, which are especially prepared for the manufacture of gaseous diffusion barriers.

5.3.2. Diffuser housings

Especially designed or prepared hermetically sealed cylindrical vessels greater than 300 mm in diameter and greater than 900 mm in length, or rectangular vessels of comparable dimensions, which have an inlet connection and two outlet connections all of which are greater than 50 mm in diameter, for containing the gaseous diffusion barrier, made of or lined with UF_6-resistant materials and designed for horizontal or vertical installation.

5.3.3. Compressors and gas blowers

Especially designed or prepared axial, centrifugal, or positive displacement compressors, or gas blowers with a suction volume capacity of 1 m^3/min or more of UF_6, and with a discharge pressure of up to several hundred kN/m^2 (100 psi), designed for long-term operation in the UF_6 environment with or without an electrical motor of appropriate power, as well as separate assemblies of such compressors and gas blowers. These compressors and gas blowers have a pressure ratio between 2:1 and 6:1 and are made of, or lined with, materials resistant to UF_6.

5.3.4. Rotary shaft seals

Especially designed or prepared vacuum seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor or the gas blower rotor with the driver motor so as to ensure a reliable seal against in-leaking of air into the inner chamber of the compressor or gas blower which is filled with UF_6. Such seals are normally designed for a buffer gas in-leakage rate of less than 1000 cm^3/min.

5.3.5. Heat exchangers for cooling UF_6

Especially designed or prepared heat exchangers made of or lined with UF_6-resistant materials (except stainless steel) or with copper or any combination of those metals, and intended for a leakage pressure change rate of less than 10 N/m^2 (0.0015 psi) per hour under a pressure difference of 100 kN/m^2 (15 psi).

5.4. Especially designed or prepared auxiliary systems, equipment and components for use in gaseous diffusion enrichment

INTRODUCTORY NOTE

The auxiliary systems, equipment and components for gaseous diffusion enrichment plants are the systems of plant needed to feed UF_6 to the gaseous diffusion assembly, to link the individual assemblies to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the "product" and "tails" UF_6 from the diffusion cascades. Because of the high inertial properties of diffusion cascades, any interruption in their operation, and especially their shut-down, leads to serious consequences. Therefore, a strict and constant maintenance of vacuum in all technological systems, automatic protection from accidents, and precise automated regulation of the gas flow is of importance in a gaseous diffusion plant. All this leads to a need to equip the plant with a large number of special measuring, regulating and controlling systems.

Normally UF_6 is evaporated from cylinders placed within autoclaves and is distributed in gaseous form to the entry point by way of cascade header pipework. The "product" and "tails" UF_6 gaseous streams flowing from exit points are passed by way of cascade header pipework to either cold traps or to compression stations where the UF_6 gas is liquefied prior to onward transfer into suitable containers for transportation or storage. Because a gaseous diffusion enrichment plant consists of a large number of gaseous diffusion assemblies arranged in cascades, there are many kilometers of cascade header pipework, incorporating thousands of welds with substantial amounts of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.

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5.4.1. Feed systems/product and tails withdrawal systems

Especially designed or prepared process systems, capable of operating at pressures of 300 kN/m^2 (45 lb/in^2) or less, including:

Feed autoclaves (or systems), used for passing UF_6 to the gaseous diffusion cascades;
Desublimers (or cold traps) used to remove UF_6 from diffusion cascades;

Liquefaction stations where UF_6 gas from the cascade is compressed and cooled to form liquid UF_6;
"Product" or "tails" stations used for transferring UF_6 into containers.

5.4.2. Header piping systems

Especially designed or prepared piping systems and header systems for handling UF_6 within the gaseous diffusion cascades. This piping network is normally of the "double" header system with each cell connected to each of the headers.

5.4.3. Vacuum systems

(a) Especially designed or prepared large vacuum manifolds, vacuum headers and vacuum pumps having a suction capacity of 5 m^3/min or more.

(b) Vacuum pumps especially designed for service in UF_6-bearing atmospheres made of, or lined with, aluminium, nickel, or alloys bearing more than 60% nickel. These pumps may be either rotary or positive, may have displacement and fluorocarbon seals, and may have special working fluids present.

5.4.4. Special shut-off and control valves

Especially designed or prepared manual or automated shut-off and control bellows valves made of UF_6-resistant materials with a diameter of 40 to 1500 mm for installation in main and auxiliary systems of gaseous diffusion enrichment plants.

5.4.5. UF_6 mass spectrometers/ion sources

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking "on-line" samples of feed, product or tails, from UF_6 gas streams and having all of the following characteristics:

1. Unit resolution for mass greater than 320;
2. Ion sources constructed of or lined with nichrome or monel or nickel plated;
3. Electron bombardment ionization sources;
4. Collector system suitable for isotopic analysis.

EXPLANATORY NOTE

The items listed above either come into direct contact with the UF_6 process gas or directly control the flow within the cascade. All surfaces which come into contact with the process gas are wholly made of, or lined with, UF_6-resistant materials. For the purposes of the sections relating to gaseous diffusion items the materials resistant to corrosion by UF_6 include stainless steel, aluminium, aluminium alloys, aluminium oxide, nickel or alloys containing 60% or more nickel and UF_6-resistant fully fluorinated hydrocarbon polymers.

5.5. Jet nozzle separation units

5.6. Vortex separation units

6. Plants for the production of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor

THE ZANGGER COMMITTEE : A HISTORY 1971-1990

The Origins

1. The origins of the Zangger Committee, also known as the Nuclear Exporters' Committee, sprang from Article III2. of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) which entered into force on 5 March 1970. Under the terms of Article III2:

> "Each State Party to the Treaty undertakes not to provide: (a) source or special fissionable material, or (b) equipment or material especially designed or prepared for the processing, use or production of special fissionable material, to any non-nuclear-weapon State for peaceful purposes, unless the source or special fissionable material shall be subject to the safeguards required by this Article."

2. Between 1971 and 1974 a group of fifteen states, some already Party, the others prospective Parties to the NPT, held a series of informal meetings in Vienna chaired by Professor Claude Zangger of Switzerland. As suppliers or potential suppliers of nuclear material and equipment their objective was to reach a common understanding on:

- the definition of what constituted "equipment or material especially designed or prepared for the processing, use or production of special fissionable material";
- the conditions and procedures that would govern exports of such equipment or material in order to meet the obligations of Article III2 on a basis of fair commercial competition.

3. The group, which came to be known as the "Zangger Committee", decided that its status was informal, and that its decisions would not be legally binding upon its members.

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The Rules of the Game - INFCIRC/209 Series

4. By 1974 the Committee had arrived at a consensus on the basic "rules of the game" which were set out in two separate memoranda dated 14 August 1974. The first defined and dealt with exports of source and special fissionable material (Article III2(a) of the NPT). The second defined and dealt with exports of equipment and non-nuclear material (Article III2(b) of the NPT). The Committee agreed to exchange information about actual exports, or issue of licenses for exports, to any non-nuclear weapon States not Party to the NPT through a system of Annual Returns which are circulated on a confidential basis amongst the membership each year in April.

5. The consensus, which formed the basis of the Committee's "Understandings" as they are known, was formally accepted by individual Member States of the Committee by an exchange of Notes amongst themselves. These amounted to unilateral declarations that the Understandings would be given effect through respective domestic export control legislation.

6. More or less in parallel with this procedure each Member State (except three) wrote identical letters to the Director General of the IAEA, enclosing edited versions of the two memoranda, informing him of its decision to act in conformity with the conditions set out in them and asking him to communicate this decision to all Member States of the Agency. The letters and memoranda were accordingly published as IAEA document INFCIRC/209 dated 3 September 1974.

7. The three exceptions (Belgium, Italy and Switzerland) subsequently wrote to the Director General informing him of their decision to comply with the undertakings of the Nuclear Suppliers' Group set out in INFCIRC/254 dated February 1978.

The "Trigger List"

8. The memorandum dealing with equipment and non-nuclear material (INFCIRC/209, Memorandum B) became known as the "Trigger List": the export of items listed on it " trigger" IAEA safeguards, ie they will be exported only if the source or special fissionable material produced, processed or used in the equipment or material in question is subject to safeguards under an Agreement with the IAEA.

Trigger List "Clarification"

9. Attached to the original Trigger List was an Annex "clarifying" or defining the items described on it in some detail. The passage of time and successive developments in technology have meant that the Committee is constantly engaged in monitoring the need for revision or further "clarification" of Trigger List items and the original Annex has thus grown considerably. To date, four clarification exercises (conducted on the basis of consensus, through the same procedure of internal notification and, where appropriate, by identical letters to the Director General of the IAEA) have taken place.

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Details of the four clarification exercises are set out below:

- In November 1977 the clarifications contained in the Trigger List Annex were updated to bring them into conformity with those of INFCIRC/254. However, three member States (Belgium, Italy and Switzerland) expressed the reserve that, in their opinion, the new item "Plants for the production of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor" (2.6.1) did not fall within the legal scope of Article III.2.(b) of the NPT and would entail an implicit modification of it. Accordingly, they made it clear that they would act on this item on the basis of their commitments under the Nuclear Suppliers' Guidelines.

  The amendments were published in the IAEA document INFCIRC/209/Mod.1. issued on 1 December 1978.

- In order to take account of the technological development which had taken place during the preceding decade in the field of isotope separation by the gas centrifuge process, the clarifications in the Trigger List Annex concerning Isotope Separation Plant Equipment were updated to include additional detail.

  The text of the new clarification was published in the IAEA document INFCIRC/209/Mod.2 of February 1984.

- For similar reasons the clarifications contained in the Trigger List Annex concerning Fuel Reprocessing Plants were updated to include further items of equipment.

  The text of the new clarification was published in the IAEA document INFCIRC/209/Mod.3 of August 1985.

- The clarifications contained in the Trigger List Annex concerning Isotope Separation Plant Equipment were further elaborated by the identification of items of equipment used for isotope separation by the gaseous diffusion method.

  The text of the new clarification was published in the IAEA document INFCIRC/209/Mod.4 of February 1990.

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Status of the Committee

10. The Committee's Understandings and the INFCIRC/209 series documents that arise from them have no status in international law but are arrangements unilaterally entered into by Member States. They make an important contribution to the non-proliferation regime, and are continuously adapted in response to evolving circumstances.

Membership

11. A list of the current Member States of the Zangger Committee is set out below.

AUSTRALIA
AUSTRIA
BELGIUM
CANADA
CZECHOSLOVAKIA
DENMARK
FINLAND
GERMAN DEMOCRATIC REPUBLIC
FEDERAL REPUBLIC OF GERMANY
GREECE
HUNGARY
IRELAND
ITALY
JAPAN
LUXEMBOURG
NETHERLANDS
NORWAY
POLAND
SWEDEN
SWITZERLAND
UNITED KINGDOM
UNITED STATES OF AMERICA
UNION OF SOVIET SOCIALIST REPUBLICS

Chairman

12. Mr Ilkka Makipentti of Finland succeeded Professor Zangger as Chairman in 1989.

VIENNA

July 1990

Annex II

INF

INFCIRC/254/Rev.1/Part 1*/
July 1992

GENERAL Distr.
Original: ENGLISH
and FRENCH

International Atomic Energy Agency

INFORMATION CIRCULAR

COMMUNICATIONS RECEIVED FROM CERTAIN MEMBER STATES REGARDING GUIDELINES FOR THE EXPORT OF NUCLEAR MATERIAL, EQUIPMENT AND TECHNOLOGY

Nuclear Transfers

1. The Director General has received notes verbales dated 1 June 1992 from the Resident Representatives to the Agency of Australia, Austria, Belgium, Bulgaria, Canada, Czech and Slovak Federal Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland, and the United States of America relating to the export of nuclear material, equipment or technology.

2. The purpose of the notes verbales is to clarify parts of the Trigger List which is incorporated in the Annex A to the Guidelines for Nuclear Transfers. A new part A of the Annex A and a revised Annex to it (new Annex B) have been incorporated in the Guidelines.

3. In the light of the wish expressed at the end of each note verbale, the text of the notes verbales is annexed hereto.

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*/ INFCIRC/254/Rev.1/Part 2 contains Guidelines for Transfers of Nuclear-related Dual-use Equipment, Material and related Technology.

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NOTE VERBALE

The Permanent Mission of [Member State] to the International Atomic Energy Agency presents its compliments to the Director General of the International Atomic Energy Agency and has the honour to refer to its letter of [date of previous communication] in which the Government of [Member State] announced its decision to act in accordance with the guidelines for nuclear transfers annexed to that letter.

The Government of [Member State] has implemented these guidelines accordingly and hopes that other Governments, who have not yet done so, may decide to base their own nuclear export policies upon the guidelines.

As a member of the European Community, the Government of [Member State] has implemented these guidelines in accordance with the Declaration of Common Policy, communicated by the Resident Representative of Italy on behalf of the European Community, in his letter of 22 March 1985. The Government of [Member State] hopes that other governments, who have not yet done so, may decide to base their own nuclear export policies upon the said guidelines.**/

In the aforementioned letter the Government of [Member State] pointed out the need to remove safeguards and non-proliferation assurances from the field of commercial competition. This need still exists.

**/ Paragraph in the notes verbales from the members of the European Community used in place of the second paragraph above.

In the years since the guidelines were formulated and published in INFCIRC/254 developments in nuclear technology have brought about the need further to clarify parts of the trigger list which is incorporated in Annex A to the guidelines. In the interest of clarity the resultant new Part A of the Annex A and a revised Annex to it (new Annex B) have been incorporated in the attached copy of the complete guidelines.

The Government of [Member State] requests that the Director General of the International Atomic Energy Agency should circulate the texts of this note and its enclosure to all member governments for their information and as a demonstration of support by the Government of [Member State] for the Agency's non-proliferation objectives and safeguards activities.

The Permanent Mission of [Member State] avails itself of this opportunity to renew to the Director General of the International Atomic Energy Agency the assurances of its highest consideration.

GUIDELINES FOR NUCLEAR TRANSFERS

1. The following fundamental principles for safeguards and export controls should apply to nuclear transfers to any non-nuclear-weapon State for peaceful purposes. In this connection, suppliers have defined an export trigger list and agreed on common criteria for technology transfers.

Prohibition on nuclear explosives

2. Suppliers should authorize transfer of items identified in the trigger list only upon formal governmental assurances from recipients explicitly excluding uses which would result in any nuclear explosive device.

Physical protection

3. (a) All nuclear materials and facilities identified by the agreed trigger list should be placed under effective physical protection to prevent unauthorized use and handling. The levels of physical protection to be ensured in relation to the type of materials, equipment and facilities, have been agreed by suppliers, taking account of international recommendations.

(b) The implementation of measures of physical protection in the recipient country is the responsibility of the Government of that country. However, in order to implement the terms agreed upon amongst suppliers, the levels of physical protection on which these measures have to be based should be the subject of an agreement between supplier and recipient.

(c) In each case special arrangements should be made for a clear definition of responsibilities for the transport of trigger list items.

Safeguards

4. Suppliers should transfer trigger list items only when covered by IAEA safeguards, with duration and coverage provisions in conformance with the GOV/1621 guidelines. Exceptions should be made only after consultation with the parties to this understanding.

5. Suppliers will jointly reconsider their common safeguards requirements, whenever appropriate.

Safeguards triggered by the transfer of certain technology

6. (a) The requirements of paragraphs 2, 3 and 4 above should also apply to facilities for reprocessing, enrichment, or heavy-water production, utilizing technology directly transferred by the supplier or derived from transferred facilities, or major critical components thereof.

(b) The transfer of such facilities, or major critical components thereof, or related technology, should require an undertaking (1) that IAEA safeguards apply to any facilities of the same type (i.e. if the design, construction or operating processes are based on the same or similar physical or chemical processes, as defined in the trigger list) constructed during an agreed period in the recipient country and (2) that there should at all times be in effect a safeguards agreement permitting the IAEA to apply Agency safeguards with respect to such facilities identified by the recipient, or by the supplier in consultation with the recipient, as using transferred technology.

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Special controls on sensitive exports

7. Suppliers should exercise restraint in the transfer of sensitive facilities, technology and weapons-usable materials. If enrichment or reprocessing facilities, equipment or technology are to be transferred, suppliers should encourage recipients to accept, as an alternative to national plants, supplier involvement and/or other appropriate multinational participation in resulting facilities. Suppliers should also promote international (including IAEA) activities concerned with multinational regional fuel cycle centres.

Special controls on export of enrichment facilities, equipment and technology

8. For a transfer of an enrichment facility, or technology therefor, the recipient nation should agree that neither the transferred facility, nor any facility based on such technology, will be designed or operated for the production of greater than 20 % enriched uranium without the consent of the supplier nation, of which the IAEA should be advised.

Controls on supplied or derived weapons-usable material

9. Suppliers recognize the importance, in order to advance the objectives of these guidelines and to provide opportunities further to reduce the risks of proliferation, of including in agreements on supply of nuclear materials or of facilities which produce weapons-usable material, provisions calling for mutual agreement between the supplier and the recipient on arrangements for reprocessing, storage, alteration, use, transfer or retransfer of any weapons-usable material involved. Suppliers should endeavour to include such provisions whenever appropriate and practicable.

Controls on retransfer

10. (a) Suppliers should transfer trigger list items, including technology defined under paragraph 6, only upon the recipient's assurance that in the case of:

(1) retransfer of such items,

or

(2) transfer of trigger list items derived from facilities originally transferred by the supplier, or with the help of equipment or technology originally transferred by the supplier;

the recipient of the retransfer or transfer will have provided the same assurances as those required by the supplier for the original transfer.

(b) In addition the supplier's consent should be required for: (1) any retransfer of the facilities, major critical components, or technology described in paragraph 6; (2) any transfer of facilities or major critical components derived from those items; (3) any retransfer of heavy water or weapons-usable material.

SUPPORTING ACTIVITIES

Physical security

11. Suppliers should promote international co-operation on the exchange of physical security information, protection of nuclear materials in transit, and recovery of stolen nuclear materials and equipment.

Support for effective IAEA safeguards

12. Suppliers should make special efforts in support of effective implementation of IAEA safeguards. Suppliers should also support the Agency's efforts to assist Member States in

the improvement of their national systems of accounting and control of nuclear material and to increase the technical effectiveness of safeguards.

Similarly, they should make every effort to support the IAEA in increasing further the adequacy of safeguards in the light of technical developments and the rapidly growing number of nuclear facilities, and to support appropriate initiatives aimed at improving the effectiveness of IAEA safeguards.

Sensitive plant design features

13. Suppliers should encourage the designers and makers of sensitive equipment to construct it in such a way as to facilitate the application of safeguards.

Consultations

14. (a) Suppliers should maintain contact and consult through regular channels on matters connected with the implementation of these guidelines.

(b) Suppliers should consult, as each deems appropriate, with other Governments concerned on specific sensitive cases, to ensure that any transfer does not contribute to risks of conflict or instability.

(c) In the event that one or more suppliers believe that there has been a violation of supplier/recipient understandings resulting from these guidelines, particularly in the case of an explosion of a nuclear device, or illegal termination or violation of IAEA safeguards by a recipient, suppliers should consult promptly through diplomatic channels in order to determine and assess the reality and extent of the alleged violation.

Pending the early outcome of such consultations, suppliers will not act in a manner that could prejudice any measure that may be adopted by other suppliers concerning their current contacts with that recipient.

Upon the findings of such consultations, the suppliers, bearing in mind Article XII of the IAEA Statute, should agree on an appropriate response and possible action which could include the termination of nuclear transfers to that recipient.

15. In considering transfers, each supplier should exercise prudence having regard to all the circumstances of each case, including any risk that technology transfers not covered by paragraph 6, or subsequent retransfers, might result in unsafeguarded nuclear materials.

16. Unanimous consent is required for any changes in these guidelines, including any which might result from the reconsideration mentioned in paragraph 5.

ANNEX A
TRIGGER LIST REFERRED TO IN GUIDELINES

PART A. Material and equipment

1. Source and special fissionable material

As defined in Article XX of the Statute of the International Atomic Energy Agency:

1.1. "Source material"

The term "source material" means uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate; any other material containing one or more of the foregoing in such concentration as the Board of Governors shall from time to time determine; and such other material as the Board of Governors shall from time to time determine.

1.2. "Special fissionable material"

i) The term "special fissionable material" means plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing; and such other fissionable material as the Board of Governors shall from time to time determine; but the term "special fissionable material" does not include source material.

ii) The term "uranium enriched in the isotopes 235 or 233" means uranium containing the isotopes 235 or 233 or both in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is greater than the ratio of the isotope 235 to the isotope 238 occurring in nature.

However, for the purposes of the Guidelines, items specified in subparagraph (a) below, and exports of source or special fissionable material to a given recipient country, within a period of 12 months, below the limits specified in subparagraph (b) below, shall not be included:

(a) Plutonium with an isotopic concentration of plutonium-238 exceeding 80%.

Special fissionable material when used in gram quantities or less as a sensing component in instruments; and

Source material which the Government is satisfied is to be used only in non-nuclear activities, such as the production of alloys or ceramics;

(b)

Special fissionable material	50 effective grams;
Natural uranium	500 kilograms;
Depleted uranium	1 000 kilograms; and
Thorium	1 000 kilograms.

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2. Equipment and Non-nuclear Materials

The designation of items of equipment and non-nuclear materials (hereafter referred to as the "Trigger List") adopted by the Government is as follows (quantities below the levels indicated in the Annex B being regarded as insignificant for practical purposes):

2.1. Reactors and equipment therefor (see Annex B, section 1.);

2.2. Non-nuclear materials for reactors (see Annex B, section 2.);

2.3. Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor (see Annex B, section 3.);

2.4. Plants for the fabrication of fuel elements (see Annex B, section 4.);

2.5. Plants for the separation of isotopes of uranium and equipment, other than analytical instruments, especially designed or prepared therefor (see Annex B, section 5.);

2.6. Plants for the production of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor (see Annex B, section 6.).

PART B. Common criteria for technology transfers under paragraph 6 of the Guidelines

(1) "Technology" means technical data in physical form designated by the supplying country as important to the design, construction, operation, or maintenance of enrichment, reprocessing, or heavy water production facilities or major critical components thereof, but excluding data available to the public, for example, in published books and periodicals, or that which has been made available internationally without restrictions upon its further dissemination.

(2) "Major critical components" are:

(a) in the case of an isotope separation plant of the gas centrifuge type: gas centrifuge assemblies, corrosion-resistant to UF_6;

(b) in the case of an isotope separation plant of the gaseous diffusion type: diffusion barrier;

(c) in the case of an isotope separation plant of the jet nozzle type: the nozzle units;

(d) in the case of an isotope separation plant of the vortex type: the vortex units.

(3) For facilities covered by paragraph 6 of the Guidelines for which no major critical component is described in paragraph 2 above, if a supplier nation should transfer in the aggregate a significant fraction of the items essential to the operation of such a facility, together with the knowhow for construction and operation of that facility, that transfer should be deemed to be a transfer of "facilities or major critical components thereof".

(4) The definitions in the preceding paragraphs are solely for the purposes of paragraph 6 of the Guidelines and this Part B, which differ from those applicable to Part A of this Trigger List, which should not be interpreted as limited by such definition.

(5) For the purposes of implementing paragraph 6 of the Guidelines, the following facilities should be deemed to be "of the same type (i.e. if their design, construction or operating processes are based on the same or similar physical or chemical processes)"

Where the technology transferred is such as to make possible the construction in the recipient State of a facility of the following type, or major critical components thereof:	The following will be deemed to be facilities of the same type:
(a) an isotope separation plant of the gaseous diffusion type	any other isotope separation plant using the gaseous diffusion process.
(b) an isotope separation plant of the gas centrifuge type	any other isotope separation plant using the gas centrifuge process.
(c) an isotope separation plant of the jet nozzle type	any other isotope separation plant using the jet nozzle process.
(d) an isotope separation plant of the vortex type	any other isotope separation plant using the vortex process.
(e) a fuel reprocessing plant using the solvent extraction process	any other fuel reprocessing plant using the solvent extraction process.
(f) a heavy water plant using the exchange process	any other heavy water plant using the exchange process.
(g) a heavy water plant using the electrolytic process	any other heavy water plant using the electrolytic process.
(h) a heavy water plant using the hydrogen distillation process	any other heavy water plant using the hydrogen distillation process.

Note: In the case of reprocessing, enrichment, and heavy water facilities whose design, construction, or operation processes are based on physical or chemical processes other than those enumerated above, a similar approach would be applied to define facilities "of the same type", and a need to define major critical components of such facilities might arise.

(6) The reference in paragraph 6(b) of the Guidelines to "any facilities of the same type constructed during an agreed period in the recipient's country" is understood to refer to such facilities (or major critical components thereof), the first operation of which commences within a period of at least 20 years from the date of the first operation of (1) a facility which has been transferred or incorporates transferred major critical components or of (2) a facility of the same type built after the transfer of technology. It is understood that during that period there would be a conclusive presumption that any facility of the same type utilized transferred technology. But the agreed period is not intended to limit the duration of the safeguards imposed or the duration of the right to identify facilities as being constructed or operated on the basis of or by the use of transferred technology in accordance with paragraph 6(b)(2) of the Guidelines.

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ANNEX B
CLARIFICATION OF ITEMS ON THE TRIGGER LIST
(as designated in Section 2 of Part A of Annex A)

1. Reactors and equipment therefor

1.1. Complete nuclear reactors

Nuclear reactors capable of operation so as to maintain a controlled self-sustaining fission chain reaction, excluding zero energy reactors, the latter being defined as reactors with a designed maximum rate of production of plutonium not exceeding 100 grams per year.

EXPLANATORY NOTE

A "nuclear reactor" basically includes the items within or attached directly to the reactor vessel, the equipment which controls the level of power in the core, and the components which normally contain or come in direct contact with or control the primary coolant of the reactor core.

It is not intended to exclude reactors which could reasonably be capable of modification to produce significantly more than 100 grams of plutonium per year. Reactors designed for sustained operation at significant power levels, regardless of their capacity for plutonium production, are not considered as "zero energy reactors".

EXPORTS

The export of the whole set of major items within this boundary will take place only in accordance with the procedures of the Guidelines. Those individual items within this functionally defined boundary which will be exported only in accordance with the procedures of the Guidelines are listed in paragraphs 1.2. to 1.7. The Government reserves the right to apply the procedures of the Guidelines to other items within the functionally defined boundary.

1.2. Reactor pressure vessels

Metal vessels, as complete units or as major shop-fabricated parts therefor, which are especially designed or prepared to contain the core of a nuclear reactor as defined in paragraph 1.1. above and are capable of withstanding the operating pressure of the primary coolant.

EXPLANATORY NOTE

A top plate for a reactor pressure vessel is covered by item 1.2. as a major shop-fabricated part of a pressure vessel.

Reactor internals (eg support columns and plates for the core and other vessel internals, control rod guide tubes, thermal shields, baffles, core grid plates, diffuser plates, etc.) are normally supplied by the reactor supplier. In some cases, certain internal support components are included in the fabrication of the pressure vessel. These items are sufficiently critical to the safety and reliability of the operation of the reactor (and, therefore, to the guarantees and liability of the reactor supplier), so that their supply, outside the basic supply arrangement for the reactor itself, would not be common practice. Therefore, although the separate supply of these unique, especially designed and prepared, critical, large and expensive items would not necessarily be considered as falling outside the area of concern, such a mode of supply is considered unlikely.

1.3. Reactor fuel charging and discharging machines

Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor as defined in paragraph 1.1. above capable of on-load operation or employing technically sophisticated positioning or alignment features to allow complex off-load fuelling operations such as those in which direct viewing of or access to the fuel is not normally available.

1.4. Reactor control rods

Rods especially designed or prepared for the control of the reaction rate in a nuclear reactor as defined in paragraph 1.1. above.

EXPLANATORY NOTE

This item includes, in addition to the neutron absorbing part, the support or suspension structures therefor if supplied separately.

1.5. Reactor pressure tubes

Tubes which are especially designed or prepared to contain fuel elements and the primary coolant in a reactor as defined in paragraph 1.1. above at an operating pressure in excess of 5.1 MPa (740 psi).

1.6. Zirconium tubes

Zirconium metal and alloys in the form of tubes or assemblies of tubes, and in quantities exceeding 500 kg in any period of 12 months, especially designed or prepared for use in a reactor as defined in paragraph 1.1. above, and in which the relation of hafnium to zirconium is less than 1:500 parts by weight.

1.7. Primary coolant pumps

Pumps especially designed or prepared for circulating liquid metal as primary coolant for nuclear reactors as defined in paragraph 1.1. above.

2. Non-nuclear materials for reactors

2.1. Deuterium and heavy water

Deuterium, heavy water (deuterium oxide) and any other deuterium compound in which the ratio of deuterium to hydrogen atoms exceeds 1:5000 for use in a nuclear reactor as defined in paragraph 1.1. above in quantities exceeding 200 kg of deuterium atoms for any one recipient country in any period of 12 months.

2.2. Nuclear grade graphite

Graphite having a purity level better than 5 parts per million boron equivalent and with a density greater than 1.50 g/cm^3 in quantities exceeding $3 \cdot 10^4$ kg (30 metric tons) for any one recipient country in any period of 12 months.

3. Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor

INTRODUCTORY NOTE

Reprocessing irradiated nuclear fuel separates plutonium and uranium from intensely radioactive fission products and other transuranic elements. Different technical processes can accomplish this separation. However, over the years Purex has become the most commonly used and accepted process. Purex involves the dissolution of irradiated nuclear fuel in nitric acid, followed by separation of the uranium, plutonium, and fission products by solvent extraction using a mixture of tributyl phosphate in an organic diluent.

Purex facilities have process functions similar to each other, including: irradiated fuel element chopping, fuel dissolution, solvent extraction, and process liquor storage. There may also be equipment for thermal denitration of uranium nitrate, conversion of plutonium nitrate to oxide or metal, and treatment of fission product waste liquor to a form suitable for long term storage or disposal. However, the specific type and configuration of the equipment performing these functions may differ between Purex facilities for several reasons, including the type and quantity of irradiated nuclear fuel to be reprocessed and the intended disposition of the recovered materials, and the safety and maintenance philosophy incorporated into the design of the facility.

A "plant for the reprocessing of irradiated fuel elements", includes the equipment and components which normally come in direct contact with and directly control the irradiated fuel and the major nuclear material and fission-product processing streams.

These processes, including the complete systems for plutonium conversion and plutonium metal production, may be identified by the measures taken to avoid criticality (eg by geometry), radiation exposure (eg by shielding), and toxicity hazards (eg by containment).

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EXPORTS

The export of the whole set of major items within this boundary will take place only in accordance with the procedures of the Guidelines.

The Government reserves to itself the right to apply the procedures of the Guidelines to other items within the functionally defined boundary as listed below.

Items of equipment that are considered to fall within the meaning of the phrase "and equipment especially designed or prepared" for the reprocessing of irradiated fuel elements include:

3.1. Irradiated fuel element chopping machines

INTRODUCTORY NOTE

This equipment breaches the cladding of the fuel to expose the irradiated nuclear material to dissolution. Especially designed metal cutting shears are the most commonly employed, although advanced equipment, such as lasers, may be used.

Remotely operated equipment especially designed or prepared for use in a reprocessing plant as identified above and intended to cut, chop or shear irradiated nuclear fuel assemblies, bundles or rods.

3.2. Dissolvers

INTRODUCTORY NOTE

Dissolvers normally receive the chopped-up spent fuel. In these critically safe vessels, the irradiated nuclear material is dissolved in nitric acid and the remaining hulls removed from the process stream.

Critically safe tanks (eg small diameter, annular or slab tanks) especially designed or prepared for use in a reprocessing plant as identified above, intended for dissolution of irradiated nuclear fuel and which are capable of withstanding hot, highly corrosive liquid, and which can be remotely loaded and maintained.

3.3. Solvent extractors and solvent extraction equipment

INTRODUCTORY NOTE

Solvent extractors both receive the solution of irradiated fuel from the dissolvers and the organic solution which separates the uranium, plutonium, and fission products. Solvent extraction equipment is normally designed to meet strict operating parameters, such as long operating lifetimes with no maintenance requirements or adaptability to easy replacement, simplicity of operation and control, and flexibility for variations in process conditions.

Especially designed or prepared solvent extractors such as packed or pulse columns, mixer settlers or centrifugal contactors for use in a plant for the reprocessing of irradiated fuel. Solvent extractors must be resistant to the corrosive effect of nitric acid. Solvent extractors are normally fabricated to extremely high standards (including special welding and inspection and quality assurance and quality control techniques) out of low carbon stainless steels, titanium, zirconium, or other high quality materials.

3.4. Chemical holding or storage vessels

INTRODUCTORY NOTE

Three main process liquor streams result from the solvent extraction step. Holding or storage vessels are used in the further processing of all three streams, as follows:

(a) The pure uranium nitrate solution is concentrated by evaporation and passed to a denitration process where it is converted to uranium oxide. This oxide is re-used in the nuclear fuel cycle.

(b) The intensely radioactive fission products solution is normally concentrated by evaporation and stored as a liquor concentrate. This concentrate may be subsequently evaporated and converted to a form suitable for storage or disposal.

(c) The pure plutonium nitrate solution is concentrated and stored pending its transfer to further process steps. In particular, holding or storage vessels for plutonium solutions are designed to avoid criticality problems resulting from changes in concentration and form of this stream.

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Especially designed or prepared holding or storage vessels for use in a plant for the reprocessing of irradiated fuel. The holding or storage vessels must be resistant to the corrosive effect of nitric acid. The holding or storage vessels are normally fabricated of materials such as low carbon stainless steels, titanium or zirconium, or other high quality materials. Holding or storage vessels may be designed for remote operation and maintenance and may have the following features for control of nuclear criticality:

(1) walls or internal structures with a boron equivalent of at least two per cent, or
(2) a maximum diameter of 175 mm (7 in) for cylindrical vessels, or
(3) a maximum width of 75 mm (3 in) for either a slab or annular vessel.

3.5. Plutonium nitrate to oxide conversion system

INTRODUCTORY NOTE

In most reprocessing facilities, this final process involves the conversion of the plutonium nitrate solution to plutonium dioxide. The main functions involved in this process are:
process feed storage and adjustment, precipitation and solid/liquor separation, calcination, product handling, ventilation, waste management, and process control.

Complete systems especially designed or prepared for the conversion of plutonium nitrate to plutonium oxide, in particular adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards.

3.6. Plutonium oxide to metal production system

INTRODUCTORY NOTE

This process, which could be related to a reprocessing facility, involves the fluorination of plutonium dioxide, normally with highly corrosive hydrogen fluoride, to produce plutonium fluoride which is subsequently reduced using high purity calcium metal to produce metallic plutonium and a calcium fluoride slag. The main functions involved in this process are: fluorination (eg involving equipment fabricated or lined with a precious metal), metal reduction (eg employing ceramic crucibles), slag recovery, product handling, ventilation, waste management and process control.

Complete systems especially designed or prepared for the production of plutonium metal, in particular adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards.

4. Plants for the fabrication of fuel elements

A "plant for the fabrication of fuel elements" includes the equipment:

(a) Which normally comes in direct contact with, or directly processes, or controls, the production flow of nuclear material, or
(b) Which seals the nuclear material within the cladding.

EXPORTS

The export of the whole set of items for the foregoing operations will take place only in accordance with the procedures of the Guidelines. The Government will also give consideration to application of the procedures of the Guidelines to individual items intended for any of the foregoing operations, as well as for other fuel fabrication operations such as checking the integrity of the cladding or the seal, and the finishing treatment of the sealed fuel.

5. Plants for the separation of isotopes of uranium and equipment, other than analytical instruments, especially designed or prepared therefor

Items of equipment that are considered to fall within the meaning of the phrase "equipment, other than analytical instruments, especially designed or prepared" for the separation of isotopes of uranium include:

5.1. Gas centrifuges and assemblies and components especially designed or prepared for use in gas centrifuges

INTRODUCTORY NOTE

The gas centrifuge normally consists of a thin-walled cylinder(s) of between 75 mm (3 in) and 400 mm (16 in) diameter contained in a vacuum environment and spun at high peripheral speed of the order of 300 m/s or more with its central axis vertical. In order to achieve high speed the materials of construction for the rotating components have to be of a high strength to density ratio and the rotor assembly, and hence its individual components, have to be manufactured to very close tolerances in order to minimize the unbalance. In contrast to other centrifuges, the gas centrifuge for uranium enrichment is characterized by having within the rotor chamber a rotating disc-shaped baffle(s) and a stationary tube arrangement for feeding and extracting the UF_6 gas and featuring at least 3 separate channels, of which 2 are connected to scoops extending from the rotor axis towards the periphery of the rotor chamber. Also contained within the vacuum environment are a number of critical items which do not rotate and which although they are especially designed are not difficult to fabricate nor are they fabricated out of unique materials. A centrifuge facility however requires a large number of these components, so that quantities can provide an important indication of end use.

5.1.1. Rotating components

(a) Complete rotor assemblies:
Thin-walled cylinders, or a number of interconnected thin-walled cylinders, manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section; If interconnected, the cylinders are joined together by flexible bellows or rings as described in section 5.1.1.(c) following. The rotor is fitted with an internal baffle(s) and end caps, as described in section 5.1.1.(d) and (e) following, if in final form. However the complete assembly may be delivered only partly assembled.

(b) Rotor tubes:
Especially designed or prepared thin-walled cylinders with thickness of 12 mm (0.5 in) or less, a diameter of between 75 mm (3 in) and 400 mm (16 in), and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

(c) Rings or Bellows:
Components especially designed or prepared to give localized support to the rotor tube or to join together a number of rotor tubes. The bellows is a short cylinder of wall thickness 3 mm (0.12 in) or less, a diameter of between 75 mm (3 in) and 400 mm (16 in), having a convolute, and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

(d) Baffles:
Disc-shaped components of between 75 mm (3 in) and 400 mm (16 in) diameter especially designed or prepared to be mounted inside the centrifuge rotor tube, in order to isolate the take-off chamber from the main separation chamber and, in some cases, to assist the UF_6 gas circulation within the main separation chamber of the rotor tube, and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

(e) Top caps/Bottom caps:
Disc-shaped components of between 75 mm (3 in) and 400 mm (16 in) diameter especially designed or prepared to fit to the ends of the rotor tube, and so contain the UF_6 within the rotor tube, and in some cases to support, retain or contain as an integrated part an element of the upper bearing (top cap) or to carry the rotating elements of the motor and lower bearing (bottom cap), and manufactured from one of the high strength to density ratio materials described in the EXPLANATORY NOTE to this Section.

EXPLANATORY NOTE

The materials used for centrifuge rotating components are:

(a) Maraging steel capable of an ultimate tensile strength of $2.05 \cdot 10^9$ N/m² (300,000 psi) or more;

(b) Aluminium alloys capable of an ultimate tensile strength of $0.46 \cdot 10^9$ N/m² (67,000 psi) or more;

(c) Filamentary materials suitable for use in composite structures and having a specific modulus of $12.3 \cdot 10^6$ m or greater and a specific ultimate tensile strength of $0.3 \cdot 10^6$ m or greater ('Specific Modulus' is the Young's Modulus in N/m² divided by the specific weight in N/m³; 'Specific Ultimate Tensile Strength' is the ultimate tensile strength in N/m² divided by the specific weight in N/m³).

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5.1.2. Static components

(a) Magnetic suspension bearings:
Especially designed or prepared bearing assemblies consisting of an annular magnet suspended within a housing containing a damping medium. The housing will be manufactured from a UF_6-resistant material (see EXPLANATORY NOTE to Section 5.2.). The magnet couples with a pole piece or a second magnet fitted to the top cap described in Section 5.1.1.(e). The magnet may be ring-shaped with a relation between outer and inner diameter smaller or equal to 1.6:1. The magnet may be in a form having an initial permeability of 0.15 H/m (120,000 in CGS units) or more, or a remanence of 98.5% or more, or an energy product of greater than 80 kJ/m^3 (10^7 gauss-oersteds). In addition to the usual material properties, it is a prerequisite that the deviation of the magnetic axes from the geometrical axes is limited to very small tolerances (lower than 0.1 mm or 0.004 in) or that homogeneity of the material of the magnet is specially called for.

(b) Bearings/Dampers:
Especially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper. The pivot is normally a hardened steel shaft polished into a hemisphere at one end with a means of attachment to the bottom cap described in section 5.1.1.(e) at the other. The shaft may however have a hydrodynamic bearing attached. The cup is pellet-shaped with a hemispherical indentation in one surface. These components are often supplied separately to the damper.

(c) Molecular pumps:
Especially designed or prepared cylinders having internally machined or extruded helical grooves and internally machined bores. Typical dimensions are as follows: 75 mm (3 in) to 400 mm (16 in) internal diameter, 10 mm (0.4 in) or more wall thickness, 1 to 1 length to diameter ratio. The grooves are typically rectangular in cross-section and 2 mm (0.08 in) or more in depth.

(d) Motor stators:
Especially designed or prepared ring-shaped stators for high speed multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuum in the frequency range of 600 - 2000 Hz and a power range of 50 - 1000 VA. The stators consist of multi-phase windings on a laminated low loss iron core comprised of thin layers typically 2.0 mm (0.08 in) thick or less.

5.2. Especially designed or prepared auxiliary systems, equipment and components for gas centrifuge enrichment plants

INTRODUCTORY NOTE

The auxiliary systems, equipment and components for a gas centrifuge enrichment plant are the systems of plant needed to feed UF_6 to the centrifuges, to link the individual centrifuges to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the 'product' and 'tails' UF_6 from the centrifuges, together with the equipment required to drive the centrifuges or to control the plant.

Normally UF_6 is evaporated from the solid using heated autoclaves and is distributed in gaseous form to the centrifuges by way of cascade header pipework. The 'product' and 'tails' UF_6 gaseous streams flowing from the centrifuges are also passed by way of cascade header pipework to cold traps (operating at about 203 K (-70°C)) where they are condensed prior to onward transfer into suitable containers for transportation or storage. Because an enrichment plant consists of many thousands of centrifuges arranged in cascades there are many kilometers of cascade header pipework, incorporating thousands of welds with a substantial amount of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.

5.2.1. Feed systems/product and tails withdrawal systems

Especially designed or prepared process systems including:

Feed autoclaves (or stations), used for passing UF_6 to the centrifuge cascades at up to 100 kPa (15 psi) and at a rate of 1 kg/h or more;

Desublimers (or cold traps) used to remove UF_6 from the cascades at up to 3 kPa (0.5 psi) pressure. The desublimers are capable of being chilled to 203 K (-70°C) and heated to 343 K (70°C);

'Product' and 'Tails' stations used for trapping UF_6 into containers.

This plant, equipment and pipework is wholly made of or lined with UF_6-resistant materials (see EXPLANATORY NOTE to this section) and is fabricated to very high vacuum and cleanliness standards.

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5.2.2. **Machine header piping systems**

Especially designed or prepared piping systems and header systems for handling UF_6 within the centrifuge cascades. The piping network is normally of the 'triple' header system with each centrifuge connected to each of the headers. There is thus a substantial amount of repetition in its form. It is wholly made of UF_6-resistant materials (see EXPLANATORY NOTE to this section) and is fabricated to very high vacuum and cleanliness standards.

5.2.3. **UF_6 mass spectrometers/ion sources**

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking 'on-line' samples of feed, product or tails, from UF_6 gas streams and having all of the following characteristics:

1. Unit resolution for atomic mass unit greater than 320;
2. Ion sources constructed of or lined with nichrome or monel or nickel plated;
3. Electron bombardment ionization sources;
4. Having a collector system suitable for isotopic analysis.

5.2.4. **Frequency changers**

Frequency changers (also known as converters or invertors) especially designed or prepared to supply motor stators as defined under 5.1.2.(d), or parts, components and sub-assemblies of such frequency changers having all of the following characteristics:

1. A multiphase output of 600 to 2000 Hz;
2. High stability (with frequency control better than 0.1%);
3. Low harmonic distortion (less than 2%); and
4. An efficiency of greater than 80%.

EXPLANATORY NOTE

The items listed above either come into direct contact with the UF_6 process gas or directly control the centrifuges and the passage of the gas from centrifuge to centrifuge and cascade to cascade.

Materials resistant to corrosion by UF_6 include stainless steel, aluminium, aluminium alloys, nickel or alloys containing 60% or more nickel.

5.3. **Especially designed or prepared assemblies and components for use in gaseous diffusion enrichment**

INTRODUCTORY NOTE

In the gaseous diffusion method of uranium isotope separation, the main technological assembly is a special porous gaseous diffusion barrier, heat exchanger for cooling the gas (which is heated by the process of compression), seal valves and control valves, and pipelines. Inasmuch as gaseous diffusion technology uses uranium hexafluoride (UF_6), all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that remain stable in contact with UF_6. A gaseous diffusion facility requires a number of these assemblies, so that quantities can provide an important indication of end use.

5.3.1. **Gaseous diffusion barriers**

(a) Especially designed or prepared thin, porous filters, with a pore size of 100 - 1,000 Å (angstroms), a thickness of 5 mm (0.2 in) or less, and for tubular forms, a diameter of 25 mm (1 in) or less, made of metallic, polymer or ceramic materials resistant to corrosion by UF_6, and

(b) especially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60 per cent or more nickel, aluminium oxide, or UF_6-resistant fully fluorinated hydrocarbon polymers having a purity of 99.9 per cent or more, a particle size less than 10 microns, and a high degree of particle size uniformity, which are especially prepared for the manufacture of gaseous diffusion barriers.

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5.3.2. **Diffuser housings**

Especially designed or prepared hermetically sealed cylindrical vessels greater than 300 mm (12 in) in diameter and greater than 900 mm (35 in) in length, or rectangular vessels of comparable dimensions, which have an inlet connection and two outlet connections all of which are greater than 50 mm (2 in) in diameter, for containing the gaseous diffusion barrier, made of or lined with UF_6-resistant materials and designed for horizontal or vertical installation.

5.3.3. **Compressors and gas blowers**

Especially designed or prepared axial, centrifugal, or positive displacement compressors, or gas blowers with a suction volume capacity of 1 m^3/min or more of UF_6, and with a discharge pressure of up to several hundred kPa (100 psi), designed for long-term operation in the UF_6 environment with or without an electrical motor of appropriate power, as well as separate assemblies of such compressors and gas blowers. These compressors and gas blowers have a pressure ratio between 2:1 and 6:1 and are made of, or lined with, materials resistant to UF_6.

5.3.4. **Rotary shaft seals**

Especially designed or prepared vacuum seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor or the gas blower rotor with the driver motor so as to ensure a reliable seal against in-leaking of air into the inner chamber of the compressor or gas blower which is filled with UF_6. Such seals are normally designed for a buffer gas in-leakage rate of less than 1000 cm^3/min (60 in^3/min).

5.3.5. **Heat exchangers for cooling UF_6**

Especially designed or prepared heat exchangers made of or lined with UF_6-resistant materials (except stainless steel) or with copper or any combination of those metals, and intended for a leakage pressure change rate of less than 10 Pa (0.0015 psi) per hour under a pressure difference of 100 kPa (15 psi).

5.4. **Especially designed or prepared auxiliary systems, equipment and components for use in gaseous diffusion enrichment**

INTRODUCTORY NOTE

The auxiliary systems, equipment and components for gaseous diffusion enrichment plants are the systems of plant needed to feed UF_6 to the gaseous diffusion assembly, to link the individual assemblies to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the "product" and "tails" UF_6 from the diffusion cascades. Because of the high inertial properties of diffusion cascades, any interruption in their operation, and especially their shut-down, leads to serious consequences. Therefore, a strict and constant maintenance of vacuum in all technological systems, automatic protection from accidents, and precise automated regulation of the gas flow is of importance in a gaseous diffusion plant. All this leads to a need to equip the plant with a large number of special measuring, regulating and controlling systems.

Normally UF_6 is evaporated from cylinders placed within autoclaves and is distributed in gaseous form to the entry point by way of cascade header pipework. The "product" and "tails" UF_6 gaseous streams flowing from exit points are passed by way of cascade header pipework to either cold traps or to compression stations where the UF_6 gas is liquefied prior to onward transfer into suitable containers for transportation or storage. Because a gaseous diffusion enrichment plant consists of a large number of gaseous diffusion assemblies arranged in cascades, there are many kilometers of cascade header pipework, incorporating thousands of welds with substantial amounts of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.

5.4.1. **Feed systems/product and tails withdrawal systems**

Especially designed or prepared process systems, capable of operating at pressures of 300 kPa (45 psi) or less, including:

Feed autoclaves (or systems), used for passing UF_6 to the gaseous diffusion cascades;
Desublimers (or cold traps) used to remove UF_6 from diffusion cascades;

Liquefaction stations where UF_6 gas from the cascade is compressed and cooled to form liquid UF_6;
"Product" or "tails" stations used for transferring UF_6 into containers.

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5.4.2. Header piping systems

Especially designed or prepared piping systems and header systems for handling UF_6 within the gaseous diffusion cascades. This piping network is normally of the "double" header system with each cell connected to each of the headers.

5.4.3. **Vacuum systems**

(a) Especially designed or prepared large vacuum manifolds, vacuum headers and vacuum pumps having a suction capacity of 5 m^3/min (175 ft^3/min) or more.

(b) Vacuum pumps especially designed for service in UF_6-bearing atmospheres made of, or lined with, aluminium, nickel, or alloys bearing more than 60% nickel. These pumps may be either rotary or positive, may have displacement and fluorocarbon seals, and may have special working fluids present.

5.4.4. **Special shut-off and control valves**

Especially designed or prepared manual or automated shut-off and control bellows valves made of UF_6-resistant materials with a diameter of 40 to 1500 mm (1.5 to 59 in) for installation in main and auxiliary systems of gaseous diffusion enrichment plants.

5.4.5. **UF_6 mass spectrometers/ion sources**

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking "on-line" samples of feed, product or tails, from UF_6 gas streams and having all of the following characteristics:

1. Unit resolution for atomic mass unit greater than 320;
2. Ion sources constructed of or lined with nichrome or monel or nickel plated;
3. Electron bombardment ionization sources;
4. Collector system suitable for isotopic analysis.

EXPLANATORY NOTE

The items listed above either come into direct contact with the UF_6 process gas or directly control the flow within the cascade. All surfaces which come into contact with the process gas are wholly made of, or lined with, UF_6-resistant materials. For the purposes of the sections relating to gaseous diffusion items the materials resistant to corrosion by UF_6 include stainless steel, aluminium, aluminium alloys, aluminium oxide, nickel or alloys containing 60% or more nickel and UF_6-resistant fully fluorinated hydrocarbon polymers.

5.5. **Jet nozzle separation units**

5.6. **Vortex separation units**

6. Plants for the production of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor

INTRODUCTORY NOTE

Heavy water can be produced by a variety of processes. However, the two processes that have proven to be commercially viable are the water-hydrogen sulphide exchange process (GS process) and the ammonia-hydrogen exchange process.

The GS process is based upon the exchange of hydrogen and deuterium between water and hydrogen sulphide within a series of towers which are operated with the top section cold and the bottom section hot. Water flows down the towers while the hydrogen sulphide gas circulates from the bottom to the top of the towers. A series of perforated trays are used to promote mixing between the gas and the water. Deuterium migrates to the water at low temperatures and to the hydrogen sulphide at high temperatures. Gas or water, enriched in deuterium, is removed from the first stage towers at the junction of the hot and cold sections and the process is repeated in subsequent stage towers. The product of the last stage, water enriched up to 30% in deuterium, is sent to a distillation unit to produce reactor grade heavy water; i.e., 99.75% deuterium oxide.

The ammonia-hydrogen exchange process can extract deuterium from synthesis gas through contact with liquid ammonia in the presence of a catalyst. The synthesis gas is fed into exchange towers and to an ammonia converter. Inside the towers the gas flows from the bottom to the top while the liquid ammonia flows from the top to the bottom. The deuterium is stripped

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from the hydrogen in the synthesis gas and concentrated in the ammonia. The ammonia then flows into an ammonia cracker at the bottom of the tower while the gas flows into an ammonia converter at the top. Further enrichment takes place in subsequent stages and reactor grade heavy water is produced through final distillation. The synthesis gas feed can be provided by an ammonia plant that, in turn, can be constructed in association with a heavy water ammonia-hydrogen exchange plant. The ammonia-hydrogen exchange process can also use ordinary water as a feed source of deuterium.

Many of the key equipment items for heavy water production plants using GS or the ammonia-hydrogen exchange processes are common to several segments of the chemical and petroleum industries. This is particularly so for small plants using the GS process. However, few of the items are available "off-the-shelf". The GS and ammonia-hydrogen processes require the handling of large quantities of flammable, corrosive and toxic fluids at elevated pressures. Accordingly, in establishing the desing and operating standards for plants and equipment using these processes, careful attention to the materials selection and specifications is required to ensure long service life with high safety and reliability factors. The choice of scale is primarily a function of economics and need. Thus, most of the equipment items would be prepared according to the requirements of the customer.

Finally, it should be noted that, in both the GS and the ammonia-hydrogen exchange processes, items of equipment which individually are not especially designed or prepared for heavy water production can be assembled into systems which are especially designed or prepared for producing heavy water. The catalyst production system used in the ammonia-hydrogen exchange process and water distillation systems used for the final concentration of heavy water to reactor-grade in either process are examples of such systems.

The items of equipment which are especially designed or prepared for the production of heavy water utilizing either the water-hydrogen sulphide exchange process or the ammonia-hydrogen exchange process include the following:

6.1. Water - Hydrogen Sulphide Exchange Towers

Exchange towers fabricated from fine carbon steel (such as ASTM A516) with diameters of 6 m (20 ft) to 9 m (30 ft), capable of operating at pressures greater than or equal to 2 MPa (300 psi) and with a corrosion allowance of 6 mm or greater, especially designed or prepared for heavy water production utilizing the water-hydrogen sulphide exchange process.

6.2. Blowers and Compressors

Single stage, low head (i.e., 0.2 MPa or 30 psi) centrifugal blowers or compressors for hydrogen - sulphide gas circulation (i.e., gas containing more than 70% H_2S) especially designed or prepared for heavy water production utilizing the water-hydrogen sulphide exchange process. These blowers or compressors have a throughput capacity greater than or equal to 56 m^3/second (120,000 SCFM) while operating at pressures greater than or equal to 1.8 MPa (260 psi) suction and have seals designed for wet H_2S service.

6.3. Ammonia-Hydrogen Exchange Towers

Ammonia-hydrogen exchange towers greater than or equal to 35 m (114.3 ft) in height with diameters of 1.5 m (4.9 ft) to 2.5 m (8.2 ft) capable of operating at pressures greater than 15 MPa (2225 psi) especially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process. These towers also have at least one flanged, axial opening of the same diameter as the cylindrical part through which the tower internals can be inserted or withdrawn.

6.4. Tower Internals and Stage Pumps

Tower internals and stage pumps especially designed or prepared for towers for heavy water production utilizing the ammonia-hydrogen exchange process. Tower internals include especially designed stage contactors which promote intimate gas/liquid contact. Stage pumps include especially designed submersible pumps for circulation of liquid ammonia within a contacting stage internal to the stage towers.

6.5. Ammonia Crackers

Ammonia crackers with operating pressures greater than or equal to 3 MPa (450 psi) especially designed or prepared for heavy water production utilizing the ammonia- hydrogen exchange process.

6.6. Infrared Absorption Analyzers

Infrared absorption analyzers capable of "on-line" hydrogen/deuterium ratio analysis where deuterium concentrations are equal to or greater than 90%.

6.7. Catalytic Burners

Catalytic burners for the conversion of enriched deuterium gas into heavy water especially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process.

ANNEX C

CRITERIA FOR LEVELS OF PHYSICAL PROTECTION

1. The purpose of physical protection of nuclear materials is to prevent unauthorized use and handling of these materials. Paragraph 3(a) of the Guidelines document calls for agreement among suppliers on the levels of protection to be ensured in relation to the type of materials, and equipment and facilities containing these materials, taking account of international recommendations.

2. Paragraph 3(b) of the Guidelines document states that implementation of measures of physical protection in the recipient country is the responsibility of the Government of that country. However, the levels of physical protection on which these measures have to be based should be the subject of an agreement between supplier and recipient. In this context these requirements should apply to all States.

3. The document INFCIRC/225 of the International Atomic Energy Agency entitled "The Physical Protection of Nuclear Material" and similar documents which from time to time are prepared by international groups of experts and updated as appropriate to account for changes in the state of the art and state of knowledge with regard to physical protection of nuclear material are a useful basis for guiding recipient States in designing a system of physical protection measures and procedures.

4. The categorization of nuclear material presented in the attached table or as it may be updated from time to time by mutual agreement of suppliers shall serve as the agreed basis for designating specific levels of physical protection in relation to the type of materials, and equipment and facilities containing these materials, pursuant to paragraph 3(a) and 3(b) of the Guidelines document.

5. The agreed levels of physical protection to be ensured by the competent national authorities in the use, storage and transportation of the materials listed in the attached table shall as a minimum include protection characteristics as follows:

CATEGORY III

Use and Storage within an area to which access in controlled.

Transportation under special precautions including prior arrangements among sender, recipient and carrier, and prior agreement between entities subject to the jurisdiction and regulation of supplier and recipient States, respectively, in case of international transport specifying time, place and procedures for transferring transport responsibility.

CATEGORY II

Use and Storage within a protected area to which access is controlled, i.e. an area under constant surveillance by guards or electronic devices, surrounded by a physical barrier with a limited number of points of entry under appropriate control, or any area with an equivalent level of physical protection.

Transportation under special precautions including prior arrangements among sender, recipient and carrier, and prior agreement between entities subject to the jurisdiction and regulation of supplier and recipient States, respectively, in case of international transport, specifying time, place and procedures for transferring transport responsibility.

CATEGORY I

Materials in this category shall be protected with highly reliable systems against unauthorized use as follows:

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Use and Storage within a highly protected area, i.e. a protected area as defined for Category II above, to which, in addition, access is restricted to persons whose trustworthiness has been determined, and which is under surveillance by guards who are in close communication with appropriate response forces. Specific measures taken in this context should have as their objective the detection and prevention of any assault, unauthorized access or unauthorized removal of material

Transportation under special precautions as identified above for transportation of Category II and III materials and, in addition, under constant surveillance by escorts and under conditions which assure close communication with appropriate response forces.

6. Suppliers should request identification by recipients of those agencies or authorities having responsibility for ensuring that levels of protection are adequately met and having responsibility for internally co-ordinating response/recovery operations in the event of unauthorized use or handling of protected materials. Suppliers and recipients should also designate points of contact within their national authorities to co-operate on matters of out-of-country transportation and other matters of mutual concern.

TABLE: CATEGORIZATION OF NUCLEAR MATERIAL

Material	Form	Category I	Category II	Category III
1. Plutonium[a]	Unirradiated[b]	2 kg or more	Less than 2 kg but more than 500 g	500 g or less[c]
2. Uranium-235	Unirradiated[b]			
	- uranium enriched to 20% ^{235}U or more	5 kg or more	Less than 5 kg but more than 1 kg	1 kg or less[c]
	- uranium enriched to 10% ^{235}U but less than 20%	-	10 kg or more	Less than 10 kg[c]
	- uranium enriched above natural, but less than 10% ^{235}U[d]			10 kg or more
3. Uranium-233	Unirradiated[b]	2 kg or more	Less than 2 kg but more than 500 g	500 g or less[c]
4. Irradiated fuel			Depleted or natural uranium, thorium or low-enriched fuel (less than 10% fissile content)[e],[f]	

a) As identified in the Trigger List.

b) Material not irradiated in a reactor or material irradiated in a reactor but with a radiation level equal to or less than 100 rads/hour at one metre unshielded.

c) Less than a radiologically significant quantity should be exempted.

d) Natural uranium, depleted uranium and thorium and quantities of uranium enriched to less than 10% not falling in Category III should be protected in accordance with prudent management practice.

e) Although this level of protection is recommended, it would be open to States, upon evaluation of the specific circumstances, to assign a different category of physical protection.

f) Other fuel which by virtue of its original fissile material content is classified as Category I or II before irradiation, may be reduced one category level while the radiation level from the fuel exceeds 100 rads/hour at one metre unshielded.

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Annex III

INF

International Atomic Energy Agency

INFORMATION CIRCULAR

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COMMUNICATIONS RECEIVED FROM CERTAIN MEMBER STATES REGARDING GUIDELINES FOR THE EXPORT OF NUCLEAR MATERIAL, EQUIPMENT AND TECHNOLOGY

Nuclear-related Dual-use Transfers

1. The Director General has received notes verbales dated 15 May 1992 from the Resident Representatives to the Agency of Australia, Austria, Belgium, Bulgaria, Canada, Czech and Slovak Federal Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, the United Kingdom of Great Britain and Northern Ireland, and the United States of America relating to the export of nuclear material, equipment and technology.

2. The purpose of the notes verbales is to provide information on those Governments' Guidelines for Transfers of Nuclear-related Dual-use Equipment, Material and related Technology.

3. In the light of the wish expressed at the end of each note verbale, the text of the notes verbales is annexed hereto.

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NOTE VERBALE

The Permanent Mission of [Member State] presents its compliments to the Director General of the International Atomic Energy Agency and has the honour to provide information on its Government's nuclear export policies and practices.

The Government of [Member State] has decided that, when considering the transfer of nuclear-related dual-use equipment, material and related technology, it will act in accordance with the provisions of the attached documents.

In reaching this decision, the Government of [Member State] is fully aware of the need to contribute to economic development while avoiding contributing in any way to the dangers of a proliferation of nuclear weapons or other nuclear explosive devices, and of the need to remove non-proliferation assurances from the field of commercial competition.

The Government of [Member State], so far as trade within the European Community is concerned, will implement these documents in the light of its commitments as a Member State of that Community.*/

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*/ Paragraph in the notes verbales from the members of the European Community.

The Government of [Member State] hopes that other governments may also decide to base their own export policies regarding nuclear-related dual-use equipment, material and related technology upon these documents.

The Government of [Member State] requests that the Director General of the International Atomic Energy Agency should circulate the texts of this letter and the documents concerned to all Member Governments for their information and as a demonstration of support by the Government of [Member State] for the Agency's non-proliferation objectives and safeguards activities.

The Permanent Mission of [Member State] avails itself of this opportunity to renew to the Director General of the International Atomic Energy Agency the assurances of its highest consideration.

GUIDELINES FOR TRANSFERS OF NUCLEAR-RELATED DUAL-USE EQUIPMENT, MATERIAL AND RELATED TECHNOLOGY

OBJECTIVE

1. With the objective of averting the proliferation of nuclear weapons, suppliers have had under consideration procedures in relation to the transfer of certain equipment, material, and related technology that could make a major contribution to a "nuclear explosive activity" or an "unsafeguarded nuclear fuel-cycle activity." In this connection, suppliers have agreed on the following principles, common definitions, and an export control list of equipment, material, and related technology. The Guidelines are not designed to impede international cooperation as long as such cooperation will not contribute to a nuclear explosive activity or an unsafeguarded nuclear fuel-cycle activity. Suppliers intend to implement the Guidelines in accordance with national legislation and relevant international commitments.

BASIC PRINCIPLE

2. Suppliers should not authorize transfers of equipment, material, or related technology identified in the Annex:

-- for use in a non-nuclear-weapon state in a nuclear explosive activity or an unsafeguarded nuclear fuel cycle activity, or

-- in general, when there is an unacceptable risk of diversion to such an activity, or when the transfers are contrary to the objective of averting the proliferation of nuclear weapons.

EXPLANATION OF TERMS

3. (a) "Nuclear explosive activity" includes research on or development, design, manufacture, construction, testing or maintenance of any nuclear explosive device or components or subsystems of such a device.

(b) "Unsafeguarded nuclear fuel-cycle activity" includes research on or development, design, manufacture, construction, operation or maintenance of any reactor, critical facility, conversion plant, fabrication plant, reprocessing plant, plant for the separation of isotopes of source or special fissionable material, or separate storage installation, where there is no obligation to accept International Atomic Energy Agency (IAEA) safeguards at the relevant facility or installation, existing or future, when it contains any source or special fissionable material; or of any heavy water production plant where there is no obligation to accept IAEA safeguards on any nuclear material produced by or used in connection with any heavy water produced therefrom; or where any such obligation is not met.

ESTABLISHMENT OF EXPORT LICENSING PROCEDURES

4. Suppliers should establish export licensing procedures for the transfer of equipment, material, and related technology identified in the Annex. These procedures should include enforcement measures for violations. In considering whether to authorize such transfers, suppliers should exercise prudence in order to carry out the Basic Principle and should take relevant factors into account, including:

(a) Whether the recipient state is a party to the Nuclear Non-Proliferation Treaty (NPT) or to the Treaty for the Prohibition of Nuclear Weapons in Latin America (Treaty of Tlatelolco), or to a similar international legally-binding nuclear non-proliferation agreement, and has an IAEA safeguards agreement in force applicable to all its peaceful nuclear activities;

(b) Whether any recipient state that is not party to the NPT, Treaty of Tlatelolco, or a similar international legally-binding nuclear non-proliferation agreement has any facilities or installations listed in paragraph 3(b) above that are operational or being designed or constructed that are not, or will not be, subject to IAEA safeguards;

(c) Whether the equipment, material, or related technology to be transferred is appropriate for the stated end-use and whether that stated end-use is appropriate for the end-user;

(d) Whether the equipment, material, or related technology to be transferred is to be used in research on or development, design, manufacture, construction, operation, or maintenance of any reprocessing or enrichment facility;

(e) Whether governmental actions, statements, and policies of the recipient state are supportive of nuclear non-proliferation and whether the recipient state is in compliance with its international obligations in the field of nonproliferation;

(f) Whether the recipients have been engaged in clandestine or illegal procurement activities; and

(g) Whether a transfer has not been authorized to the end-user or whether the end-user has diverted for purposes inconsistent with the Guidelines any transfer previously authorized.

CONDITIONS FOR TRANSFERS

5. In the process of determining that the transfer will not pose any unacceptable risk of diversion, in accordance with the Basic Principle and to meet the objectives of the Guidelines, the supplier should obtain, before authorizing the transfer and in a manner consistent with its national law and practices, the following:

(a) a statement from the end-user specifying the uses and end-use locations of the proposed transfers; and

(b) an assurance explicitly stating that the proposed transfer or any replica thereof will not be used in any nuclear explosive activity or unsafeguarded nuclear fuel-cycle activity.

CONSENT RIGHTS OVER RETRANSFERS

6. Before authorizing the transfer of equipment, material, or related technology identified in the Annex to a country not adhering to the Guidelines, suppliers should obtain assurances that their consent will be secured, in a manner consistent with their national law and practices, prior to any retransfer to a third country of the equipment, material, or related technology, or any replica thereof.

CONCLUDING PROVISIONS

7. The supplier reserves to itself discretion as to the application of the Guidelines to other items of significance in addition to those identified in the Annex, and as to the application of other conditions for transfer that it may consider necessary in addition to those provided for in paragraph 5 of the Guidelines.

8. In furtherance of the effective implementation of the Guidelines, suppliers should, as necessary and appropriate, exchange relevant information and consult with other states adhering to the Guidelines.

9. In the interest of international peace and security, the adherence of all states to the Guidelines would be welcome.

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ANNEX

LIST OF NUCLEAR-RELATED DUAL-USE EQUIPMENT AND MATERIALS AND RELATED TECHNOLOGY

Note: The International System of Units (SI) is used in this Annex. In many places, the approximately equivalent physical quantity in English units is given in parentheses ( ) after the SI quantity. In all cases the physical quantity defined in SI units should be considered the official recommended control value. However, some machine tool parameters are given in their customary units, which are not SI.

Commonly used abbreviations (and their prefixes denoting size) in this Annex are as follows.

A — ampere(s)
°C — degree(s) Celsius
Ci — curie(s)
cm^3 — cubic centimeter(s)
dB — decibel (s)
dBm — decibel referred to 1 milliwatt
g — gram(s); also, acceleration of gravity (9.81 m/$second^2$)
GBq — gigabecquerel(s)
GHz — gigahertz
Hz — hertz
J — joule(s)
K — kelvin
keV — thousand electron volt(s)
kg — kilogram(s)
kHz — kilohertz
kN — kilonewton(s)
kPa — kilopascal(s)
kW — kilowatt(s)
m — meter(s)
MeV — million electron volt(s)
MHz — megahertz
MPa — megapascal(s)
MW — megawatt(s)
μF — microfarad(s)
μm — micrometer(s)
μs — microsecond(s)
mm — millimeter(s)
N — newton(s)
nm — nanometer(s)
ns — nanosecond(s)
nH — nanohenry(ies)
ps — picosecond(s)
RMS — root mean square
TIR — total indicator reading
W — watt(s)

GENERAL NOTE

The following paragraphs are applied to the List of Nuclear-Related Dual-Use Equipment, Material, and Related Technology.

1. The description of any item on the List includes that item in either new or second-hand condition.

2. When the description of any item on the List contains no qualifications or specifications, it is regarded as including all varieties of that item. Category captions are only for convenience in reference and do not affect the interpretation of item definitions.

3. The object of these controls should not be defeated by the transfer of any non-controlled item (including plants) containing one or more controlled components when the controlled component or components are the principal element of the item and can feasibly be removed or used for other purposes.

   Note:
   In judging whether the controlled component or components are to be considered the principal element, governments should weigh the factors of quantity, value, and technological know-how involved and other special circumstances which might establish the controlled component or components as the principal element of the item being procured.

4. The object of these controls should not be defeated by the transfer of component parts. Each government will take such action as it can to achieve this aim and will continue to seek a workable definition for component parts, which could be used by all the suppliers.

TECHNOLOGY CONTROLS

The transfer of "technology" directly associated with any items in the List will be subject to as great a degree of scrutiny and control as will the equipment itself, to the extent permitted by national legislation.

Controls on "technology" transfer do not apply to information "in the public domain" or to "basic scientific research."

Note: — The item on machine tools contains specific controls on technology.

STATEMENT OF UNDERSTANDING

The approval of any List item for export also authorizes the export to the same end user of the minimum technology required for the installation, operation, maintenance, and repair of the item.

DEFINITIONS

"Technology" — means specific information required for the "development," "production," or "use" of any item contained in the List. This information may take the form of "technical data" or "technical assistance."

"basic scientific research" — Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena and observable facts, not primarily directed toward a specific practical aim or objective.

"development" - is related to all phases before "production" such as:

- design
- design research
- design analysis
- design concepts
- assembly and testing of prototypes
- pilot production schemes
- design data
- process of transforming design data into a product
- configuration design
- integration design
- layouts

"in the public domain" — "In the public domain," as it applies herein, means technology that has been made available without restrictions upon its further dissemination. (Copyright restrictions do not remove technology from being in the public domain.)

"production" - means all production phases such as:

- construction
- production engineering
- manufacture
- integration
- assembly (mounting)
- inspection
- testing
- quality assurance

"Specially designed software"

The minimum "operating systems," "diagnostic systems," "maintenance systems," and "application software" necessary to be executed on particular equipment to perform the

function for which it was designed. To make other, incompatible equipment perform the same function requires:
(a) modification of this "software" or
(b) addition of "programs."

"technical assistance" — "Technical assistance" may take forms such as: instruction, skills, training, working knowledge, consulting services.
NOTE: "Technical assistance" may involve transfer of "technical data."

"technical data" — "Technical data" may take forms such as blueprints, plans, diagrams, models, formulae, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.

"use" — Operation, installation (including on-site installation), maintenance (checking), repair, overhaul and refurbishing.

ANNEX CONTENTS

ANNEX

LIST OF NUCLEAR-RELATED DUAL-USE EQUIPMENT AND MATERIALS AND RELATED TECHNOLOGY

1. INDUSTRIAL EQUIPMENT

1.1. **Spin-forming and flow-forming machines which:**

a. according to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control; and

b. with two or more axes that can be coordinated simultaneously for "contouring control,"

and precision rotor-forming mandrels designed to form cylindrical rotors of inside diameter between 75 mm (3 in.) and 400 mm (16 in.) and specially designed software therefor.

Note: The only spin-forming machines controlled by this entry are those combining the function of spin-forming and flow-forming.

1.2. **"Numerical control" units, specially designed "motion control boards" for "numerical control" applications on machine tools, "numerically controlled" machine tools, specially designed "software," and technology as follows.**

Detailed specifications of the equipment are shown in the Appendix.

1.3. **Dimensional inspection machines, devices, or systems, as follows, specially designed software therefor.**

(a) Computer controlled or numerically controlled dimensional inspection machines having both of the following characteristics:

(1) two or more axes; *and*

(2) a one-dimensional length "measurement uncertainty" equal to or less (better) than (1.25 + L/1000) μm tested with a probe of an "accuracy" of less (better) than 0.2 μm (L is the measured length in millimeters) (Ref: VDI/VDE 2617 parts 1 and 2);

(b) Linear and angular displacement measuring devices, as follows:

(1) linear measuring instruments having any of the following characteristics:

(i) non-contact type measuring systems with a "resolution" equal to or less (better) than 0.2 μm within a measuring range up to 0.2 mm;

(ii) linear variable differential transformer (LVDT) systems having both of the following characteristics:

(A) "linearity" equal to or less (better) than 0.1% within a measuring range up to 5 mm; *and*

(B) drift equal to or less (better) than 0.1% per day at a standard ambient test room temperature ±1 K; *or*

(iii) measuring systems that have both of the following characteristics:

(A) contain a "laser"; *and*

(B) maintain for at least 12 hours, over a temperature range of ±1 K around a standard temperature and a standard pressure:

(1) a "resolution" over their full scale of 0.1 μm or better; *and*

(2) with a "measurement uncertainty" equal to or less (better) than (0.2 + L/2000) μm (L is the measured length in millimeters); *except* measuring interferometer systems, without closed or open loop feedback, containing a "laser" to measure slide movement errors of machine tools, dimensional inspection machines, or similar equipment;

(2) angular measuring instruments having an "angular position deviation" equal to or less (better) than 0.00025°;

Note: The sub-item (b)(2) of this item does not control optical instruments, such as autocollimators, using collimated light to detect angular displacement of a mirror.

(c) Systems for simultaneously linear-angular inspection of hemishells, having both of the following characteristics:

(1) "measurement uncertainty" along any linear axis equal to or less (better) than 3.5 μm per 5 mm; *and*

(2) "angular position deviation" equal to or less than 0.02°.

Note: Specially designed software for the systems described in paragraph (c) of this item includes software for simultaneous measurements of wall thickness and contour.

Technical Note 1: Machine tools that can be used as measuring machines are controlled if they meet or exceed the criteria specified for the machine tool function or the measuring machine function.

Technical Note 2: A machine described in this section, 1.3., is controlled if it exceeds the control threshold anywhere within its operating range

Technical Note 3: The probe used in determining the measurement uncertainty of a dimensional inspection system shall be as described in VDI/VDE 2617 parts 2, 3, and 4

Technical Note 4: All parameters of measurement values in this item represent plus/minus, i.e., not total band.

"Measurement uncertainty"

The characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95%. It includes the uncorrected systematic deviations, the uncorrected backlash, and the random deviations (Reference: VDI/DE 2617).

"Resolution"

The least increment of a measuring device; on digital instruments, the least significant bit (Reference: ANSI B-89.1.12).

"Linearity"

(Usually measured in terms of nonlinearity) is the maximum deviation of the actual characteristic (average of upscale and downscale readings), positive or negative, from a straight line so positioned as to equalize and minimize the maximum deviations.

"Angular position deviation"

The maximum difference between angular position and the actual, very accurately measured angular position after the workpiece mount of the table has been turned out of its initial position. (Reference: VDI/VDE 2617. Draft: "Rotary table on coordinate measuring machines."

1.4. Vacuum or controlled environment (inert gas) induction furnaces capable of operation above 850°C and having induction coils 600 mm (24 in.) or less in diameter, and power supplies specially designed for induction furnaces with a power supply of 5 kW or more.

Technical Note: This entry does not control furnaces designed for the processing of semiconductor wafers.

1.5. "Isostatic presses" capable of achieving a maximum working pressure of 69 MPa (10,000 psi) or greater and having a chamber cavity with an inside diameter in excess of 152 mm (6 in.) and specially designed dies and molds, and controls and "specially designed software" therefor.

Technical Notes:

(1) The inside chamber dimension is that of the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other.

(2) "Isostatic presses"
Equipment capable of pressurizing a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal pressure in all directions within the cavity upon a workpiece or material.

1.6. "Robots" and "end-effectors" having either of the following characteristics:

(a) Specially designed to comply with national safety standards applicable to handling high explosives (for example, meeting electrical code ratings for high explosives); or

(b) Specially designed or rated as radiation hardened to withstand greater than 5 x 10^4 grays (Si) (5 x 10^6 rad (Si)) without operational degradation;

and specially designed controllers and "specially designed software" therefor.

Technical Notes:

(1) "Robot"
A manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use "sensors," and has all of the following characteristics:
(a) is multifunctional;
(b) is capable of positioning or orienting material, parts, tools, or special devices through variable movements in three-dimensional space;
(c) incorporates three or more closed or open loop servo-devices which may include stepping motors; *and*
(d) has "user-accessible programmability" by means of teach/playback method or by means of an electronic computer which may be a programmable logic controlled, i.e., without mechanical intervention.

N.B.:
The above definition does not include the following devices:
(a) Manipulation mechanisms which are only manually/teleoperator controllable;
(b) Fixed sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic, or electrical means;
(c) Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed, but adjustable, stops such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed program pattern. Variations or modifications of the program pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;
(d) Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is variable but the sequence proceeds

only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;

(e) Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.

(2) "End-effectors"
"End-effectors" include grippers, "active tooling units," and any other tooling that is attached to the baseplate on the end of a "robot" manipulator arm.

(3) The definition in (a) above is not designed to control robots specially designed for nonnuclear industrial applications such as automobile paint-spraying booths.

1.7. Vibration test equipment using digital control techniques and feedback or closed loop test equipment and software therefor capable of vibrating a system at 10 g RMS or more between 20 Hz and 2000 Hz, imparting forces of 50 kN (11,250 lbs) or greater.

1.8. Vacuum and controlled atmosphere metallurgical melting and casting furnaces as follows; and specially configured computer control and monitoring systems and "specially designed software" therefor:

(a) Arc remelt and casting furnaces with consumable electrode capacities between 1000 cm^3 and 20,000 cm^3 and capable of operating with melting temperatures above 1700°C,

(b) Electron beam melting and plasma atomization and melting furnaces with a power of 50 kW or greater and capable of operating with melting temperatures above 1200°C.

2. MATERIALS

2.1. **Aluminum alloys capable of an ultimate tensile strength of 460 MPa (0.46 x 10^9 N/m^2) or more at 293 K (20°C), in the form of tubes or solid forms (including forgings) with an outside diameter of more than 75 mm (3 in.).**

Technical Note: The phrase "capable of" encompasses aluminum alloys before or after heat treatment.

2.2. **Beryllium as follows: metal, alloys containing more than 50% of beryllium by weight, compounds containing beryllium, and manufactures thereof, *except*:**

(a) *Metal windows for X-ray machines;*

(b) *Oxide shapes in fabricated or semi-fabricated forms specially designed for electronic component parts or as substrates for electronic circuits.*

Technical Note: This control applies to waste and scrap containing beryllium as defined here.

2.3. **High-purity (99.99% or greater) bismuth with very low silver content (less than 10 parts per million).**

2.4. **Boron and boron compounds, mixtures, and loaded materials in which the boron-10 isotope is more than 20% by weight of the total boron content.**

2.5. **Calcium (high purity) containing both less than 1000 parts per million by weight of metallic impurities other than magnesium and less than 10 parts per million of boron.**

2.6. **Chlorine Trifluoride (ClF_3).**

2.7. **Crucibles made of materials resistant to liquid actinide metals, as follows:**

(a) **Crucibles with a volume of between 150 mℓ and 8 liters and made of or coated with any of the following materials having a purity of 98% or greater:**
- (i) **Calcium fluoride (CaF_2),**
- (ii) **Calcium zirconate (metazirconate) (Ca_2ZrO_3)**
- (iii) **Cerium sulfide (Ce_2S_3)**
- (iv) **Erbium oxide (erbia) (Er_2O_3),**
- (v) **Hafnium oxide (hafnia) (HfO_2),**
- (vi) **Magnesium oxide (MgO),**

(vii) Nitrided niobium-titanium-tungsten alloy (approximately 50% Nb, 30%Ti, 20%W)

(viii) Yttrium oxide (yttria) (Y_2O_3)

(ix) Zirconium oxide (zirconia) (ZrO_2)

(b) Crucibles with a volume of between 50 mℓ and 2 liters and made of or lined with tantalum, having a purity of 99.9% or greater.

(c) Crucibles with a volume of between 50 mℓ and 2 liters and made of or lined with tantalum (having a purity of 98% or greater) coated with tantalum carbide, nitride, or boride (or any combination of these).

2.8. (a) Carbon or aramid "fibrous and filamentary" materials having a "specific modulus" of 12.7 x 10^6 m or greater or a "specific tensile strength" of 23.5 x 10^4 m or greater; or

(b) Glass "fibrous and filamentary" materials having a "specific modulus" of 3.18 x 10^6 m or greater and a "specific tensile strength" of 7.62 x 10^4 m or greater.

(c) Composite structures in the form of tubes with an inside diameter of between 75 mm (3 in.) and 400 mm (16 in.) made with "fibrous and filamentary" materials controlled in (a) above.

Technical Note:

(a) The term "fibrous and filamentary materials" includes continuous monofilaments, continuous yarns, and tapes.

(b) "Specific modulus" is the Young's modulus in N/m^2 divided by the specific weight in N/m^3 when measured at a temperature of 23 ± 2°C and a relative humidity of 50 ± 5%;

(c) "Specific tensile strength" is the ultimate tensile strength in N/m^2 divided by the specific weight in N/m^3 when measured at a temperature of 23 ± 2°C and a relative humidity of 50 ± 5%.

2.9. Hafnium of the following description: metal, alloys, and compounds of hafnium containing more than 60% hafnium by weight and manufactures thereof.

2.10. Lithium (isotopically enriched in lithium-6) as follows:

(a) Metal hydrides or alloys containing lithium enriched in the 6 isotope (^6Li) to a concentration higher than the one existing in nature (7.5% on an atom percentage basis);

(b) Any other materials containing lithium enriched in the 6 isotope (including compounds, mixtures, and concentrates), ***except ^6Li incorporated in thermoluminescent dosimeters.***

2.11. **Magnesium (high purity) containing both less than 200 parts per million by weight of metallic impurities other than calcium and less than 10 parts per million of boron.**

2.12. **Maraging steel capable of an ultimate tensile strength of 2050 MPa (2.050 x 10^9 N/m^2) (300,000 lb/in.^{2}) or more at 293 K (20°C)** ***except forms in which no linear dimension exceeds 75 mm.***

Technical Note: The phrase "capable of" encompasses maraging steel before or after heat treatment.

2.13. **Radium-226** ***except radium contained in medical applicators.***

2.14. **Titanium alloys capable of an ultimate tensile strength of 900 MPa (0.9 x 10^9 N/m^2) (130,500 lb/in.^{2}) or more at 293 K (20°C) in the form of tubes or solid forms (including forgings) with an outside diameter of more than 75 mm (3 in.).**

Technical Note: The phrase "capable of" encompasses titanium alloys before or after heat treatment.

2.15. **Tungsten, as follows: parts made of tungsten, tungsten carbide, or tungsten alloys (greater than 90% tungsten) having a mass greater than 20 kg and a hollow cylindrical symmetry (including cylinder segments) with an inside diameter greater than 100 mm (4 in.) but less than 300 mm (12 in.),** ***except parts specifically designed for use as weights or gamma-ray collimators.***

2.16. **Zirconium as follows: metal, alloys containing more than 50% zirconium by weight, and compounds in which the ratio of hafnium content to zirconium content is less than 1 part to 500 parts by weight, and manufactures wholly thereof;** ***except zirconium in the form of foil having a thickness not exceeding 0.10 mm (0.004 in.).***

Technical Note: This control applies to waste and scrap containing zirconium as defined here.

3. URANIUM ISOTOPE SEPARATION EQUIPMENT AND COMPONENTS

3.1. Electrolytic cells for fluorine production with a production capacity greater than 250 g of fluorine per hour.

3.2. Rotor fabrication and assembly equipment and bellows-forming mandrels and dies, as follows:

(a) Rotor assembly equipment for assembly of gas centrifuge rotor tube sections, baffles, and end caps. Such equipment includes precision mandrels, clamps, and shrink fit machines.

(b) Rotor straightening equipment for alignment of gas centrifuge rotor tube sections to a common axis. (Note: Normally such equipment will consist of precision measuring probes linked to a computer that subsequently controls the action of, for example, pneumatic rams used for aligning the rotor tube sections.)

(c) Bellows-forming mandrels and dies for producing single-convolution bellows (bellows made of high-strength aluminum alloys, maraging steel, or high-strength filamentary materials). The bellows have all of the following dimensions:

(1) 75-mm to 400-mm (3-in. to 16-in.) inside diameter;
(2) 12.7 mm (0.5 in.) or more in length; and
(3) single convolution depth more than 2 mm (0.08 in.).

3.3. Centrifugal multiplane balancing machines, fixed or portable, horizontal or vertical, as follows:

(a) Centrifugal balancing machines designed for balancing flexible rotors having a length of 600 mm or more and having all of the following characteristics:
(1) a swing or journal diameter of 75 mm or more;
(2) mass capability of from 0.9 to 23 kg (2 to 50 lb.); and
(3) capable of balancing speed of revolution more than 5000 rpm;

(b) Centrifugal balancing machines designed for balancing hollow cylindrical rotor components and having all of the following characteristics:
(1) a journal diameter of 75 mm or more;
(2) mass capability of from 0.9 to 23 kg (2 to 50 lb.);
(3) capable of balancing to a residual imbalance of 0.010 kg-mm/kg per plane or better; and
(4) belt drive type;

and "specially designed software" therefor.

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3.4. Filament winding machines in which the motions for positioning, wrapping, and winding fibers are coordinated and programmed in two or more axes, specially designed to fabricate composite structures or laminates from fibrous and filamentary materials and capable of winding cylindrical rotors of diameter between 75 mm (3 in.) and 400 mm (16 in.) and lengths of 600 mm (24 in.) or greater; coordinating and programming controls therefor; precision mandrels; and "specially designed software" therefor.

3.5. Frequency changers (also known as converters or inverters) or generators having all of the following characteristics:

(a) A multiphase output capable of providing a power of 40 W or more;

(b) Capable of operating in the frequency range between 600 and 2000 Hz;

(c) Total harmonic distortion below 10%; and

(d) Frequency control better than 0.1%.

except such frequency changers specially designed or prepared to supply "motor stators" (as defined below) and having the characteristics listed in (b) and (d) above, together with a total harmonic distortion of less than 2% and an efficiency of greater than 80%.

<u>Definition</u>:

"Motor stators": specially designed or prepared ring-shaped stators for high-speed multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuuum in the frequency range of 600-2000 Hz and a power range of 50-1000 VA. The stators consist of multiphase windings on a laminated low-loss iron core comprising thin layers typically 2.0 mm (008 in.) thick or less.

3.6. Lasers, laser amplifiers, and oscillators as follows:

(a) Copper vapor lasers with 40 W or greater average output power operating at wavelengths between 500 nm and 600 nm;

(b) Argon ion lasers with greater than 40 W average output power operating at wavelengths between 400 nm and 515 nm;

(c) Neodymium-doped (other than glass) lasers as follows:

(1) having an output wavelength between 1000 nm and 1100 nm, being pulse-excited and Q-switched with a pulse duration equal to or greater than 1 ns, and having either of the following:
(a) A single-transverse mode output having an average output power exceeding 40 W;
(b) A multiple-transverse mode output having an average output power exceeding 50 W;

(2) operating at a wavelength between 1000 nm and 1100 nm and incorporating frequency doubling giving an output wavelength between 500 nm and 550 nm with an average power at the doubled frequency (new wavelength) of greater than 40 W;

(d) Tunable pulsed single-mode dye oscillators capable of an average power output of greater than 1 W, a repetition rate greater than 1 kHz, a pulse less than 100 ns, and a wavelength between 300 nm and 800 nm;

(e) Tunable pulsed dye laser amplifiers and oscillators, *except single mode oscillators*, with an average power output of greater than 30 W, a repetition rate greater than 1 kHz, a pulse width less than 100 ns, and a wavelength between 300 nm and 800 nm;

(f) Alexandrite lasers with a bandwidth of 0.005 nm or less, a repetition rate of greater than 125 Hz, and an average power output greater than 30 W operating at wavelengths between 720 nm and 800 nm;

(g) Pulsed carbon dioxide lasers with a repetition rate greater than 250 Hz, an average power output of greater than 500 W, and a pulse of less than 200 ns operating at wavelengths between 9000 nm and 11,000 nm;

N.B. This specification is not intended to control the higher power (typically 1 to 5 kW) industrial CO_2 lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width more than 200 ns.

(h) Pulsed excimer lasers (XeF, XeCl, KrF) with a repetition rate greater than 250 Hz and an average power output of greater than 500 W operating at wavelengths of bedtween 240 and 360 nm;

(i) Para-hydrogen Raman shifters designed to operate at 16 μm output wavelength and at a repetition rate greater than 250 Hz.

Technical Note: Machine tools, measuring devices, and associated technology that have the potential for use in the nuclear industry are controlled under items 1.2 and 1.3 of this list.

3.7. Mass spectrometers capable of measuring ions of 230 atomic mass units or greater and having a resolution of better than 2 parts in 230, and ion sources therefor as follows:

(a) Inductively coupled plasma mass spectrometers (ICP/MS);

(b) Glow discharge mass spectrometers (GDMS);

(c) Thermal ionization mass spectrometers (TIMS);

(d) Electron bombardment mass spectrometers which have a source chamber constructed from or lined with or plated with materials resistant to UF_6;

(e) Molecular beam mass spectrometers as follows:
  (1) which have a source chamber constructed from or lined with or plated with stainless steel or molybdenum and have a cold trap capable of cooling to 193 K (-80°C) or less; or
  (2) which have a source chamber constructed from or lined with or plated with materials resistant to UF_6; or

(f) Mass spectrometers equipped with a microfluorination ion source designed for use with actinides or actinide fluorides;

except

specially designed or prepared magnetic or quadrupole mass spectrometers capable of taking "on-line" samples of feed, product, or tails from UF_6 gas streams and having all of the following characteristics:
  (1) Unit resolution for mass greater than 320;
  (2) Ion sources constructed of or lined with nichrome or monel or nickel-plated;
  (3) Electron bombardment ionization sources;
  (4) Having a collector system suitable for isotopic analysis.

3.8. Instruments capable of measuring pressures up to 13 kPa (2 psi, 100 torr) to an accuracy of better than 1% (full-scale), with corrosion-resistant pressure-sensing elements constructed of nickel, nickel alloys, phosphor bronze, stainless steel, aluminum, or aluminum alloys.

3.9. Valves 5 mm (0.2 in.) or greater in diameter, with a bellows seal, wholly made of or lined with aluminum, aluminum alloy, nickel, or alloy containing 60% or more nickel, either manually or automatically operated.

3.10. Superconducting solenoidal electromagnets with all of the following characteristics:

(a) capable of creating magnetic fields of more than 2 teslas (20 kilogauss);

(b) with an L/D (length divided by inner diameter) greater than 2;

(c) with an inner diameter of more than 300 mm; and

(d) with a magnetic field uniform to better than 1% over the central 50% of the inner volume.

<u>Note:</u>

The item does not cover magnets specially designed for and exported as parts of medical nuclear magnetic resonance (NMR) imaging systems. It is understood that the wording "as part of" does not necessarily mean physical part in the same shipment. Separate shipments from different sources are allowed, provided the related export documents clearly specify the "part of" relationship.

3.11. Vacuum pumps with an input throat size of 38 cm (15 in.) or greater with a pumping speed of 15,000 liters/second or greater and capable of producing an ultimate vacuum better than 10^{-4} Torr (0.76×10^{-4} mbar).

Technical Note: The ultimate vacuum is determined at the input of the pump with the input of the pump blocked off.

3.12. Direct current high-power supplies capable of continuously producing, over a time period of 8 hours, 100 V or greater with current output of 500 amps or greater and with current or voltage regulation better than 0.1%.

3.13. High-voltage direct current power supplies capable of continuously producing, over a time period of 8 hours, 20,000 V or greater with current output of 1 amp or greater and with current or voltage regulation better than 0.1% .

3.14. Electromagnetic isotope separators, designed for or equipped with, single or multiple ion sources capable of providing a total ion beam current of 50 mA or greater.

Notes:

1. This entry will control separators capable of enriching stable isotopes as well as those for uranium. A separator capable of separating the isotopes of lead with a one-mass unit difference is inherently capable of enriching the isotopes of uranium with a three-unit mass difference.
2. This entry includes separators with the ion sources and collectors both in the magnetic field and those configurations in which they are external to the field.
3. A single 50-mA ion source will produce less than 3 g of separated HEU per year from natural abundance feed.

4. HEAVY WATER PRODUCTION PLANT RELATED EQUIPMENT
(Other Than Trigger List Items)

4.1. Specialized packings for use in separating heavy water from ordinary water and made of phosphor bronze mesh or copper (both chemically treated to improve wettability) and designed for use in vacuum distillation towers.

4.2. Pumps circulating solutions of diluted or concentrated potassium amide catalyst in liquid ammonia (KNH_2/NH_3), with all of the following characteristics:

(a) airtight (i.e., hermetically sealed);

(b) for <u>concentrated</u> potassium amide solutions (1% or greater), operating pressure of 1.5-60 MPa [15-600 atmospheres (atm)]; for <u>dilute</u> potassium amide solutions (less than 1%), operating pressure of 20-60 MPa (200-600 atm); *and*

(c) a capacity greater than 8.5 m^3/h (5 cubic feet per minute).

4.3. Water-hydrogen sulfide exchange tray columns constructed from fine carbon steel (such as ASTM A516) with a diameter of 1.8 m (6 ft.) or greater to operate at a nominal pressure of 2 MPa (300 psi) or greater, except columns which are specially designed or prepared for the production of heavy water. Internal contactors of the columns are segmented trays with an effective assembled diameter of 1.8 m (6 ft.) or greater, such as sieve trays, valve trays, bubble cap trays, and turbogrid trays designed to facilitate countercurrent contacting and constructed of materials resistant to corrosion by hydrogen sulfide/water mixtures, such as 304L or 316 stainless steel.

4.4. Hydrogen-cryogenic distillation columns having all of the following applications:

(a) designed to operate with internal temperatures of -238°C (35 K) or less;

(b) designed to operate at internal pressure of 0.5 to 5 MPa (5 to 50 atmospheres);

(c) constructed of fine-grain stainless steels of the 300 series with low sulfur content or equivalent cryogenic and H_2-compatible materials; and

(d) with internal diameters of 1 m or greater and effective lengths of 5 m or greater.

45. Ammonia synthesis convertors, ammonia synthesis units in which the synthesis gas (nitrogen and hydrogen) is withdrawn from an ammonia/hydrogen high-pressue exchange column and the synthesized ammonia is returned to said column.

5. IMPLOSION SYSTEMS DEVELOPMENT EQUIPMENT

5.1. **Flash x-ray generators or pulsed electron accelerators with peak energy of 500 keV or greater, as follows,** ***except accelerators that are component parts of devices designed for purposes other than electron beam or x-ray radiation (electron microscopy, for example) and those designed for medical purposes:***

(a) **Having an accelerator peak electron energy of 500 keV or greater but less than 25 MeV and with a figure of merit (K) of 0.25 or greater, where K is defined as:**

$$K = 1.7 \times 10^{3} V^{2.65} Q \ ,$$

where V is the peak electron energy in million electron volts and Q is the total accelerated charge in coulombs if the accelerator beam pulse duration is less than or equal to 1 μs; if the accelerator beam pulse duration is greater than 1 μs, Q is the maximum accelerated charge in 1 μs [Q equals the integral of i with respect to t, over the lesser of 1 μs or the time duration of the beam pulse ($Q = \int i dt$), where i is beam current in amperes and t is time in seconds] ***or,***

(b) **Having an accelerator peak electron energy of 25 MeV or greater and a peak power greater than 50 MW. [Peak power = (peak potential in volts) x (peak beam current in amperes).]**

Technical Note:

Time duration of the beam pulse — In machines, based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1 μs or the duration of the bunched beam packet resulting from one microwave modulator pulse.

Peak beam current — In machines based on microwave accelerating cavities, the peak beam current is the average current in the time duration of a bunched beam packet.

5.2. **Multistage light gas guns or other high-velocity gun systems (coil, electromagnetic, electrothermal, or other advanced systems) capable of accelerating projectiles to 2 km per second or greater.**

5.3. **Mechanical rotating mirror cameras**

Mechanical framing cameras with recording rates greater than 225,000 frames per second; streak cameras with writing speeds greater than 0.5 mm per microsecond; and parts, including specially designed synchronizing electronics and specially designed rotor assemblies (consisting of turbines, mirrors, and bearings).

5.4. Electronic streak and framing cameras and tubes as follows:

(a) Electronic streak cameras capable of 50 ns or less time resolution and streak tubes therefor;

(b) Electronic (or electronically shuttered) framing cameras capable of 50 ns or less frame exposure time;

(c) Framing tubes and solid-state imaging devices for use with cameras controlled in sub-item (b) above, as follows:

(1) proximity focused image intensifier tubes having the photocathode deposited on a transparent conductive coating to decrease photocathode sheet resistance;
(2) gate silicon intensifier target (SIT) vidicon tubes, where a fast system allows gating the photoelectrons from the photocathode before they impinge on the SIT plate;
(3) Kerr or pockel cell electro-optical shuttering; or
(4) Other framing tubes and solid-state imaging devices having a fast-image gating time of less than 50 ns specially designed for cameras controlled by sub-item (b) above.

5.5. Specialized instrumentation for hydrodynamic experiments as follows:

(a) Velocity interferometers for measuring velocities in excess of 1 km per second during time intervals less than 10 μs. (VISARs, Doppler laser interferometers, DLIs, etc.);

(b) manganin gauges for pressures greater than 100 kilobars; or

(c) quartz pressure transducers for pressures greater than 100 kilobars.

6. EXPLOSIVES AND RELATED EQUIPMENT

6.1. Detonators and multipoint initiation systems (exploding bridge wire, slapper, etc.)

(a) Electrically driven explosive detonators as follows:

(1) exploding bridge (EB);
(2) exploding bridge wire (EBW);
(3) slapper; and
(4) exploding foil initiators (EFI).

(b) Arrangements using single or multiple detonators designed to nearly simultaneously initiate an explosive surface (over greater than 5000 mm^2) from a single firing signal (with an initiation timing spread over the surface of less than 2.5 μs).

Description clarification: The detonators of concern all utilize a small electrical conductor (bridge, bridge wire, or foil) that explosively vaporizes when a fast, high-current electrical pulse is passed through it. In nonslapper types, the exploding conductor starts a chemical detonation in a contacting high-explosive material such as PETN (pentaerythritoltetranitrate). In slapper detonators, the explosive vaporization of the electrical conductor drives a "flyer" or "slapper" across a gap, and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by magnetic force. The term "exploding foil" detonator may refer to either an EB or a slapper-type detonator. Also, the word "initiator" is sometimes used in place of the word "detonator."

Detonators using only primary explosives, such as lead azide, are not subject to control.

6.2. Electronic components for firing sets (switching devices and pulse discharge capacitors)

6.2.1. Switching devices

(a) Cold-cathode tubes (including gas krytron tubes and vacuum sprytron tubes), whether gas filled or not, operating similarly to a spark gap, containing three or more electrodes, and having all of the following characteristics:

(1) Anode peak voltage rating of 2500 V or more,
(2) Anode peak current rating of 100 A or more,
(3) Anode delay time of 10 μs or less, and

(b) Triggered spark-gaps having an anode delay time of 15 μs or less and rated for a peak current of 500 A or more;

(c) Modules or assemblies with a fast switching function having all of the following characteristics:

(1) Anode peak voltage rating greater than 2000 V;
(2) anode peak current rating of 500 A or more; and
(3) turn-on time of 1 μs or less.

6.2.2. Capacitors with the following characteristics:

(a) Voltage rating greater than 1.4 kV, energy storage greater than 10 J, capacitance greater than 0.5 μF, and series inductance less than 50 nH, *or*

(b) Voltage rating greater than 750 V, capacitance greater than 0.25 μF, and series inductance less than 10 nH.

6.3. Firing sets and equivalent high-current pulse generators (for controlled detonators), as follows:

(a) Explosive detonator firing sets designed to drive multiple controlled detonators covered under item 6.1. above;

(b) Modular electrical pulse generators (pulsers) designed for portable, mobile, or ruggedized use (including xenon flash-lamp drivers) having all the following characteristics:

(1) capable of delivering their energy in less than 15 μs;

(2) having an output greater than 100 A;

(3) having a rise time of less than 10 μs into loads of less than 40 ohms. (Rise time is defined as the time interval from 10% to 90% current amplitude when driving a resistive load);

(4) enclosed in a dust-tight enclosure;

(5) no dimension greater than 25.4 cm (10 in.);

(6) weight less than 25 kg (55 lb.); and

(7) specified for use over an extended temperature range (-50°C to 100°C) or specified as suitable for aerospace use.

6.4. High explosives or substances or mixtures containing more than 2% of any of the following:

(a) Cyclotetramethylenetetranitramine (HMX);

(b) Cyclotrimethylenetrinitramine (RDX);

(c) Triaminotrinitrobenzene (TATB);

(d) **Any explosive with a crystal density greater than 1.8 g/cm³ and having a detonation velocity greater than 8000 m/s; or**

(e) **Hexanitrostilbene (HNS).**

7. NUCLEAR TESTING EQUIPMENT AND COMPONENTS

7.1 **Oscilloscopes and transient recorders and specially designed components as follows: plug-in units, external amplifiers, pre-amplifiers, sampling devices, and cathode ray tubes for analog oscilloscopes.**

(a) **Non-modular analog oscilloscopes having a "bandwidth" of 1 GHz or greater;**

(b) **Modular analog oscilloscope systems having either of the following characteristics:**

(i) **a mainframe with a "bandwidth" of 1 GHz or greater; or**

(ii) **Plug-in modules with an individual "bandwidth" of 4 GHz or greater;**

(c) **Analog sampling oscilloscopes for the analysis of recurring phenomena with an effective "bandwidth" greater than 4 GHz;**

(d) **Digital oscilloscopes and transient recorders, using analog-to-digital conversion techniques, capable of storing transients by sequentially sampling single-shot inputs at successive intervals of less than 1 ns (greater than 1 giga-sample per second), digitizing to 8 bits or greater resolution and storing 256 or more samples.**

Technical Note: "Bandwidth" is defined as the band of frequencies over which the deflection on the cathode ray tube does not fall below 70.7% of that at the maximum point measured with a constant input voltage to the oscilloscope amplifier.

7.2. **Photomultiplier tubes with a photocathode area of greater than 20 cm^2 having an anode pulse rise time of less than 1 ns.**

7.3. **High-speed pulse generators with output voltages greater than 6 V into a less than 55-ohm resistive load, and with pulse transition times less than 500 ps (defined as the time interval between 10% and 90% voltage amplitude).**

8. OTHER

8.1. Neutron generator systems, including tubes, designed for operation without an external vacuum system and utilizing electrostatic acceleration to induce a tritium-deuterium nuclear reaction.

8.2. Equipment related to nuclear material handling and processing and to nuclear reactors as follows:

8.2.1. Remote manipulators that provide mechanical translation of human operator actions by electrical, hydraulic, or mechanical means to an operating arm and terminal fixture that can be used to provide remote actions in radiochemical separation operations and "hot cells." The manipulators have a capability to penetrate 0.6 m or more (2 ft. or more) of cell wall or, alternatively, bridge over the top of a cell wall with a thickness of 0.6 m or more (2 ft. or more);

8.2.2. High-density (lead glass or other) radiation shielding windows greater than 0.3 m (1 ft.) on a side and with a density greater than 3 g/cm^3 and a thickness of 100 mm or greater; and specially designed frames therefor;

8.2.3. Radiation-hardened TV cameras specially designed or rated as radiation hardened to withstand greater than 5 x 10^4 grays (Si) (5 x 10^6 rad (Si)) without operational degradation and specially designed lenses used therein.

8.3. Tritium, tritium compounds, and mixtures containing tritium in which the ratio of tritium to hydrogen by atoms exceeds 1 part in 1000 *except a product or device containing not more than 40 Ci of tritium in any chemical or physical form.*

8.4. Facilities or plants for the production, recovery, extraction, concentration, or handling of tritium, and equipment as follows:

(a) Hydrogen or helium refrigeration units capable of cooling to -250°C (23 K) or less, with heat removal capacity greater than 150 watts or

(b) Hydrogen isotope storage and purification systems using metal hydrides as the storage, or purification medium.

8.5. Platinized catalysts specially designed or prepared for promoting the hydrogen isotope exchange reaction between hydrogen and water for the recovery of tritium from heavy water or for the production of heavy water.

8.6. Helium in any form isotopically enriched in the helium-3 isotope, whether or not mixed with other materials or contained in any equipment or device, *except products or devices containing less than 1 g of helium-3.*

8.7. Alpha-emitting radionuclides and equipment containing such radionuclides as follows:

All alpha-emitting radionuclides having an alpha half-life of 10 days or greater but less than 200 years, including compounds and mixtures containing these radionuclides with a total alpha activity of 1 curie per kilogram (37 GBq/kg) or greater ***except for devices containing less than 100 millicuries (3.7 GBq) of alpha activity per device.***

ANNEX APPENDIX: Detailed Specifications for Machine Tools (Item 1.2. in List of Nuclear Dual-Use Export Controls)

1.2. "Numerical control" units, specially designed "motion control boards" for "numerical control" applications on machine tools, "numerically controlled" machine tools, specially designed "software," and technology as follows.

(a) **"Numerical control" units for machine tools, as follows:**

(1) Having more than four interpolating axes that can be coordinated simultaneously for "contouring control" *or*

(2) Having two, three, or four interpolating axes that can be coordinated simultaneously for "contouring control" and one or more of the following conditions are fulfilled:

(i) Capable of "real-time processing" of data to modify the tool path during the machining operation by automatic calculation and modification of "part program" data for machining in two or more axes by means of measuring cycles and access to source data;

(ii) Capable of receiving directly (on-line) and processing computer-aided design (CAD) data for internal preparation of machine instructions; or

(iii) Capable, without modification, according to the manufacturer's technical specifications, of accepting additional boards that would permit increasing the number of interpolating axes that can be coordinated simultaneously for "contouring control," above the control levels, even if they do not contain these additional boards.

(b) **"Motion control boards" specially designed for machine tools having one or more of the following characteristics:**

(1) Providing interpolation in more than four axes;

(2) Capable of "real time processing" described in (a)(2)(i); *or*

(3) Capable of receiving and processing CAD data as described in (a)(2)(ii) above.

> **Note 1:** Subitems (a) and (b) do not control "numerical control" units and "motion control boards" if
>
> (a) Modified for and incorporated in uncontrolled machines; *or*
>
> (b) Specially designed for uncontrolled machines.
>
> **Note 2:** "Software" (including documentation) for "numerical control" units that may be exported must be:
>
> (a) In machine executable form only; and
>
> (b) Limited to the minimum necessary for the use (i.e., installation, operation, and maintenance) of these units.

(c) **Machine tools, as follows, for removing or cutting metals, ceramics, or composites, which, according to the manufacturer's technical specifications, can be equipped with electronic devices for simultaneous "contouring control" in two or more axes:**

<u>Technical Note:</u>

1. The c-axis on jig grinders used to maintain grinding wheels normal to the work surfaces is not considered a contouring rotary axis.
2. Not counted in the total number of contouring axes are secondary parallel contouring axes, e.g., a secondary rotary axis, the center line of which is parallel to the primary rotary axis.
3. Axis nomenclature shall be in accordance with International Standard-ISO 841, "Numerical Control Machines Axis and Motion Nomenclature."
4. Rotary axes do not necessarily have to rotate over 360°. A rotary axis can be driven by a linear device, e.g., a screw or a rack-and-pinion.

(1) **Machine tools for turning, grinding, milling, or any combination thereof that:**
- (i) Have two or more axes that can be coordinated simultaneously for "contouring control"; *and*
- (ii) Have any of the following characteristics:
  - (A) Two or more contouring rotary axes;
  - (B) One or more contouring "tilting spindles";

    <u>Note:</u> (c)(1)(ii)(B) applies to machine tools for grinding or milling only.

  - (C) "Camming" (axial displacement) in one revolution of the spindle less (better) than 0.0006 mm total indicator reading (TIR);

    <u>Note:</u> (c)(1)(ii)(C) applies to machine tools for turning only.

  - (D) "Run out" (out-of-true running) in one revolution of the spindle less (better) than 0.0006 TIR.
  - (E) The "positioning accuracies," with all compensations available, are less (better) than:
    - (1) 0.001° on any rotary axis
    - (2) (a) 0.004 mm along any linear axis (overall positioning) for grinding machines
      - (b) 0.006 mm along any linear axis (overall positioning) for milling or turning machines

      <u>Note:</u> (c)(1)(ii)(E)(2)(b) does not control milling or turning machine tools with a positioning accuracy along one linear axis, with all compensations available, equal to or greater (worse) than 0.005 mm.

Notes: 1. Sub-item (c) does not control cylindrical external, internal, and external-internal grinding machines having all of the following characteristics:

(a) Not centerless (shoe-type) grinding machines;

(b) Limited to cylindrical grinding;

(c) A maximum workpiece outside diameter or length of 150 mm;

(d) Only two axes that can be coordinated simultaneously for "contouring control"; *and*

(e) No contouring c axis.

(2) Sub-item (c) does not control machines designed specifically as jig grinders having both of the following characteristics:

(a) Axes limited to x, y, c, and a, where the c axis is used to maintain the grinding wheel normal to the work surface, and the a axis is configured to grind barrel cams *and*

(b) A spindle "run-out" not less (not better) than 0.0006 mm.

(3) Sub-item (c) does not control tool or cutter grinding machines having all of the following characteristics:

(a) Shipped as a complete system with "software" specially designed for the production of tools or cutters;

(b) No more than two rotary axes that can be coordinated simultaneously for "contouring control";

(c) "Run-out" (out-of-true running) in one revolution of the spindle not less (not better) than 0.0006 mm TIR; *and*

(d) The "positioning accuracies," with all compensations available, are not less (not better) than:

(i) 0.004 mm along any linear axis for overall positioning; or

(ii) 0.001° for any rotary axis.

(2) **Electrical discharge machines (EDM);**

(i) Of the wire feed type that have five or more axes that can be coordinated simultaneously for "contouring control";

(ii) Non-wire EDMs that have two or more contouring rotary axes and that can be coordinated simultaneously for "contouring control."

(3) Other machine tools for removing metals, ceramics, or composites:
 (i) By means of:
  (A) Water or other liquid jets, including those employing abrasive additives;
  (B) Electron beam; *or*
  (C) "Laser" beam; *and*
 (ii) Having two or more rotary axes that:
  (A) Can be coordinated simultaneously for "contouring control"; *and*
  (B) Have a "positioning accuracy" of less (better) than 0.003°.

(d) "Software"
(1) "Software" specially designed or modified for the "development," "production," or "use" of equipment controlled by sub-categories (a), (b), or (c) above;
(2) Specific "software," as follows:
 (i) "Software" to provide "adaptive control" and having both of the following characteristics:
  (A) For "flexible manufacturing units" (FMUs) that consist at least of equipment described in (b)(1) and (b)(2) of the definition of "flexible manufacturing units"; *and*
  (B) Capable of generating or modifying, in "real time processing," "part program" data by using the signals obtained simultaneously by means of at least two detection techniques, such as:
   (1) Machine vision (optical ranging);
   (2) Infrared imaging;
   (3) Acoustical imaging (acoustical ranging);
   (4) Tactile measurement;
   (5) Inertial positioning;
   (6) Force measurement;
   (7) Torque measurement.

<u>Note:</u> This sub-item does not control "software" that only provides rescheduling of functionally identical equipment within "flexible manufacturing units" using prestored "part programs" and a prestored strategy for the distribution of the "part programs."

 (ii) "Software" for electronic devices other than those described in sub-items (a) or (b) that provides the "numerical control" capability of the equipment controlled in sub-item 1.2.

(e) Technology
(1) "Technology" for the "development" of equipment controlled by sub-items (a), (b), or (c) above, (f) or (g) below, and of the sub-item (d).
(2) "Technology" for the "production" of equipment controlled by sub-items (a), (b), or (c) above, (f) or (g) below;
(3) Other "technology":
 (i) For the "development" of interactive graphics as an integrated part in "numerical control" units for preparation or modification of "part programs";
 (ii) For the "development" of integration "software" for incorporation of expert systems for advanced decision support of shop floor operations into "numerical control" units.

(f) **Components and parts for machine tools controlled by sub-item (c) as follows:**

(1) Spindle assemblies, consisting of spindles and bearings as a minimal assembly, with radial ("run-out") or axial ("camming") axis motion in one revolution of the spindle less (better) than 0.0006 mm TIR;

(2) Linear position feedback units (e.g., inductive-type devices, graduated scales, "laser," or infrared systems) having, with compensation, an overall "accuracy" better than 800 + (600 x L x 10^{-3}) nm , where L equals the effective length in millimeters of the linear measurement; *except* measuring interferometer systems, without closed or open loop feedback, containing a "laser" to measure slide movement errors of machine tools, dimensional inspection machines, or similar equipment;

(3) Rotary position feedback units (e.g., inductive-type devices, graduated scales, "laser," or infrared systems) having, with compensation, an "accuracy" less (better) than 0.00025° of arc; *except* measuring interferometer systems, without closed or open loop feedback, containing a "laser" to measure slide movement errors of machine tools, dimensional inspection machines, or similar equipment;

(4) Slide way assemblies consisting of a minimal assembly of ways, bed, and slide having all of the following characteristics:

(i) A yaw, pitch, or roll of less (better) than 2 seconds of arc TIR (Ref. ISO/DIS 230-1 over full travel);

(ii) A horizontal straightness of less (better) than 2 μm per 300 mm length; *and*

(iii) A vertical straightness of less (better) than 2 μm over full travel per 300 mm length;

(5) Single-point diamond-cutting tool inserts having all of the following characteristics:

(i) A flawless and chip-free cutting edge when magnified 400 times in any direction;

(ii) A cutting radius out-of-roundness less (better) than 0.002 mm TIR (also peak-to-peak); *and*

(iii) A cutting radius between 0.1 and 5.0 mm, inclusive.

(g) **Specially designed components or sub-assemblies, as follows, capable of upgrading, according to the manufacturer's specifications, "numerical control" units, motion control boards, machine tools, or feedback devices to or above the levels controlled in sub-items (a), (b), (c), (f)(2), or (f)(3):**

(1) Printed circuit boards with mounted components and "software" therefor;

(2) "Compound rotary tables."

<u>Technical Note</u>: **Definitions of Terms:**

"accuracy" — Usually measured in terms of inaccuracy, defined as the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

"adaptive control" — a control system that adjusts the response from conditions detected during the operation (Ref. ISO 2806-1980).

"camming" (axial displacement) — Axial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle faceplate at a point next to the circumference of the spindle faceplate (Ref. ISO 230 Part 1-1986, paragraph 5.63).

"compound rotary table" — A table allowing the workpiece to rotate and tilt about two non-parallel axes, which can be coordinated simultaneously for "contouring control."

"contouring control" — Two or more "numerically controlled" motions operating in accordance with instructions that specify the next required position and the required feed rates to that position. These feed rates are varied in relation to each other so that a desired contour is generated (Ref. ISO/DIS 2806-1980).

"digital computer" — Equipment which can, in the form of one or more discrete variables:

a. Accept data;
b. Store data or instructions in fixed or alterable (writable) storage devices;
c. Process data by means of a stored sequence of instructions which is modifiable; and
d. Provide output of data.

N.B.: Modifications of a stored sequence of instructions include replacement of fixed storage devices, but not a physical change in wiring or interconnections.

"flexible manufacturing unit (FMU)" [sometimes also referred to as "flexible manufacturing system" (FMS)" or "flexible manufacturing cell (FMC)"]

An entity which includes a combination of at least:

a. A "digital computer" including its own "main storage" and its own related equipment; and
b. Two or more of the following:
    1. A machine tool described in Section 1.2.;
    2. A dimensional inspection machine described in Section 1.3.;
    3. A "robot" controlled by Section 1.6.;
    4. Digitally controlled equipment controlled by Section 3.4.

"laser" — An assembly of components which produce coherent light that is amplified by stimulated emission of radiation.

"main storage" — The primary storage for data or instructions for rapid access by a central processing unit. It consists of the internal storage of a "digital computer" and any hierarchical extension thereto, such as cache storage or non-sequentially accessed extended storage.

"microprogram" — A sequence of elementary instructions, maintained in a special storage, the execution of which is initiated by the introduction of its reference instruction into an instruction register.

"motion control board" — An electronic assembly specially designed to provide a computer system with the capability to coordinate simultaneously the motion of axes of machine tools for "contouring control."

"numerical control" — The automatic control of a process performed by a device that makes use of numeric data usually introduced as the operation is in progress (Ref. ISO 2382).

"part program" — An ordered set of instructions in a language and in a format required to cause operations to be effected under automatic control, which is either written in the form of a machine program on an input medium or prepared as input data for processing in a computer to obtain a machine program (Ref. ISO 2806-1980).

"positioning accuracy"

Of "numerically controlled" machine tools is to be determined and presented in accordance with paragraph 2.13, in conjunction with the requirements below:

(a) Test conditions (ISO/DIS/230/2, paragraph 3):

(1) For 12 hours before and during measurements, the machine tool and accuracy measuring equipment will be kept at the same ambient temperature. During the premeasurement time, the slides of the machine will be continuously cycled identically to the way they will be cycled during the accuracy measurements;

(2) The machine shall be equipped with any mechanical, electronic, or software compensation to be exported with the machine;

(3) Accuracy of measuring equipment for the measurements shall be at least four times more accurate than the expected machine tool accuracy;

(4) Power supply for slide drives shall be as follows:

(i) Line voltage variation shall not be greater than ±10% of nominal rated voltage;

(ii) Frequency variation shall not be greater than ±2 Hz of normal frequency;

(iii) Lineouts or interrupted service are not permitted.

(b) Test Program (paragraph 4):

(1) Feed rate (velocity of slides) during measurement shall be the rapid traverse rate;

N.B.: In the case of machine tools which generate optical quality surfaces, the feed rate shall be equal to or less than 50 mm per minute;

(2) Measurements shall be made in an incremental manner from one limit of the axis travel to the other without returning to the starting position for each move to the target position;

(3) Axes not being measured shall be retained at mid-travel during test of an axis.

(c) Presentation of test results (paragraph 2):

The results of the measurements must include:

(1) "positioning accuracy" (A) *and*

(2) The mean reversal error (B).

"program" — A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

"real-time processing" — Processing of data by an electronic computer in response to an external event according to time requirements imposed by the external event.

"robot" — A manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use "sensors" and has all the following characteristics:

a. Is multifunctional;

b. Is capable of positioning or orienting material, parts, tools or special devices through variable movements in three-dimensional space;

c. Incorporates three or more closed or open loop servo-devices which may include stepping motors; and
d. Has "user-accessible programmability" by means of teach/playback method or by means of an electronic computer which may be a programmable logic controller, i.e., without mechanical intervention

N.B.: The above definition does not include the following devices:
- a. Manipulation mechanisms which are only manually/teleoperator controllable;
- b. Fixed sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic or electrical means;
- c. Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed, but adjustable, stops, such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed program pattern. Variations or modifications of the program pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;
- d. Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is variable, but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;
- e. Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.

"run out" (out-of-true running) — Radial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle axis at a point on the external or internal revolving surface to be tested (Ref. ISO 230 Part 1-1986, paragraph 5.61).

"sensors" — Detectors of a physical phenomenon, the output of which (after conversion into a signal that can be interpreted by a controller) is able to generate "programs" or modify programmed instructions or numerical program data. This includes "sensors" with machine vision, infrared imaging, acoustical imaging, tactile feel, inertial position measuring, optical or acoustic ranging or force or torque measuring capabilities.

"software" — A collection of one or more "programs" or "microprograms" fixed in any tangible medium of expression.

"tilting spindle" — A tool-holding spindle that, during the machining process, alters the angular position of its center line with respect to any other axis.

"user-accessible programmability"

The facility allowing a user to insert, modify or replace "programs" by means other than:

(a) A physical change in wiring or interconnections; or

(b) The setting of function controls including entry of parameters.
