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*Number 35 of 2003*

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**CONTAINMENT OF NUCLEAR WEAPONS ACT 2003**

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ARRANGEMENT OF SECTIONS

PART 1

PRELIMINARY

Section

1. Short title and commencement.
2. Interpretation.

PART 2

NUCLEAR ACTIVITIES, EQUIPMENT AND MATERIAL

3. Production, use, etc., of equipment, material, etc., prohibited unless authorised.

PART 3

INSPECTION AND ENFORCEMENT

4. Designation of National Authority.
5. International inspectors.
6. Authorised officers.
7. Inspections.
8. Members of Garda Síochána to have powers of authorised officers in certain circumstances.

PART 4

MISCELLANEOUS

9. Information and documents.
10. Disclosure of information.
11. Privileged information and evidence.

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

Section

12. Giving of false or misleading information.
13. Regulations.
14. Offences and penalties.
15. Forfeiture.
16. Prosecution of summary offences.
17. Expenses of Minister.

SCHEDULE

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ACT REFERRED TO

Radiological Protection Act 1991

1991, No. 9



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Number 35 of 2003

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**CONTAINMENT OF NUCLEAR WEAPONS ACT 2003**

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AN ACT TO IMPLEMENT THE STATE'S OBLIGATIONS UNDER THE PROTOCOL, DONE AT VIENNA ON 22 SEPTEMBER 1998, ADDITIONAL TO THE AGREEMENT, DONE AT BRUSSELS ON 5 APRIL 1973, BETWEEN NON-NUCLEAR WEAPONS STATES OF THE EUROPEAN ATOMIC ENERGY COMMUNITY, THE EUROPEAN ATOMIC ENERGY COMMUNITY AND THE INTERNATIONAL ATOMIC ENERGY AGENCY IN IMPLEMENTATION OF ARTICLE III(1) AND (4) OF THE TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS, WHICH SAID TREATY WAS DONE AT LONDON, MOSCOW AND WASHINGTON ON 1 JULY 1968 AND TO PROVIDE FOR RELATED MATTERS.

[17th November, 2003]

BE IT ENACTED BY THE OIREACHTAS AS FOLLOWS:

PART 1

PRELIMINARY

**1.**—(1) This Act may be cited as the Containment of Nuclear Weapons Act 2003. Short title and commencement.

(2) This Act comes into operation on such day as the Minister by order appoints.

**2.**—(1) In this Act, unless the context otherwise requires— Interpretation.

“this Act” includes regulations made under *section 13*;

“Agency” means the International Atomic Energy Agency;

“authorised officer” means—

(a) an officer of the National Authority appointed under *section 6(1)* to be an authorised officer, or

(b) an international inspector;

“function” includes power and duty;

“international inspector” means a person who holds a certificate issued under *section 5(1)*;

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

Pt.1 S.2

“Minister” means the Minister for the Environment, Heritage and Local Government;

“National Authority” means the Radiological Protection Institute of Ireland, or any other authority designated by regulations made under *section 13* to be the National Authority in place of that Institute;

“place” includes any means of transport and any building or structure on land, including land covered by water;

“prescribed” means prescribed by regulations made under *section 13*;

“the Protocol” means the Protocol done at Vienna on 22 September 1998, additional to the Agreement between Non-Nuclear Weapons States of the European Atomic Energy Community, the European Atomic Energy Community and the International Atomic Energy Agency in implementation of Article III(1) and (4) of the Treaty on the Non-Proliferation of Nuclear Weapons, which, for convenience of reference, is set out in the English language, in the *Schedule* to this Act;

“thing” includes any equipment, material or substance relevant to the information to be provided in Article 2 or Annex III of the Protocol or listed in Annex I or II.

(2) Unless the context otherwise requires, all words and expressions used in this Act have the same meaning as in the Protocol.

(3) In this Act—

(a) a reference to a section is a reference to a section of this Act, unless it is indicated that reference to some other enactment is intended,

(b) a reference to a subsection, paragraph or subparagraph is a reference to the subsection, paragraph or subparagraph of the provision in which the reference occurs, unless it is indicated that a reference to some other provision is intended, and

(c) a reference to an Annex by number is a reference to the Annex so numbered, to the Protocol.

PART 2

NUCLEAR ACTIVITIES, EQUIPMENT AND MATERIAL

Production, use, etc., of equipment, material, etc., prohibited unless authorised.

**3.—**(1) Except as authorised by regulations made under *section 13*, a person shall not—

(a) engage in an activity listed in Annex I or relevant to the information to be provided in Article 2 of the Protocol, or

(b) produce, use, acquire, transfer or process any equipment or material listed in Annex I or II.

(2) A person who contravenes *subsection (1)* is guilty of an offence and is liable—

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

- (a) on summary conviction, to a fine not exceeding €3,000, or to imprisonment for a term not exceeding 6 months, or both, or
- (b) on conviction on indictment, to a fine not exceeding €500,000, or to imprisonment for a term not exceeding 4 years, or both.

Pt.2 S.3

PART 3

INSPECTION AND ENFORCEMENT

4.—(1) The Radiological Protection Institute of Ireland is the designated National Authority for the purpose of carrying out the State's obligations under the Protocol.

Designation of  
National Authority.

(2) The Radiological Protection Institute of Ireland has such powers as are necessary to enable it to perform its function as the National Authority under this Act.

5.—(1) The National Authority or the Minister for Enterprise, Trade and Employment may issue to any person who is a member of an inspection team of the Agency that has been authorised under the Protocol to conduct on behalf of the Agency inspections in the State under Articles 4 to 9 of the Protocol, a certificate—

International  
inspectors.

- (a) identifying the person by name and indicating the person's status and authority to conduct inspections in the State,
- (b) specifying any prescribed privileges and immunities applicable to the person, and
- (c) setting out such other information and any conditions (including restrictions) applicable to the person's inspection activities in the State as the National Authority or the Minister for Enterprise, Trade and Employment, as the case may be, considers appropriate.

(2) Subject to such conditions, if any, as are applicable to the person's inspection activities in the State set out in the certificate, an international inspector has all the powers of an authorised officer.

(3) An international inspector shall, on the request of a person in charge of a place to be inspected by the international inspector, show the certificate to that person.

6.—(1) The National Authority or the Minister for Enterprise, Trade and Employment may appoint such and so many officers of the Authority or the Minister as the National Authority or the Minister, as the case may be, thinks fit, to be authorised officers for the purposes of this Act.

Authorised officers.

(2) The National Authority or the Minister for Enterprise, Trade and Employment, as the case may be, shall issue to every such authorised officer a warrant of the officer's appointment and, when exercising a power conferred on an authorised officer under this Act the officer shall, on being so requested by a person affected, show the warrant to that person.

7.—(1) An authorised officer may, for the purposes of ensuring that this Act is being complied with—

Inspections.

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

Pt.3 S.7

- (a) at any reasonable time and consistent with the provisions of the Protocol, enter any place (with reasonable force if necessary, provided it is authorised by a warrant under *subsection (5)*)—
  - (i) in respect of which under *section 9* information has been or is required to be provided, or
  - (ii) in, at or on which there are reasonable grounds to believe an offence against this Act has been or is being committed,
- (b) inspect the place,
- (c) request any person in, at or on the place to give to the authorised officer access to any area, or thing in, at or on the place,
- (d) secure under a warrant under *subsection (5)*, for later inspection, any such place or area, or any thing in, at or on the place,
- (e) examine any thing in, at or on the place,
- (f) request any person in charge of or employed in, at or on the place to produce to the authorised officer such information contained in the records, files, papers or electronic information systems kept in, at or on, or used in relation to, the place and, in the case of such information in a non-legible form, to reproduce it in a legible form,
- (g) inspect and take copies of or extracts from any such records, files, papers or electronic information systems in, at or on the place, including in the case of information in a non-legible form, copies of or extracts from such information in a permanent legible form,
- (h) remove and retain, under a warrant under *subsection (5)*, those records, files or papers, or equipment used in such information systems, for such period as may be reasonable for further examination or until the conclusion of any legal proceedings,
- (i) have photographs taken of any thing in, at or on the place and remove the photographs from the place,
- (j) where appropriate, install, use and maintain in, at or on the place monitoring instruments, systems and seals, in a manner consistent with the Protocol,
- (k) require any person in, at or on the place to give to the authorised officer any information that the officer may reasonably require in the inspection or investigation,
- (l) take samples for analysis of any thing in, at or on the place, without payment, and analyse those samples or remove them from the place for analysis outside the place,
- (m) as regards any thing the authorised officer finds in, at or on the place, require any person in, at or on the place, or who appears to the officer to be in possession of the thing, to supply without payment, for test, examination or analysis, sufficient samples thereof,

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

- (n) cause any thing found in, at or on the place the possession or use of which appears to the authorised officer to constitute an offence under this Act, to be dismantled or subjected to any process or test (but not so as to damage or destroy it unless it is in the circumstances necessary for the purposes of this Act, and where an authorised officer proposes to exercise this power in the case of a thing found in, at or on the place, the officer shall, if required by a person who at the time is present in, at or on and has responsibility in relation to the place, cause anything which is to be done by virtue of that power to be done in the presence of that person), Pt.3 S.7
- (o) take possession of any such thing in, at or on the place and retain it for so long as is necessary for all or any of the following purposes:
- (i) to examine or arrange for its examination and do to it anything that he or she has power to do under *paragraph (h)*,
  - (ii) to ensure that it is not tampered with before the examination is completed,
  - (iii) to ensure that it is available for use as evidence in any proceedings,
- (p) require any person in, at or on the place to afford the authorised officer such facilities and assistance within the person's control or responsibilities as are reasonably necessary to enable the officer to exercise any of the powers conferred on an authorised officer by or under this Act, and
- (q) exercise such other powers as may be necessary to ensure that this Act or the Protocol is complied with.
- (2) Before exercising a power to take possession of, seize, remove or retain conferred by *subsection (1)* in the case of any thing, an authorised officer shall, so far as it is reasonably practicable to do, consult such persons as appear to him or her to be appropriate for the purposes of ascertaining what danger, if any, there may be in doing anything that he or she proposes to do under that power.
- (3) An authorised officer shall not, except with the consent of the occupier, enter a private dwelling unless he or she has obtained a warrant under *subsection (5)* authorising such entry.
- (4) Where an authorised officer in the exercise of his or her powers under this section is prevented from entering any place, an application may be made to the District Court for a warrant under *subsection (5)* authorising such entry.
- (5) Without prejudice to the powers conferred on an authorised officer by or under any other provision of this section, if a judge of the District Court is satisfied on the sworn information of an authorised officer that there are reasonable grounds for suspecting that there is information required by an authorised officer under this section held in, at or on any place, or there is a thing that an authorised officer requires to inspect for the purposes of this Act, or that such an inspection is likely to disclose evidence of a contravention of this Act, the judge may issue a warrant authorising an authorised officer, accompanied by other authorised officers or members of the

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
Act 2003.

Pr.3 S.7

Garda Síochána, at any time or times within one month from the date of issue of the warrant, to enter the place, if necessary by the use of reasonable force, and exercise all or any of the powers conferred on an authorised officer by or under this Act.

(6) An application for a warrant under *subsection (5)* shall be made to the judge of the District Court in the district court district in which the place is situated.

(7) Where, by or under this section, a warrant under *subsection (5)* would otherwise be required to exercise a power, it is not so required if the conditions for obtaining a warrant exist but, by reason of exigent circumstances, it would not be practicable to obtain the warrant.

(8) An authorised officer, where he or she considers it necessary, may be accompanied by a member of the Garda Síochána when exercising a power conferred on an authorised officer by or under this Act.

(9) A person who—

- (a) obstructs or interferes with an authorised officer in the exercise of the officer's powers under this Act,
- (b) refuses or fails to comply with a request by an authorised officer under this Act, or
- (c) makes a statement to an authorised officer which the person knows to be false or misleading or which he or she does not believe to be true,

is guilty of an offence.

Members of Garda Síochána to have powers of authorised officers in certain circumstances.

**8.**—Where a member of the Garda Síochána suspects, on reasonable grounds, that an offence under this Act has been or is being committed in, at or on any place or by any person, the member has and may exercise in relation to that place or person, in addition to any powers that he or she may have by virtue of being a member of the Garda Síochána, any of the powers of an authorised officer under this Act.

PART 4

MISCELLANEOUS

Information and documents.

**9.**—A person who—

- (a) does anything under an authorisation under regulations made under *section 13* and referred to in *section 3*,
- (b) engages in an activity listed in Annex I or relevant to the information to be provided in Article 2 of the Protocol or Annex III,
- (c) produces, uses, acquires, transfers or processes any equipment or material listed in Annex I or II, whether or not authorised as referred to in *paragraph (a)*, or
- (d) imports into the State from any other Member State of the European Community equipment or non-nuclear material referred to in Annex III or exports such equipment or material from the State to any other Member State of the European Community,

shall—

- (i) provide the prescribed information, at the prescribed time and in the prescribed form, to the National Authority,

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

the Minister for Enterprise, Trade and Employment or the Revenue Commissioners, as the case may be, and

Pt.4 S.9

- (ii) keep and maintain the prescribed documents in the State, at the person's place of business or at such other place as may be designated by the National Authority, in the prescribed manner and for the prescribed period and, on request by the National Authority, the Minister for Enterprise, Trade and Employment or the Revenue Commissioners, provide the documents to the National Authority, the Minister for Enterprise, Trade and Employment or the Revenue Commissioners, as the case may be.

**10.**—(1) The National Authority, the Minister for Enterprise, Trade and Employment or the Revenue Commissioners may send a notice to any person who it or he or she believes, on reasonable grounds, has information or documents relevant to the enforcement of this Act or the Protocol, requesting the person to provide the information or document to the National Authority, the Minister for Enterprise, Trade and Employment or the Revenue Commissioners, as the case may be.

Disclosure of information.

(2) A person who receives a notice referred to in *subsection (1)* shall provide the requested information and documents as requested in the form and within the time specified in the notice.

**11.**—(1) Subject to this section, information and documents obtained pursuant to this Act or the Protocol are privileged.

Privileged information and evidence.

(2) Information and documents are not privileged to the extent that they are required to be disclosed or communicated for the purposes of an emergency involving public safety.

(3) No person in possession of privileged information or documents shall knowingly, without the written consent of the person from whom they were obtained, communicate it or them or allow it or them to be communicated to any person, or allow any person to have access to it or them, except—

- (a) for the purposes of the enforcement of this Act or of giving effect to the Protocol, or
- (b) pursuant to an obligation of the State under the Protocol.

(4) Notwithstanding any other Act or law, no person is required, in connection with any legal proceedings, to produce any statement or other record containing privileged information or documents, or to give evidence relating to it or them, unless the proceedings relate to the enforcement of this Act.

**12.**—A person who knowingly or recklessly makes a statement which is false or misleading in a material particular in giving any information to—

Giving of false or misleading information.

- (a) the National Authority, the Minister for Enterprise, Trade and Employment or the Revenue Commissioners or an authorised officer, for the purposes of this Act, or

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

Pt.4 S.12

- (b) an international inspector exercising powers under *section 5* or *7*,

is guilty of an offence.

Regulations.

**13.**—(1) The Minister may, in consultation with the Minister for Enterprise, Trade and Employment or, as the case requires, the Revenue Commissioners, for the primary purpose of facilitating the gathering of information and the monitoring of activities relating to the location, quantities and movement in, into and out of the State of things for the purposes of the Protocol, make such regulations as he or she considers necessary or expedient for carrying out and giving effect to this Act and the Protocol.

(2) Without prejudice to the generality of *subsection (1)*, the regulations may—

- (a) designate an authority to be the National Authority for the purposes of this Act in place of the Radiological Protection Institute of Ireland,
- (b) assign to the National Authority, the Minister for Enterprise, Trade and Employment and the Revenue Commissioners authority and responsibility for the performance of functions of the State under the Protocol, relating to—
- (i) the collection and reporting of information about the location, construction of and activities at facilities,
  - (ii) the format and procedures for the collection and transfer of information for the purposes of the Protocol,
  - (iii) the scale of operations and estimation of production capacity at facilities,
  - (iv) the location within the State, and import and export of, equipment and material, and
  - (v) the location within the State, and use or proposed use, of materials of or in excess of particular quantities,
- and regulate the performance of those functions and responsibilities,
- (c) prescribe matters in respect of which the implementation of specified provisions of the Protocol that is the responsibility of the State may be entrusted to the Commission of the European Communities as provided in Annex III,
- (d) prescribe conditions under which activities referred to in *section 3(a)* or *(b)* may be carried on, under licence or otherwise, so that there is a full disclosure and assurance of the provision of information for the purposes of the Protocol,
- (e) provide for the issue, variation, suspension and cancellation of licences for the carrying out of such activities,
- (f) provide for the payment of fees, and the manner of calculating the fees, in respect of such licences,

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

- (g) prescribe the extent to which licensing functions performed by the Radiological Protection Institute of Ireland under section 30 of the Radiological Protection Act 1991, as amended, may govern the carrying on of an activity referred to in *section 3*, Pt.4 S.13
- (h) regulate access to locations and facilities within the State by the Agency and officials of the Agency in accordance with the Protocol,
- (i) regulate the privileges and immunities of officials of the Agency by reference to the Agreement on the Privileges and Immunities of the International Atomic Energy Agency approved by the Board of Governors of the Agency on 1 July 1959, the instrument of acceptance of which was deposited by the State on 29 February 1972,
- (j) prescribe the procedures to be followed by authorised officers performing their functions under this Act or for the purposes of the Protocol, and
- (k) prescribe anything that by this Act is required or permitted to be prescribed.

(3) Regulations made under this section shall be laid before each House of the Oireachtas as soon as may be after they are made and, if a resolution annulling a regulation is passed by either House within the next 21 days on which that House has sat after a regulation is laid before it, the regulation is annulled accordingly but without prejudice to the validity of anything previously done under the regulation.

**14.—**(1) A person who contravenes *section 7(9), 9, 10, 11(3) or 12* or a regulation made under *section 13* is guilty of an offence and is liable on summary conviction to a fine not exceeding €3,000, or to imprisonment for a term not exceeding 6 months, or both. Offences and penalties.

(2) Where an offence under this Act is committed by a body corporate or by a person acting on behalf of a body corporate and is proved to have been so committed with the consent, connivance or approval of, or to have been attributable to any neglect on the part of, any person who, when the offence was committed, was a director, manager, secretary or other similar officer of the body corporate or a person who was purporting to act in any such capacity, that person (as well as the body corporate) is guilty of an offence and is liable to be proceeded against and punished as if guilty of the offence committed by the body corporate.

**15.—**(1) Where a person is convicted of an offence under *section 3*, the court by which he or she is convicted may order that any thing listed in Annex I or II or other thing seized, by means of or in respect of which the offence was committed, be forfeited to the State, and anything so forfeited shall be disposed of as the Minister may direct. Forfeiture.

(2) Where any thing listed in Annex I or II or other thing has been seized under this Act and the owner of the thing, or the person in whose possession it was at the time of seizure, consents in writing to its forfeiture, it is forfeited to the State and shall be disposed of as the Minister may direct.

(3) An authorised officer may apply for an order (“forfeiture order”) for the forfeiture of any thing listed in Annex I or II or other thing to the State, whether or not a person has been convicted of or

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

Pt.4 S.15

charged with an offence under this Act in relation to it and whether or not the owner or person who has the right to its possession is within the jurisdiction of the State or, after reasonable inquiry, can be found, on the grounds that the possession of the thing in the circumstances in which it was found is prohibited under this Act or the Protocol.

(4) An application under *subsection (3)* shall be made to a judge of the District Court in whose district court district the owner or person who has a right to possession resides or carries on business, or if that person is not within the jurisdiction of the State or cannot, after reasonable inquiry, be found, to a judge of the District Court in whose district court district the thing is located.

(5) Any person aggrieved by a forfeiture order or by a decision of the District Court not to make such an order, may appeal to the Circuit Court in whose circuit a forfeiture order has been made or refused, against that order or decision by the District Court.

(6) Where the District Court makes a forfeiture order, the order so made may contain such provisions as appear to the court to be appropriate for delaying the coming into force of the order (including provisions relating to the custody and safe storage of the thing) pending the making and determination of any appeal.

(7) Where a thing listed in Annex I or II or other thing is forfeited under a forfeiture order under *subsection (3)*, it shall be destroyed, denatured, adapted for lawful use or otherwise dealt with in accordance with such directions, not in conflict with the Protocol, as the Minister may give.

(8) A thing may be seized and forfeited under this section notwithstanding that it may be affixed to land, and an authorised officer may, with such reasonable force and assistance as is necessary to achieve that purpose, sever the thing from the land.

Prosecution of  
summary offences.

**16.**—Proceedings in relation to a summary offence under this Act may be brought and prosecuted by the National Authority or the Minister for Enterprise, Trade and Employment, as the case may be.

Expenses of  
Minister.

**17.**—The expenses incurred by the Minister or the Minister for Enterprise, Trade and Employment or the Revenue Commissioners in the administration of this Act shall, to such extent as may be sanctioned by the Minister for Finance, be paid out of moneys provided by the Oireachtas.

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
*Act 2003.*

SCHEDULE

*Section 2(1).*

PROTOCOL ADDITIONAL

TO THE AGREEMENT BETWEEN THE REPUBLIC OF AUSTRIA, THE KINGDOM OF BELGIUM, THE KINGDOM OF DENMARK, THE REPUBLIC OF FINLAND, THE FEDERAL REPUBLIC OF GERMANY, THE HELLENIC REPUBLIC, IRELAND, THE ITALIAN REPUBLIC, THE GRAND DUCHY OF LUXEMBOURG, THE KINGDOM OF THE NETHERLANDS, THE PORTUGUESE REPUBLIC, THE KINGDOM OF SPAIN, THE KINGDOM OF SWEDEN, THE EUROPEAN ATOMIC ENERGY COMMUNITY AND THE INTERNATIONAL ATOMIC ENERGY AGENCY IN IMPLEMENTATION OF ARTICLE III (1) AND (4) OF THE TREATY ON THE NON-PROLIFERATION OF NUCLEAR WEAPONS

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

*Preamble*

WHEREAS the Republic of Austria, the Kingdom of Belgium, the Kingdom of Denmark, the Republic of Finland, the Federal Republic of Germany, the Hellenic Republic, Ireland, the Italian Republic, the Grand Duchy of Luxembourg, the Kingdom of the Netherlands, the Portuguese Republic, the Kingdom of Spain and the Kingdom of Sweden (hereinafter referred to as “the States”) and the European Atomic Energy Community (hereinafter referred to as “the Community”) are parties to an Agreement between the States, the Community and the International Atomic Energy Agency (hereinafter referred to as the “Agency”) in implementation of Article III (1) and (4) of the Treaty on the Non-Proliferation of Nuclear Weapons (hereinafter referred to as the “Safeguards Agreement”), which entered into force on 21 February 1977;

AWARE OF the desire of the international community to further enhance nuclear non-proliferation by strengthening the effectiveness and improving the efficiency of the Agency’s safeguards system;

RECALLING that the Agency must take into account in the implementation of safeguards the need to: avoid hampering the economic and technological development in the Community or international co-operation in the field of peaceful nuclear activities; respect health, safety, physical protection and other security provisions in force and the rights of individuals; and take every precaution to protect commercial, technological and industrial secrets as well as other confidential information coming to its knowledge;

WHEREAS the frequency and intensity of activities described in this Protocol shall be kept to the minimum consistent with the objective of strengthening the effectiveness and improving the efficiency of Agency safeguards;

NOW THEREFORE the Community, the States and the Agency have agreed as follows:

RELATIONSHIP BETWEEN THE PROTOCOL AND THE  
SAFEGUARDS AGREEMENT

*Article 1*

The provisions of the Safeguards Agreement shall apply to this Protocol to the extent that they are relevant to and compatible with the provisions of this Protocol. In case of conflict between the provisions of the Safeguards Agreement and those of this Protocol, the provisions of this Protocol shall apply.

PROVISION OF INFORMATION

*Article 2*

- a. Each State shall provide the Agency with a declaration containing the information identified in sub-paragraphs (i), (ii), (iv), (ix) and (x) below. The Community shall provide the Agency with a declaration containing the information identified in sub-paragraphs (v), (vi) and (vii) below. Each State and the Community shall provide the Agency with a declaration containing the information identified in sub-paragraphs (iii) and (viii) below.

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
*Act 2003.*

- (i) A general description of and information specifying the location of nuclear fuel cycle-related research and development activities not involving nuclear material carried out anywhere that are funded, specifically authorised or controlled by, or carried out on behalf of, the State concerned. SCH.1
- (ii) Information identified by the Agency on the basis of expected gains in effectiveness or efficiency, and agreed to by the State concerned, on operational activities of safeguards relevance at facilities and locations outside facilities where nuclear material is customarily used.
- (iii) A general description of each building on each site, including its use and, if not apparent from that description, its contents. The description shall include a map of the site.
- (iv) A description of the scale of operations for each location engaged in the activities specified in Annex I to this Protocol.
- (v) Information specifying the location, operational status and the estimated annual production capacity of uranium mines and concentration plants and thorium concentration plants in each State, and the current annual production of such mines and concentration plants. The Community shall provide, upon request by the Agency, the current annual production of an individual mine or concentration plant. The provision of this information does not require detailed nuclear material accountancy.
- (vi) Information regarding source material which has not reached the composition and purity suitable for fuel fabrication or for being isotopically enriched, as follows:
- (a) The quantities, the chemical composition, the use or intended use of such material, whether in nuclear or non-nuclear use, for each location in the States at which the material is present in quantities exceeding ten metric tons of uranium and/or twenty metric tons of thorium, and for other locations with quantities of more than one metric ton, the aggregate for the States as a whole if the aggregate exceeds ten metric tons of uranium or twenty metric tons of thorium. The provision of this information does not require detailed nuclear material accountancy;
- (b) The quantities, the chemical composition and the destination of each export from the States to a state outside the Community, of such material for specifically non-nuclear purposes in quantities exceeding:
- (1) Ten metric tons of uranium, or for successive exports of uranium to the same state, each of less than ten metric tons,

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

but exceeding a total of ten metric tons for the year;

(2) Twenty metric tons of thorium, or for successive exports of thorium to the same state, each of less than twenty metric tons, but exceeding a total of twenty metric tons for the year;

(c) The quantities, chemical composition, current location and use or intended use of each import into the States from outside the Community of such material for specifically non-nuclear purposes in quantities exceeding:

(1) Ten metric tons of uranium, or for successive imports of uranium each of less than ten metric tons, but exceeding a total of ten metric tons for the year;

(2) Twenty metric tons of thorium, or for successive imports of thorium each of less than twenty metric tons, but exceeding a total of twenty metric tons for the year;

it being understood that there is no requirement to provide information on such material intended for a non-nuclear use once it is in its non-nuclear end-use form.

(vii) (a) Information regarding the quantities, uses and locations of nuclear material exempted from safeguards pursuant to Article 37 of the Safeguards Agreement;

(b) Information regarding the quantities (which may be in the form of estimates) and uses at each location, of nuclear material exempted from safeguards pursuant to Article 36(b) of the Safeguards Agreement but not yet in a non-nuclear end-use form, in quantities exceeding those set out in Article 37 of the Safeguards Agreement. The provision of this information does not require detailed nuclear material accountancy.

(viii) Information regarding the location or further processing of intermediate or high-level waste containing plutonium, high enriched uranium or uranium-233 on which safeguards have been terminated pursuant to Article 11 of the Safeguards Agreement. For the purpose of this paragraph, "further processing" does not include repackaging of the waste or its further conditioning not involving the separation of elements, for storage or disposal.

(ix) The following information regarding specified equipment and non-nuclear material listed in Annex II:

(a) For each export out of the Community of such equipment and material: the identity, quantity, location of intended use in the receiving state

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
*Act 2003.*

and date or, as appropriate, expected date, of Sch.1  
export;

- (b) Upon specific request by the Agency, confirmation by the importing State of information provided to the Agency by a state outside of the Community concerning the export of such equipment and material to the importing State.
    - (x) General plans for the succeeding ten-year period relevant to the development of the nuclear fuel cycle (including planned nuclear fuel cycle-related research and development activities) when approved by the appropriate authorities in the State.
- b. Each State shall make every reasonable effort to provide the Agency with the following information:
  - (i) A general description of and information specifying the location of nuclear fuel cycle-related research and development activities not involving nuclear material which are specifically related to enrichment, reprocessing of nuclear fuel or the processing of intermediate or high-level waste containing plutonium, high enriched uranium or uranium-233 that are carried out anywhere in the State concerned but which are not funded, specifically authorised or controlled by, or carried out on behalf of, that State. For the purpose of this paragraph, “processing” of intermediate or high-level waste does not include repackaging of the waste or its conditioning not involving the separation of elements, for storage or disposal.
  - (ii) A general description of activities and the identity of the person or entity carrying out such activities, at locations identified by the Agency outside a site which the Agency considers might be functionally related to the activities of that site. The provision of this information is subject to a specific request by the Agency. It shall be provided in consultation with the Agency and in a timely fashion.
- c. Upon request by the Agency, a State or the Community, or both, as appropriate, shall provide amplifications or clarifications of any information provided under this Article, in so far as relevant for the purpose of safeguards.

*Article 3*

- a. Each State or the Community, or both, as appropriate, shall provide to the Agency the information identified in Article 2.a.(i), (iii), (iv), (v), (vi)(a), (vii) and (x) and Article 2.b.(i) within 180 days of the entry into force of this Protocol.
- b. Each State or the Community, or both, as appropriate, shall provide to the Agency, by 15 May of each year, updates of the information referred to in paragraph a. above for the period covering the previous calendar year. If there has been no change to the information previously provided, each State or the Community, or both, as appropriate, shall so indicate.

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

- c. The Community shall provide to the Agency, by 15 May of each year, the information identified in Article 2.a.(vi)(b) and (c) for the period covering the previous calendar year.
- d. Each State shall provide to the Agency on a quarterly basis the information identified in Article 2.a.(ix)(a). This information shall be provided within sixty days of the end of each quarter.
- e. The Community and each State shall provide to the Agency the information identified in Article 2.a.(viii) 180 days before further processing is carried out and, by 15 May of each year, information on changes in location for the period covering the previous calendar year.
- f. Each State and the Agency shall agree on the timing and frequency of the provision of the information identified in Article 2.a.(ii).
- g. Each State shall provide to the Agency the information in Article 2.a.(ix)(b) within sixty days of the Agency's request.

COMPLEMENTARY ACCESS

*Article 4*

The following shall apply in connection with the implementation of complementary access under Article 5 of this Protocol:

- a. The Agency shall not mechanistically or systematically seek to verify the information referred to in Article 2; however, the Agency shall have access to:
  - (i) Any location referred to in Article 5.a.(i) or (ii) on a selective basis in order to assure the absence of undeclared nuclear material and activities;
  - (ii) Any location referred to in Article 5.b. or c. to resolve a question relating to the correctness and completeness of the information provided pursuant to Article 2 or to resolve an inconsistency relating to that information;
  - (iii) Any location referred to in Article 5.a.(iii) to the extent necessary for the Agency to confirm, for safeguards purposes, the Community's, or, as appropriate, a State's declaration of the decommissioned status of a facility or location outside facilities where nuclear material was customarily used.
- b.
  - (i) Except as provided in paragraph (ii) below, the Agency shall give the State concerned, or for access under Article 5.a. or under Article 5.c. where nuclear material is involved, the State concerned and the Community, advance notice of access of at least 24 hours;
  - (ii) For access to any place on a site that is sought in conjunction with design information verification visits or ad hoc or routine inspections on that site, the period of advance notice shall, if the Agency so requests, be at least two hours but, in exceptional circumstances, it may be less than two hours.

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
*Act 2003.*

- c. Advance notice shall be in writing and shall specify the reasons for access and the activities to be carried out during such access. SCH.1
- d. In the case of a question or inconsistency, the Agency shall provide the State concerned and, as appropriate, the Community with an opportunity to clarify and facilitate the resolution of the question or inconsistency. Such an opportunity will be provided before a request for access, unless the Agency considers that delay in access would prejudice the purpose for which the access is sought. In any event, the Agency shall not draw any conclusions about the question or inconsistency until the State concerned and, as appropriate, the Community have been provided with such an opportunity.
- e. Unless otherwise agreed to by the State concerned, access shall only take place during regular working hours.
- f. The State concerned, or for access under Article 5.a. or under Article 5.c. where nuclear material is involved, the State concerned and the Community, shall have the right to have Agency inspectors accompanied during their access by its representatives and, as appropriate, by Community inspectors provided that Agency inspectors shall not thereby be delayed or otherwise impeded in the exercise of their functions.

*Article 5*

Each State shall provide the Agency with access to:

- a.
  - (i) Any place on a site;
  - (ii) Any location identified under Article 2.a.(v)-(viii);
  - (iii) Any decommissioned facility or decommissioned location outside facilities where nuclear material was customarily used.
- b. Any location identified by the State concerned under Article 2.a.(i), Article 2.a.(iv), Article 2.a.(ix)(b) or Article 2.b., other than those referred to in paragraph a.(i) above, provided that if the State concerned is unable to provide such access, that State shall make every reasonable effort to satisfy Agency requirements, without delay, through other means.
- c. Any location specified by the Agency, other than locations referred to in paragraphs a. and b. above, to carry out location-specific environmental sampling, provided that if the State concerned is unable to provide such access, that State shall make every reasonable effort to satisfy Agency requirements, without delay, at adjacent locations or through other means.

*Article 6*

When implementing Article 5, the Agency may carry out the following activities:

- a. For access in accordance with Article 5.a.(i) or (iii): visual observation; collection of environmental samples; utilization of radiation detection and measurement devices; application of seals and other identifying and tamper indicating devices specified in Subsidiary Arrangements; and other objective measures which have been demonstrated to be technically feasible and the use of which has been agreed by the Board of Governors (hereinafter referred to as the "Board") and following consultations between the Agency, the Community and the State concerned.

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

- b. For access in accordance with Article 5.a.(ii): visual observation; item counting of nuclear material; non-destructive measurements and sampling; utilization of radiation detection and measurement devices; examination of records relevant to the quantities, origin and disposition of the material; collection of environmental samples; and other objective measures which have been demonstrated to be technically feasible and the use of which has been agreed by the Board and following consultations between the Agency, the Community and the State concerned.
- c. For access in accordance with Article 5.b.: visual observation; collection of environmental samples; utilization of radiation detection and measurement devices; examination of safeguards relevant production and shipping records; and other objective measures which have been demonstrated to be technically feasible and the use of which has been agreed by the Board and following consultations between the Agency and the State concerned.
- d. For access in accordance with Article 5.c., collection of environmental samples and, in the event the results do not resolve the question or inconsistency at the location specified by the Agency pursuant to Article 5.c., utilization at that location of visual observation, radiation detection and measurement devices, and, as agreed by the State concerned and, where nuclear material is involved, the Community, and the Agency, other objective measures.

*Article 7*

- a. Upon request by a State, the Agency and that State shall make arrangements for managed access under this Protocol in order to prevent the dissemination of proliferation sensitive information, to meet safety or physical protection requirements, or to protect proprietary or commercially sensitive information. Such arrangements shall not preclude the Agency from conducting activities necessary to provide credible assurance of the absence of undeclared nuclear materials and activities at the location in question, including the resolution of a question relating to the correctness and completeness of the information referred to in Article 2 or of an inconsistency relating to that information.
- b. A State may, when providing the information referred to in Article 2, inform the Agency of the places at a site or location at which managed access may be applicable.
- c. Pending the entry into force of any necessary Subsidiary Arrangements, a State may have recourse to managed access consistent with the provisions of paragraph a. above.

*Article 8*

Nothing in this Protocol shall preclude a State from offering the Agency access to locations in addition to those referred to in Articles 5 and 9 or from requesting the Agency to conduct verification activities at a particular location. The Agency shall, without delay, make every reasonable effort to act upon such a request.

*Article 9*

Each State shall provide the Agency with access to locations specified by the Agency to carry out wide-area environmental sampling, provided that if a State is unable to provide such access that State

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
*Act 2003.*

shall make every reasonable effort to satisfy Agency requirements at alternative locations. The Agency shall not seek such access until the use of wide-area environmental sampling and the procedural arrangements therefor have been approved by the Board and following consultations between the Agency and the State concerned. SCH.1

*Article 10*

- a. The Agency shall inform the State concerned and, as appropriate, the Community of:
  - (i) The activities carried out under this Protocol, including those in respect of any questions or inconsistencies the Agency had brought to the attention of the State concerned and, as appropriate, the Community within sixty days of the activities being carried out by the Agency.
  - (ii) The results of activities in respect of any questions or inconsistencies the Agency had brought to the attention of the State concerned and, as appropriate, the Community as soon as possible but in any case within thirty days of the results being established by the Agency.
- b. The Agency shall inform the State concerned and the Community of the conclusions it has drawn from its activities under this Protocol. The conclusions shall be provided annually.

DESIGNATION OF AGENCY INSPECTORS

*Article 11*

- a. (i) The Director General shall notify the Community and the States of the Board's approval of any Agency official as a safeguards inspector. Unless the Community advises the Director General of the rejection of such an official as an inspector for the States within three months of receipt of notification of the Board's approval, the inspector so notified to the Community and the States shall be considered designated to the States;
  - (ii) The Director General, acting in response to a request by the Community or on his own initiative, shall immediately inform the Community and the States of the withdrawal of the designation of any official as an inspector for the States.
- b. A notification referred to in paragraph a. above shall be deemed to be received by the Community and the States seven days after the date of the transmission by registered mail of the notification by the Agency to the Community and the States.

VISAS

*Article 12*

Each State shall, within one month of the receipt of a request therefor, provide the designated inspector specified in the request with appropriate multiple entry/exit and/or transit visas, where required, to enable the inspector to enter and remain on the territory of the State concerned for the purpose of carrying out his/her functions. Any visas required shall be valid for at least one year and shall be

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

renewed, as required, to cover the duration of the inspector's designation to the States.

SUBSIDIARY ARRANGEMENTS

*Article 13*

- a. Where a State or the Community, as appropriate, or the Agency indicate that it is necessary to specify in Subsidiary Arrangements how measures laid down in this Protocol are to be applied, that State, or that State and the Community and the Agency shall agree on such Subsidiary Arrangements within ninety days of the entry into force of this Protocol or, where the indication of the need for such Subsidiary Arrangements is made after the entry into force of this Protocol, within ninety days of the date of such indication.
- b. Pending the entry into force of any necessary Subsidiary Arrangements, the Agency shall be entitled to apply the measures laid down in this Protocol.

COMMUNICATIONS SYSTEMS

*Article 14*

- a. Each State shall permit and protect free communications by the Agency for official purposes between Agency inspectors in that State and Agency Headquarters and/or Regional Offices, including attended and unattended transmission of information generated by Agency containment and/or surveillance or measurement devices. The Agency shall have, in consultation with the State concerned, the right to make use of internationally established systems of direct communications, including satellite systems and other forms of telecommunication, not in use in that State. At the request of a State, or the Agency, details of the implementation of this paragraph in that State with respect to the attended or unattended transmission of information generated by Agency containment and/or surveillance or measurement devices shall be specified in the Subsidiary Arrangements.
- b. Communication and transmission of information as provided for in paragraph a. above shall take due account of the need to protect proprietary or commercially sensitive information or design information which the State concerned regards as being of particular sensitivity.

PROTECTION OF CONFIDENTIAL INFORMATION

*Article 15*

- a. The Agency shall maintain a stringent regime to ensure effective protection against disclosure of commercial, technological and industrial secrets and other confidential information coming to its knowledge, including such information coming to the Agency's knowledge in the implementation of this Protocol.
- b. The regime referred to in paragraph a. above shall include, among others, provisions relating to:
  - (i) General principles and associated measures for the handling of confidential information;

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

- (ii) Conditions of staff employment relating to the protection of confidential information; SCH.1
  - (iii) Procedures in cases of breaches or alleged breaches of confidentiality.
- c. The regime referred to in paragraph a. above shall be approved and periodically reviewed by the Board.

ANNEXES

*Article 16*

- a. The Annexes to this Protocol shall be an integral part thereof. Except for the purposes of amendment of Annexes I and II, the term “Protocol” as used in this instrument means this Protocol and the Annexes together.
- b. The list of activities specified in Annex I, and the list of equipment and material specified in Annex II, may be amended by the Board upon the advice of an open-ended working group of experts established by the Board. Any such amendment shall take effect four months after its adoption by the Board.
- c. Annex III to this Protocol specifies how measures in this Protocol shall be implemented by the Community and the States.

ENTRY INTO FORCE

*Article 17*

- a. This Protocol shall enter into force on the date on which the Agency receives from the Community and the States written notification that their respective requirements for entry into force have been met.
- b. The States and the Community may, at any date before this Protocol enters into force, declare that they will apply this Protocol provisionally.
- c. The Director General shall promptly inform all Member States of the Agency of any declaration or provisional application of, and of the entry into force of, this Protocol.

DEFINITIONS

*Article 18*

For the purpose of this Protocol:

- a. *Nuclear fuel cycle-related research and development activities* means those activities which are specifically related to any process or system development aspect of any of the following:
  - conversion of nuclear material;
  - enrichment of nuclear material;
  - nuclear fuel fabrication;
  - reactors;
  - critical facilities;
  - reprocessing of nuclear fuel;
  - processing (not including repackaging or conditioning not involving the separation of elements, for storage or

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
Act 2003.

SCH.1

disposal) of intermediate or high-level waste containing plutonium, high enriched uranium or uranium-233;

but do not include activities related to theoretical or basic scientific research or to research and development on industrial radioisotope applications, medical, hydrological and agricultural applications, health and environmental effects and improved maintenance.

- b. *Site* means that area delimited by the Community and a State in the relevant design information for a facility, including a closed-down facility, and in the relevant information on a location outside facilities where nuclear material is customarily used, including a closed-down location outside facilities where nuclear material was customarily used (this is limited to locations with hot cells or where activities related to conversion, enrichment, fuel fabrication or reprocessing were carried out). *Site* shall also include all installations, co-located with the facility or location, for the provision or use of essential services, including: hot cells for processing irradiated materials not containing nuclear material; installations for the treatment, storage and disposal of waste; and buildings associated with specified activities identified by the State concerned under Article 2.a.(iv) above.
- c. *Decommissioned facility* or *decommissioned location outside facilities* means an installation or location at which residual structures and equipment essential for its use have been removed or rendered inoperable so that it is not used to store and can no longer be used to handle, process or utilize nuclear material.
- d. *Closed-down facility* or *closed-down location outside facilities* means an installation or location where operations have been stopped and the nuclear material removed but which has not been decommissioned.
- e. *High enriched uranium* means uranium containing 20 percent or more of the isotope uranium-235.
- f. *Location-specific environmental sampling* means the collection of environmental samples (e.g. air, water, vegetation, soil, smears) at, and in the immediate vicinity of, a location specified by the Agency for the purpose of assisting the Agency to draw conclusions about the absence of undeclared nuclear material or nuclear activities at the specified location.
- g. *Wide-area environmental sampling* means the collection of environmental samples (e.g. air, water, vegetation, soil, smears) at a set of locations specified by the Agency for the purpose of assisting the Agency to draw conclusions about the absence of undeclared nuclear material or nuclear activities over a wide area.
- h. *Nuclear material* means any source or any special fissionable material as defined in Article XX of the Statute. The term source material shall not be interpreted as applying to ore or ore residue. Any determination by the Board under Article XX of the Statute of the Agency after the entry into force of this Protocol which adds to the materials considered to be source material or special fissionable material shall have effect under this Protocol only upon acceptance by the Community and the States.

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

i. *Facility* means: SCH.1

- (i) A reactor, a critical facility, a conversion plant, a fabrication plant, a reprocessing plant, an isotope separation plant or a separate storage installation; or
- (ii) Any location where nuclear material in amounts greater than one effective kilogram is customarily used.

j. *Location outside facilities* means any installation or location, which is not a facility, where nuclear material is customarily used in amounts of one effective kilogram or less.

Done at Vienna in duplicate, on the 22nd day of September 1998 in Danish, Dutch, English, Finnish, French, German, Greek, Italian, Portuguese, Spanish and Swedish languages, the texts of which are equally authentic except that, in case of divergence, those texts concluded in the official languages of the IAEA Board of Governors shall prevail.

ANNEX I

LIST OF ACTIVITIES REFERRED TO IN ARTICLE 2.a.(iv)  
OF THE PROTOCOL

- (i) The manufacture of *centrifuge rotor tubes* or the assembly of *gas centrifuges*.

*Centrifuge rotor tubes* means thin-walled cylinders as described in entry 5.1.1(b) of Annex II.

*Gas centrifuges* means centrifuges as described in the Introductory Note to entry 5.1 of Annex II.

- (ii) The manufacture of *diffusion barriers*.

*Diffusion barriers* means thin, porous filters as described in entry 5.3.1(a) of Annex II.

- (iii) The manufacture or assembly of *laser-based systems*.

*Laser-based systems* means systems incorporating those items as described in entry 5.7 of Annex II.

- (iv) The manufacture or assembly of *electromagnetic isotope separators*.

*Electromagnetic isotope separators* means those items referred to in entry 5.9.1 of Annex II containing ion sources as described in 5.9.1(a) of Annex II.

- (v) The manufacture or assembly of *columns* or *extraction equipment*.

*Columns* or *extraction equipment* means those items as described in entries 5.6.1, 5.6.2, 5.6.3, 5.6.5, 5.6.6, 5.6.7 and 5.6.8 of Annex II.

- (vi) The manufacture of *aerodynamic separation nozzles* or *vortex tubes*.

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
Act 2003.

SCH.1

*Aerodynamic separation nozzles* or *vortex tubes* means separation nozzles and vortex tubes as described respectively in entries 5.5.1 and 5.5.2 of Annex II.

- (vii) The manufacture or assembly of *uranium plasma generation systems*.

*Uranium plasma generation systems* means systems for the generation of uranium plasma as described in entry 5.8.3 of Annex II.

- (viii) The manufacture of *zirconium tubes*.

*Zirconium tubes* means tubes as described in entry 1.6 of Annex II.

- (ix) The manufacture or upgrading of *heavy water or deuterium*.

*Heavy water or deuterium* means deuterium, heavy water (deuterium oxide) and any other deuterium compound in which the ratio of deuterium to hydrogen atoms exceeds 1:5000.

- (x) The manufacture of *nuclear grade graphite*.

*Nuclear grade graphite* means graphite having a purity level better than 5 parts per million boron equivalent and with a density greater than 1.50 g/cm<sup>3</sup>.

- (xi) The manufacture of *flasks for irradiated fuel*.

A *flask for irradiated fuel* means a vessel for the transportation and/or storage of irradiated fuel which provides chemical, thermal and radiological protection, and dissipates decay heat during handling, transportation and storage.

- (xii) The manufacture of *reactor control rods*.

*Reactor control rods* means rods as described in entry 1.4 of Annex II.

- (xiii) The manufacture of *criticality safe tanks and vessels*.

*Criticality safe tanks and vessels* means those items as described in entries 3.2 and 3.4 of Annex II.

- (xiv) The manufacture of *irradiated fuel element chopping machines*.

*Irradiated fuel element chopping machines* means equipment as described in entry 3.1 of Annex II.

- (xv) The construction of *hot cells*.

*Hot cells* means a cell or interconnected cells totalling at least 6 m<sup>3</sup> in volume with shielding equal to or greater than the equivalent of 0.5 m of concrete, with a density of 3.2 g/cm<sup>3</sup> or greater, outfitted with equipment for remote operations.

LIST OF SPECIFIED EQUIPMENT AND NON-NUCLEAR  
MATERIAL FOR THE REPORTING OF EXPORTS AND  
IMPORTS ACCORDING TO ARTICLE 2.a.(ix)

**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”.

**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

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

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.

EXPLANTORY 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 the primary coolant for nuclear reactors as defined in paragraph 1.1. above.

EXPLANATORY NOTE

Especially designed or prepared pumps may include elaborate sealed or multi-sealed systems to prevent leakage of primary coolant, canned-driven pumps, and pumps with inertial mass systems. This definition encompasses pumps certified to NC-1 or equivalent standards.

**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<sup>3</sup> for use in a nuclear reactor as defined in paragraph

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

1.1. above in quantities exceeding  $3 \times 10^4$  kg (30 metric tons) Sch.1  
for any one recipient country in any period of 12 months.

NOTE

For the purpose of reporting, the Government will determine whether or not the exports of graphite meeting the above specifications are for nuclear reactor use.

**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 (e.g. by geometry), radiation exposure (e.g. by shielding), and toxicity hazards (e.g. by containment).

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

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

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 (e.g. 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. SCH.1

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 (e.g. involving equipment fabricated or lined with a precious metal), metal reduction (e.g. 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.

SCH.1

**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.

**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 or more 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.

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

(b) Rotor tubes:

SCH.1

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 or more 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<sub>6</sub> 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<sub>6</sub> 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  $2.05 \times 10^9$  N/m<sup>2</sup> (300,000 psi) or more;
- (b) Aluminium alloys capable of an ultimate tensile strength of  $0.46 \times 10^9$  N/m<sup>2</sup> (67,000 psi) or more;
- (c) Filamentary materials suitable for use in composite structures and having a specific modulus of  $12.3 \times 10^6$  m or greater and a specific ultimate tensile strength of  $0.3 \times 10^6$  m or greater ('Specific Modulus' is the Young's Modulus in N/m<sup>2</sup> divided by the specific weight in N/m<sup>3</sup>; 'Specific Ultimate Tensile Strength' is the ultimate tensile strength in N/m<sup>2</sup> divided by the specific weight in N/m<sup>3</sup>).

SCH.1

**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<sub>6</sub>-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<sup>3</sup> (10<sup>7</sup> 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 with 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, with the length equal to or greater than the diameter. 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.

(e) Centrifuge housing/recipients:

Components especially designed or prepared to contain the rotor tube assembly of a gas centrifuge. The housing consists of a rigid cylinder of wall thickness up to 30 mm (1.2 in) with precision machined ends to locate the bearings and with one or more flanges for mounting. The machined ends are parallel to each other and perpendicular to the cylinder's longitudinal axis to within 0.05 degrees or less. The housing may also be a honeycomb type structure to accommodate several rotor tubes. The housings are made of or protected by materials resistant to corrosion by UF<sub>6</sub>.

(f) Scoops:

SCH.1

Especially designed or prepared tubes of up to 12 mm (0.5 in) internal diameter for the extraction of UF<sub>6</sub> gas from within the rotor tube by a Pitot tube action (that is, with an aperture facing into the circumferential gas flow within the rotor tube, for example by bending the end of a radially disposed tube) and capable of being fixed to the central gas extraction system. The tubes are made of or protected by materials resistant to corrosion by UF<sub>6</sub>.

## 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<sub>6</sub> 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<sub>6</sub> from the centrifuges, together with the equipment required to drive the centrifuges or to control the plant.

Normally UF<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> into containers.

This plant, equipment and pipework is wholly made of or lined with UF<sub>6</sub>-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<sub>6</sub> within the centrifuge cascades.

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

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<sub>6</sub>-resistant materials (see EXPLANATORY NOTE to this section) and is fabricated to very high vacuum and cleanliness standards.

**5.2.3. UF<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub>), 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<sub>6</sub>. 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**

SCH.1

- (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<sub>6</sub>, 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<sub>6</sub>-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 (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<sub>6</sub>-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<sup>3</sup>/min or more of UF<sub>6</sub> and with a discharge pressure of up to several hundred kPa (100 psi), designed for long-term operation in the UF<sub>6</sub> 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<sub>6</sub>.

**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<sub>6</sub>. Such seals are normally designed for a buffer gas in-leakage rate of less than 1000 cm<sup>3</sup>/min (60 in<sup>3</sup>/min).

**5.3.5. Heat exchangers for cooling UF<sub>6</sub>**

Especially designed or prepared heat exchangers made of or lined with UF<sub>6</sub>-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 100kPa (15 psi).

SCH.1

**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<sub>6</sub> 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<sub>6</sub> from the diffusion cascades. Because of the high inertial properties of diffusion cascades, any interruption in their operation, and especially their shutdown, 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> to the gaseous diffusion cascades;

Desublimers (or cold traps) used to remove UF<sub>6</sub> from diffusion cascades;

Liquefaction stations where UF<sub>6</sub> gas from the cascade is compressed and cooled to form liquid UF<sub>6</sub>;

'Product' or 'tails' stations used for transferring UF<sub>6</sub> into containers.

**5.4.2. Header piping systems**

Especially designed or prepared piping systems and header systems for handling UF<sub>6</sub> 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**

SCH.1

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

(b) Vacuum pumps especially designed for service in UF<sub>6</sub>-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<sub>6</sub>-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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub> 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<sub>6</sub>-resistant materials. For the purposes of the sections relating to gaseous diffusion items the materials resistant to corrosion by UF<sub>6</sub> include stainless steel, aluminium, aluminium alloys, aluminium oxide, nickel or alloys containing 60% or more nickel and UF<sub>6</sub>-resistant fully fluorinated hydrocarbon polymers.

**5.5. Especially designed or prepared systems, equipment and components for use in aerodynamic enrichment plants**

**INTRODUCTORY NOTE**

In aerodynamic enrichment processes, a mixture of gaseous UF<sub>6</sub> and light gas (hydrogen or helium) is compressed and then passed through separating elements wherein isotopic separation is accomplished by the generation of high centrifugal forces over a curved-wall geometry. Two processes of this type have been successfully developed: the separation nozzle process and the vortex tube process. For both processes the main components of a separation stage include cylindrical vessels housing the special separation elements (nozzles or vortex tubes), gas compressors and heat exchangers to remove the heat of compression. An

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

aerodynamic plant requires a number of these stages, so that quantities can provide an important indication of end use. Since aerodynamic processes use UF<sub>6</sub>, 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<sub>6</sub>.

EXPLANATORY NOTE

The items listed in this section either come into direct contact with the UF<sub>6</sub> 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 protected by UF<sub>6</sub>-resistant materials. For the purposes of the section relating to aerodynamic enrichment items, the materials resistant to corrosion by UF<sub>6</sub> include copper, stainless steel, aluminium, aluminium alloys, nickel or alloys containing 60% or more nickel and UF<sub>6</sub>-resistant fully fluorinated hydrocarbon polymers.

**5.5.1. Separation nozzles**

Especially designed or prepared separation nozzles and assemblies thereof. The separation nozzles consist of slit-shaped, curved channels having a radius of curvature less than 1 mm (typically 0.1 to 0.05 mm), resistant to corrosion by UF<sub>6</sub> and having a knife-edge within the nozzle that separates the gas flowing through the nozzle into two fractions.

**5.5.2. Vortex tubes**

Especially designed or prepared vortex tubes and assemblies thereof. The vortex tubes are cylindrical or tapered, made of or protected by materials resistant to corrosion by UF<sub>6</sub>, having a diameter of between 0.5 cm and 4 cm, a length to diameter ratio of 20:1 or less and with one or more tangential inlets. The tubes may be equipped with nozzle-type appendages at either or both ends.

EXPLANATORY NOTE

The feed gas enters the vortex tube tangentially at one end or through swirl vanes or at numerous tangential positions along the periphery of the tube.

**5.5.3. Compressors and gas blowers**

Especially designed or prepared axial, centrifugal or positive displacement compressors or gas blowers made of or protected by materials resistant to corrosion by UF<sub>6</sub> and with a suction volume capacity of 2 m<sup>3</sup>/min or more of UF<sub>6</sub>/carrier gas (hydrogen or helium) mixture.

EXPLANATORY NOTE

These compressors and gas blowers typically have a pressure ratio between 1.2:1 and 6:1.

**5.5.4. Rotary shaft seals**

Especially designed or prepared rotary shaft seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor rotor or the gas blower rotor with the driver motor so as to ensure a reliable seal against out-leakage of process gas or in-leakage of air or seal gas into

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

the inner chamber of the compressor or gas blower which is filled with a UF<sub>6</sub>/carrier gas mixture. SCH.1

**5.5.5. Heat exchangers for gas cooling**

Especially designed or prepared heat exchangers made of or protected by materials resistant to corrosion by UF<sub>6</sub>.

**5.5.6. Separation element housings**

Especially designed or prepared separation element housings, made of or protected by materials resistant to corrosion by UF<sub>6</sub>, for containing vortex tubes or separation nozzles.

EXPLANATORY NOTE

These housings may be cylindrical vessels greater than 300 mm in diameter and greater than 900 mm in length, or may be rectangular vessels of comparable dimensions, and may be designed for horizontal or vertical installation.

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

Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by UF<sub>6</sub>, including:

- (a) Feed autoclaves, ovens, or systems used for passing UF<sub>6</sub> to the enrichment process;
- (b) Desublimers (or cold traps) used to remove UF<sub>6</sub> from the enrichment process for subsequent transfer upon heating;
- (c) Solidification or liquefaction stations used to remove UF<sub>6</sub> from the enrichment process by compressing and converting UF<sub>6</sub> to a liquid or solid form;
- (d) 'Product' or 'tails' stations used for transferring UF<sub>6</sub> into containers.

**5.5.8. Header piping systems**

Especially designed or prepared header piping systems, made of or protected by materials resistant to corrosion by UF<sub>6</sub>, for handling UF<sub>6</sub> within the aerodynamic cascades. This piping network is normally of the 'double' header design with each stage or group of stages connected to each of the headers.

**5.5.9. Vacuum systems and pumps**

- (a) Especially designed or prepared vacuum systems having a suction capacity of 5 m<sup>3</sup>/min or more, consisting of vacuum manifolds, vacuum headers and vacuum pumps, and designed for service in UF<sub>6</sub>-bearing atmospheres,
- (b) Vacuum pumps especially designed or prepared for service in UF<sub>6</sub>-bearing atmospheres and made of or protected by materials resistant to corrosion by UF<sub>6</sub>. These pumps may use fluorocarbon seals and special working fluids.

SCH.1

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

Especially designed or prepared manual or automated shut-off and control bellows valves made of or protected by materials resistant to corrosion by UF<sub>6</sub> with a diameter of 40 to 1500 mm for installation in main and auxiliary systems of aerodynamic enrichment plants.

**5.5.11. UF<sub>6</sub> 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<sub>6</sub> 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.

**5.5.12. UF<sub>6</sub>/carrier gas separation systems**

Especially designed or prepared process systems for separating UF<sub>6</sub> from carrier gas (hydrogen or helium).

**EXPLANATORY NOTE**

These systems are designed to reduce the UF<sub>6</sub> content in the carrier gas to 1 ppm or less and may incorporate equipment such as:

- (a) Cryogenic heat exchangers and cryoseparators capable of temperatures of -120°C or less, or
- (b) Cryogenic refrigeration units capable of temperatures of -120°C or less, or
- (c) Separation nozzle or vortex tube units for the separation of UF<sub>6</sub> from carrier gas, or
- (d) UF<sub>6</sub> cold traps capable of temperatures of -20°C or less.

**5.6. Especially designed or prepared systems, equipment and components for use in chemical exchange or ion exchange enrichment plants**

**INTRODUCTORY NOTE**

The slight difference in mass between the isotopes of uranium causes small changes in chemical reaction equilibria that can be used as a basis for separation of the isotopes. Two processes have been successfully developed: liquid-liquid chemical exchange and solid-liquid ion exchange.

In the liquid-liquid chemical exchange process, immiscible liquid phases (aqueous and organic) are countercurrently contacted to give the cascading effect of thousands of separation stages. The aqueous phase consists of uranium chloride in hydrochloric acid solution; the organic phase consists of an extractant containing uranium chloride in an organic solvent. The contactors employed in the separation cascade

can be liquid-liquid exchange columns (such as pulsed columns with sieve plates) or liquid centrifugal contactors. Chemical conversions (oxidation and reduction) are required at both ends of the separation cascade in order to provide for the reflux requirements at each end. A major design concern is to avoid contamination of the process streams with certain metal ions. Plastic, plastic-lined (including use of fluorocarbon polymers) and/or glass-lined columns and piping are therefore used. SCH.1

In the solid-liquid ion-exchange process, enrichment is accomplished by uranium adsorption/desorption on a special, very fast-acting, ion-exchange resin or adsorbent. A solution of uranium in hydrochloric acid and other chemical agents is passed through cylindrical enrichment columns containing packed beds of the adsorbent. For a continuous process, a reflux system is necessary to release the uranium from the adsorbent back into the liquid flow so that 'product' and 'tails' can be collected. This is accomplished with the use of suitable reduction/oxidation chemical agents that are fully regenerated in separate external circuits and that may be partially regenerated within the isotopic separation columns themselves. The presence of hot concentrated hydrochloric acid solutions in the process requires that the equipment be made of or protected by special corrosion-resistant materials.

**5.6.1. Liquid-liquid exchange columns (Chemical exchange)**

Countercurrent liquid-liquid exchange columns having mechanical power input (i.e., pulsed columns with sieve plates, reciprocating plate columns, and columns with internal turbine mixers), especially designed or prepared for uranium enrichment using the chemical exchange process. For corrosion resistance to concentrated hydrochloric acid solutions, these columns and their internals are made of or protected by suitable plastic materials (such as fluorocarbon polymer) or glass. The stage residence time of the columns is designed to be short (30 seconds or less).

**5.6.2. Liquid-liquid centrifugal contactors (Chemical exchange)**

Liquid-liquid centrifugal contactors especially designed or prepared for uranium enrichment using the chemical exchange process. Such contactors use rotation to achieve dispersion of the organic and aqueous streams and then centrifugal force to separate the phases. For corrosion resistance to concentrated hydrochloric acid solutions, the contactors are made of or are lined with suitable plastic materials (such as fluorocarbon polymers) or are lined with glass. The stage residence time of the centrifugal contactors is designed to be short (30 seconds or less).

**5.6.3. Uranium reduction systems and equipment (Chemical exchange)**

- (a) Especially designed or prepared electrochemical reduction cells to reduce uranium from one valence state to another for uranium enrichment using the chemical exchange process. The cell materials in contact with process solutions must be corrosion resistant to concentrated hydrochloric acid solutions.

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

EXPLANATORY NOTE

- (a) The cell cathodic compartment must be designed to prevent re-oxidation of uranium to its higher valence state. To keep the uranium in the cathodic compartment, the cell may have an impervious diaphragm membrane constructed of special cation exchange material. The cathode consists of a suitable solid conductor such as graphite.
- (b) Especially designed or prepared systems at the product end of the cascade for taking the  $U^{4+}$  out of the organic stream, adjusting the acid concentration and feeding to the electrochemical reduction cells.

EXPLANATORY NOTE

These systems consist of solvent extraction equipment for stripping the  $U^{4+}$  from the organic stream into an aqueous solution, evaporation and/or other equipment to accomplish solution pH adjustment and control, and pumps or other transfer devices for feeding to the electrochemical reduction cells. A major design concern is to avoid contamination of the aqueous stream with certain metal ions. Consequently, for those parts in contact with the process stream, the system is constructed of equipment made of or protected by suitable materials (such as glass, fluorocarbon polymers, polyphenyl sulfate, polyether sulfone, and resin-impregnated graphite).

**5.6.4. Feed preparation systems (Chemical exchange)**

Especially designed or prepared systems for producing high-purity uranium chloride feed solutions for chemical exchange uranium isotope separation plants.

EXPLANATORY NOTE

These systems consist of dissolution, solvent extraction and/or ion exchange equipment for purification and electrolytic cells for reducing the uranium  $U^{6+}$  or  $U^{4+}$  to  $U^{3+}$ . These systems produce uranium chloride solutions having only a few parts per million of metallic impurities such as chromium, iron, vanadium, molybdenum and other bivalent or higher multi-valent cations. Materials of construction for portions of the system processing high-purity  $U^{3+}$  include glass, fluorocarbon polymers, polyphenyl sulfate or polyether sulfone plastic-lined and resin-impregnated graphite.

**5.6.5. Uranium oxidation systems (Chemical exchange)**

Especially designed or prepared systems for oxidation of  $U^{3+}$  to  $U^{4+}$  for return to the uranium isotope separation cascade in the chemical exchange enrichment process.

EXPLANATORY NOTE

These systems may incorporate equipment such as:

- (a) Equipment for contacting chlorine and oxygen with the aqueous effluent from the isotope separation equipment and extracting the resultant  $U^{4+}$  into the stripped organic stream returning from the product end of the cascade,

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

- (b) Equipment that separates water from hydrochloric acid so that the water and the concentrated hydrochloric acid may be reintroduced to the process at the proper locations. SCH.1

**5.6.6. Fast-reacting ion exchange resins/adsorbents (ion exchange)**

Fast-reacting ion-exchange resins or adsorbents especially designed or prepared for uranium enrichment using the ion exchange process, including porous macroreticular resins, and/or pellicular structures in which the active chemical exchange groups are limited to a coating on the surface of an inactive porous support structure, and other composite structures in any suitable form including particles or fibers. These ion exchange resins/adsorbents have diameters of 0.2 mm or less and must be chemically resistant to concentrated hydrochloric acid solutions as well as physically strong enough so as not to degrade in the exchange columns. The resins/adsorbents are especially designed to achieve very fast uranium isotope exchange kinetics (exchange rate half-time of less than 10 seconds) and are capable of operating at a temperature in the range of 100°C to 200°C.

**5.6.7. Ion exchange columns (Ion exchange)**

Cylindrical columns greater than 1000 mm in diameter for containing and supporting packed beds of ion exchange resin/adsorbent, especially designed or prepared for uranium enrichment using the ion exchange process. These columns are made of or protected by materials (such as titanium or fluorocarbon plastics) resistant to corrosion by concentrated hydrochloric acid solutions and are capable of operating at a temperature in the range of 100°C to 200°C and pressures above 0.7 MPa (102 psia).

**5.6.8. Ion exchange reflux systems (Ion exchange)**

- (a) Especially designed or prepared chemical or electrochemical reduction systems for regeneration of the chemical reducing agent(s) used in ion exchange uranium enrichment cascades.
- (b) Especially designed or prepared chemical or electrochemical oxidation systems for regeneration of the chemical oxidizing agent(s) used in ion exchange uranium enrichment cascades.

**EXPLANATORY NOTE**

The ion exchange enrichment process may use, for example, trivalent titanium ( $Ti^{3+}$ ) as a reducing cation in which case the reduction system would regenerate  $Ti^{3+}$  by reducing  $Ti^{4+}$ .

The process may use, for example, trivalent iron ( $Fe^{3+}$ ) as an oxidant in which case the oxidation system would regenerate  $Fe^{3+}$  by oxidizing  $Fe^{2+}$ .

**5.7. Especially designed or prepared systems, equipment and components for use in laser-based enrichment plants**

**INTRODUCTORY NOTE**

Present systems for enrichment processes using lasers fall into two categories: those in which the process medium is atomic uranium vapor and those in which the process medium is the vapor of a uranium compound. Common

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

nomenclature for such processes include: first category — atomic vapor laser isotope separation (AVLIS or SILVA); second category — molecular laser isotope separation (MLIS or MOLIS) and chemical reaction by isotope selective laser activation (CRISLA). The systems, equipment and components for laser enrichment plants embrace: (a) devices to feed uranium-metal vapor (for selective photo-ionization) or devices to feed the vapor of a uranium compound (for photo-dissociation or chemical activation); (b) devices to collect enriched and depleted uranium metal as ‘product’ and ‘tails’ in the first category, and devices to collect dissociated or reacted compounds as ‘product’ and unaffected material as ‘tails’ in the second category; (c) process laser systems to selectively excite the uranium-235 species; and (d) feed preparation and product conversion equipment. The complexity of the spectroscopy of uranium atoms and compounds may require incorporation of any of a number of available laser technologies.

EXPLANATORY NOTE

Many of the items listed in this section come into direct contact with uranium metal vapor or liquid or with process gas consisting of  $UF_6$  or a mixture of  $UF_6$  and other gases. All surfaces that come into contact with the uranium or  $UF_6$  are wholly made of or protected by corrosion-resistant materials. For the purposes of the section relating to laser-based enrichment items, the materials resistant to corrosion by the vapor or liquid of uranium metal or uranium alloys include yttria-coated graphite and tantalum; and the materials resistant to corrosion by  $UF_6$  include copper, stainless steel, aluminium, aluminium alloys, nickel or alloys containing 60% or more nickel and  $UF_6$ -resistant fully fluorinated hydrocarbon polymers.

**5.7.1. Uranium vaporization systems (AVLIS)**

Especially designed or prepared uranium vaporization systems which contain high-power strip or scanning electron beam guns with a delivered power on the target of more than 2.5 kW/cm.

**5.7.2. Liquid uranium metal handling systems (AVLIS)**

Especially designed or prepared liquid metal handling systems for molten uranium or uranium alloys, consisting of crucibles and cooling equipment for the crucibles.

EXPLANATORY NOTE

The crucibles and other parts of this system that come into contact with molten uranium or uranium alloys are made of or protected by materials of suitable corrosion and heat resistance. Suitable materials include tantalum, yttria-coated graphite, graphite coated with other rare earth oxides or mixtures thereof.

**5.7.3. Uranium metal ‘product’ and ‘tails’ collector assemblies (AVLIS)**

Especially designed or prepared ‘product’ and ‘tails’ collector assemblies for uranium metal in liquid or solid form.

EXPLANATORY NOTE

SCH.1

Components for these assemblies are made of or protected by materials resistant to the heat and corrosion of uranium metal vapor or liquid (such as yttria-coated graphite or tantalum) and may include pipes, valves, fittings, 'gutters', feed-throughs, heat exchangers and collector plates for magnetic, electrostatic or other separation methods.

**5.7.4. Separator module housings (AVLIS)**

Especially designed or prepared cylindrical or rectangular vessels for containing the uranium metal vapor source, the electron beam gun, and the 'product' and 'tails' collectors.

EXPLANATORY NOTE

These housings have multiplicity of ports for electrical and water feed-throughs, laser beam windows, vacuum pump connections and instrumentation diagnostics and monitoring. They have provisions for opening and closure to allow refurbishment of internal components.

**5.7.5. Supersonic expansion nozzles (MLIS)**

Especially designed or prepared supersonic expansion nozzles for cooling mixtures of  $UF_6$  and carrier gas to 150 K or less and which are corrosion resistant to  $UF_6$ .

**5.7.6. Uranium pentafluoride product collectors (MLIS)**

Especially designed or prepared uranium pentafluoride ( $UF_5$ ) solid product collectors consisting of filter, impact, or cyclone-type collectors, or combinations thereof, and which are corrosion resistant to the  $UF_5/UF_6$  environment.

**5.7.7.  $UF_6$ /carrier gas compressors (MLIS)**

Especially designed or prepared compressors for  $UF_6$ /carrier gas mixtures, designed for long term operation in a  $UF_6$  environment. The components of these compressors that come into contact with process gas are made of or protected by materials resistant to corrosion by  $UF_6$ .

**5.7.8. Rotary shaft seals (MLIS)**

Especially designed or prepared rotary shaft seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor rotor with the driver motor so as to ensure a reliable seal against out-leakage of process gas or in-leakage of air or seal gas into the inner chamber of the compressor which is filled with a  $UF_6$ /carrier gas mixture.

**5.7.9. Fluorination systems (MLIS)**

Especially designed or prepared systems for fluorinating  $UF_5$  (solid) to  $UF_6$  (gas).

EXPLANATORY NOTE

These systems are designed to fluorinate the collected  $UF_5$  powder to  $UF_6$  for subsequent collection in product containers or for transfer as feed to MLIS units for additional enrichment. In one approach, the fluorination reaction may be accomplished within the isotope separation system to react and recover directly off the 'product' collectors. In another approach, the  $UF_5$  powder may be

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

removed/transferred from the 'product' collectors into a suitable reaction vessel (e.g., fluidized-bed reactor, screw reactor or flame tower) for fluorination. In both approaches, equipment for storage and transfer of fluorine (or other suitable fluorinating agents) and for collection and transfer of UF<sub>6</sub> are used.

**5.7.10. UF<sub>6</sub> mass spectrometers/ion sources (MLIS)**

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking 'on-line' samples of feed, 'product' or 'tails', from UF<sub>6</sub> 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.

**5.7.11. Feed systems/product and tails withdrawal systems (MLIS)**

Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by UF<sub>6</sub>, including:

- (a) Feed autoclaves, ovens, or systems used for passing UF<sub>6</sub> to the enrichment process;
- (b) Desublimers (or cold traps) used to remove UF<sub>6</sub> from the enrichment process for subsequent transfer upon heating;
- (c) Solidification or liquefaction stations used to remove UF<sub>6</sub> from the enrichment process by compressing and converting UF<sub>6</sub> to a liquid or solid form;
- (d) 'Product' or 'tails' stations used for transferring UF<sub>6</sub> into containers.

**5.7.12. UF<sub>6</sub>/carrier gas separation systems (MLIS)**

Especially designed or prepared process systems for separating UF<sub>6</sub> from carrier gas. The carrier gas may be nitrogen, argon, or other gas.

**EXPLANATORY NOTE**

These systems may incorporate equipment such as:

- (a) Cryogenic heat exchangers or cryoseparators capable of temperatures of -120°C or less, or
- (b) Cryogenic refrigeration units capable of temperatures of -120°C or less, or
- (c) UF<sub>6</sub> cold traps capable of temperatures of -20°C or less.

**5.7.13. Laser systems (AVLIS, MLIS and CRISLA)**

Lasers or laser systems especially designed or prepared for the separation of uranium isotopes.

**EXPLANATORY NOTE**

The laser system for the AVLIS process usually consists of two lasers: a copper vapor laser and a dye laser. The laser system for MLIS usually consists of a CO<sub>2</sub> or excimer laser

and a multi-pass optical cell with revolving mirrors at both ends. Lasers or laser systems for both processes require a spectrum frequency stabilizer for operation over extended periods of time. SCH.1

**5.8. Especially designed or prepared systems, equipment and components for use in plasma separation enrichment plants**

INTRODUCTORY NOTE

In the plasma separation process, a plasma of uranium ions passes through an electric field tuned to the U-235 ion resonance frequency so that they preferentially absorb energy and increase the diameter of their corkscrew-like orbits. Ions with a large-diameter path are trapped to produce a product enriched in U-235. The plasma, which is made by ionizing uranium vapor, is contained in a vacuum chamber with a high-strength magnetic field produced by a superconducting magnet. The main technological systems of the process include the uranium plasma generation system, the separator module with superconducting magnet and metal removal systems for the collection of 'product' and 'tails'.

**5.8.1. Microwave power sources and antennae**

Especially designed or prepared microwave power sources and antennae for producing or accelerating ions and having the following characteristics: greater than 30 GHz frequency and greater than 50 kW mean power output for ion production.

**5.8.2. Ion excitation coils**

Especially designed or prepared radio frequency ion excitation coils for frequencies of more than 100 kHz and capable of handling more than 40 kW mean power.

**5.8.3. Uranium plasma generation systems**

Especially designed or prepared systems for the generation of uranium plasma, which may contain high-power strip or scanning electron beam guns with a delivered power on the target of more than 2.5 kW/cm.

**5.8.4. Liquid uranium metal handling systems**

Especially designed or prepared liquid metal handling systems for molten uranium or uranium alloys, consisting of crucibles and cooling equipment for the crucibles.

EXPLANATORY NOTE

The crucibles and other parts of this system that come into contact with molten uranium or uranium alloys are made of or protected by materials of suitable corrosion and heat resistance. Suitable materials include tantalum, yttria-coated graphite, graphite coated with other rare earth oxides or mixtures thereof.

**5.8.5. Uranium metal 'product' and 'tails' collector assemblies**

Especially designed or prepared 'product' and 'tails' collector assemblies for uranium metal in solid form. These collector assemblies are made of or protected by materials resistant to the heat and corrosion of uranium metal vapor, such as yttria-coated graphite or tantalum.

SCH.1

**5.8.6. Separator module housings**

Cylindrical vessels especially designed or prepared for use in plasma separation enrichment plants for containing the uranium plasma source, radio-frequency drive coil and the 'product' and 'tails' collectors.

EXPLANATORY NOTE

These housings have a multiplicity of ports for electrical feed-throughs, diffusion pump connections and instrumentation diagnostics and monitoring. They have provisions for opening and closure to allow for refurbishment of internal components and are constructed of a suitable non-magnetic material such as stainless steel.

**5.9. Especially designed or prepared systems, equipment and components for use in electromagnetic enrichment plants**

INTRODUCTORY NOTE

In the electromagnetic process, uranium metal ions produced by ionization of a salt feed material (typically  $UCl_4$ ) are accelerated and passed through a magnetic field that has the effect of causing the ions of different isotopes to follow different paths. The major components of an electromagnetic isotope separator include: a magnetic field for ion-beam diversion/separation of the isotopes, an ion source with its acceleration system, and a collection system for the separated ions. Auxiliary systems for the process include the magnet power supply system, the ion source high-voltage power supply system, the vacuum system, and extensive chemical handling systems for recovery of product and cleaning/recycling of components.

**5.9.1. Electromagnetic isotope separators**

Electromagnetic isotope separators especially designed or prepared for the separation of uranium isotopes, and equipment and components therefor, including:

(a) Ion sources

Especially designed or prepared single or multiple uranium ion sources consisting of a vapor source, ionizer, and beam accelerator, constructed of suitable materials such as graphite, stainless steel, or copper, and capable of providing a total ion beam current of 50 mA or greater.

(b) Ion collectors

Collector plates consisting of two or more slits and pockets especially designed or prepared for collection of enriched and depleted uranium ion beams and constructed of suitable materials such as graphite or stainless steel.

(c) Vacuum housings

Especially designed or prepared vacuum housings for uranium electromagnetic separators, constructed of suitable non-magnetic materials such as stainless steel and designed for operation at pressures of 0.1 Pa or lower.

EXPLANATORY NOTE

SCH.1

The housings are specially designed to contain the ion sources, collector plates and water-cooled liners and have provision for diffusion pump connections and opening and closure for removal and reinstallation of these components.

(d) Magnet pole pieces

Especially designed or prepared magnet pole pieces having a diameter greater than 2 m used to maintain a constant magnetic field within an electromagnetic isotope separator and to transfer the magnetic field between adjoining separators.

**5.9.2. High voltage power supplies**

Especially designed or prepared high-voltage power supplies for ion sources, having all of the following characteristics: capable of continuous operation, output voltage of 20,000 V or greater, output current of 1 A or greater, and voltage regulation of better than 0.01% over a time period of 8 hours.

**5.9.3. Magnet power supplies**

Especially designed or prepared high-power, direct current magnet power supplies having all of the following characteristics: capable of continuously producing a current output of 500 A or greater at a voltage of 100 V or greater and with a current or voltage regulation better than 0.01% over a period of 8 hours.

**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

SCH.1

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 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 design 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 process, 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<sub>2</sub>S) especially designed or prepared for heavy water production utilizing

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

the water-hydrogen sulphide exchange process. These blowers or compressors have a throughput capacity greater than or equal to 56 m<sup>3</sup>/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<sub>2</sub>S service. SCH.1

**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.

**7. PLANTS FOR THE CONVERSION OF URANIUM AND EQUIPMENT ESPECIALLY DESIGNED OR PREPARED THEREFOR**

**INTRODUCTORY NOTE**

Uranium conversion plants and systems may perform one or more transformations from one uranium chemical species to another, including: conversion of uranium ore concentrates to UO<sub>3</sub>, conversion of UO<sub>3</sub> to UO<sub>2</sub>, conversion of uranium oxides to UF<sub>4</sub> or UF<sub>6</sub>, conversion of UF<sub>4</sub> to UF<sub>6</sub>, conversion of UF<sub>6</sub> to UF<sub>4</sub>, conversion of UF<sub>4</sub> to uranium metal, and conversion of uranium fluorides to UO<sub>2</sub>. Many of the key equipment items for uranium conversion plants are common to several segments of the chemical process industry. For example, the types of equipment employed in

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
Act 2003.

SCH.1

these processes may include: furnaces, rotary kilns, fluidized bed reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. However, few of the items are available “off-the-shelf”; most would be prepared according to the requirements and specifications of the customer. In some instances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (HF, F<sub>2</sub>, ClF<sub>3</sub>, and uranium fluorides). Finally, it should be noted that, in all of the uranium conversion processes, items of equipment which individually are not especially designed or prepared for uranium conversion can be assembled into systems which are especially designed or prepared for use in uranium conversion.

**7.1. Especially designed or prepared systems for the conversion of uranium ore concentrates to UO<sub>3</sub>**

EXPLANATORY NOTE

Conversion of uranium ore concentrates to UO<sub>3</sub> can be performed by first dissolving the ore in nitric acid and extracting purified uranyl nitrate using a solvent such as tributyl phosphate. Next, the uranyl nitrate is converted to UO<sub>3</sub> either by concentration and denitration or by neutralization with gaseous ammonia to produce ammonium diuranate with subsequent filtering, drying, and calcining.

**7.2. Especially designed or prepared systems for the conversion of UO<sub>3</sub> to UF<sub>6</sub>**

EXPLANATORY NOTE

Conversion of UO<sub>3</sub> to UF<sub>6</sub> can be performed directly by fluorination. The process requires a source of fluorine gas or chlorine trifluoride.

**7.3. Especially designed or prepared systems for the conversion of UO<sub>3</sub> to UO<sub>2</sub>**

EXPLANATORY NOTE

Conversion of UO<sub>3</sub> to UO<sub>2</sub> can be performed through reduction of UO<sub>3</sub> with cracked ammonia gas or hydrogen.

**7.4. Especially designed or prepared systems for the conversion of UO<sub>2</sub> to UF<sub>4</sub>**

EXPLANATORY NOTE

Conversion of UO<sub>2</sub> to UF<sub>4</sub> can be performed by reacting UO<sub>2</sub> with hydrogen fluoride gas (HF) at 300-500°C.

**7.5. Especially designed or prepared systems for the conversion of UF<sub>4</sub> to UF<sub>6</sub>**

EXPLANATORY NOTE

Conversion of UF<sub>4</sub> to UF<sub>6</sub> is performed by exothermic reaction with fluorine in a tower reactor. UF<sub>6</sub> is condensed from the hot effluent gases by passing the effluent stream through a cold trap cooled to -10°C. The process requires a source of fluorine gas.

[2003.] *Containment of Nuclear Weapons* [No. 35.]  
Act 2003.

**7.6. Especially designed or prepared systems for the conversion of UF<sub>4</sub> to U metal** SCH.1

EXPLANATORY NOTE

Conversion of UF<sub>4</sub> to U metal is performed by reduction with magnesium (large batches) or calcium (small batches). The reaction is carried out at temperatures above the melting point of uranium (1130°C).

**7.7. Especially designed or prepared systems for the conversion of UF<sub>6</sub> to UO<sub>2</sub>**

EXPLANATORY NOTE

Conversion of UF<sub>6</sub> to UO<sub>2</sub> can be performed by one of three processes. In the first, UF<sub>6</sub> is reduced and hydrolyzed to UO<sub>2</sub> using hydrogen and steam. In the second, UF<sub>6</sub> is hydrolyzed by solution in water, ammonia is added to precipitate ammonium diuranate, and the diuranate is reduced to UO<sub>2</sub> with hydrogen at 820°C. In the third process, gaseous UF<sub>6</sub>, CO<sub>2</sub>, and NH<sub>3</sub> are combined in water, precipitating ammonium uranyl carbonate. The ammonium uranyl carbonate is combined with steam and hydrogen at 500-600°C to yield UO<sub>2</sub>.

UF<sub>6</sub> to UO<sub>2</sub> conversion is often performed as the first stage of a fuel fabrication plant.

**7.8. Especially designed or prepared systems for the conversion of UF<sub>6</sub> to UF<sub>4</sub>**

EXPLANATORY NOTE

Conversion of UF<sub>6</sub> to UF<sub>4</sub> is performed by reduction with hydrogen.

### ANNEX III

To the extent that the measures in this Protocol involve nuclear material declared by the Community and without prejudice to Article 1 of this Protocol, the Agency and the Community shall cooperate to facilitate implementation of those measures and shall avoid unnecessary duplication of activities.

The Community shall provide the Agency with information relating to transfers, for both nuclear and non-nuclear purposes, from each State to another Member State of the Community and to such transfers to each State from another Member State of the Community that corresponds to the information to be provided under Article 2.a.(vi)(b) under Article 2.a.(vi)(c) in relation to exports and imports of source material which has not reached the composition and purity suitable for fuel fabrication or for being isotopically enriched.

Each State shall provide the Agency with information relating to transfers to or from another Member State of the Community that corresponds to the information on specified equipment and non-nuclear material listed in Annex II of this Protocol to be provided under Article 2.a.(ix)(a) in relation to exports and, upon specific request of the Agency, under Article 2.a.(ix)(b) in relation to imports.

With regard to the Community's Joint Research Centre, the Community shall also implement the measures which this Protocol sets

[No. 35.] *Containment of Nuclear Weapons* [2003.]  
*Act 2003.*

SCH.1

out for States, as appropriate in close collaboration with the State on whose territory an establishment of the Centre is located.

The Liaison Committee, established under Article 25(a) of the Protocol referred to in Article 26 of the Safeguards Agreement, will be extended in order to allow for participation by representatives of the States and adjustment to the new circumstances resulting from this Protocol.

For the sole purposes of the implementation of this Protocol, and without prejudice to the respective competences and responsibilities of the Community and its Member States, each State which decides to entrust to the Commission of the European Communities implementation of certain provisions which under this Protocol are the responsibility of the States, shall so inform the other Parties to the Protocol through a side letter. The Commission of the European Communities shall inform the other Parties to the Protocol of its acceptance of any such decisions.