Annex IV*
Nuclear-Related Dual-Use Equipment, Material, Software, and Related Technology

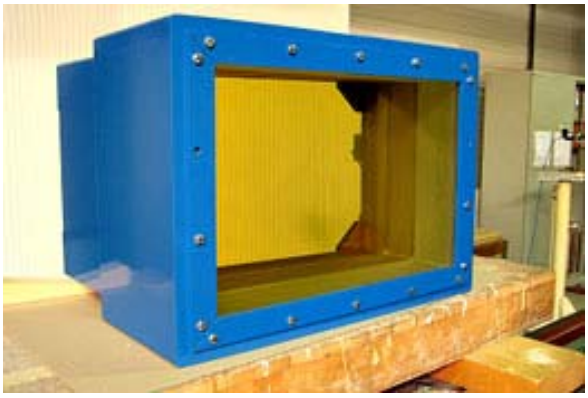
Pursuant to paragraph 5 (b) of resolution 2087 (2013), the items contained in this document are subject to the provisions of paragraph 8 (a), 8 (b) and 8 (c) of resolution 1718 (2006) under the DPRK sanctions regime;
and resolution 1929 (2010) under the Iran sanctions regime
(corresponding with document INF/CIRC/254/Rev.8/Part2)

* Annex IV to Enrico Carisch and Loraine Rickard-Martin, "United Nations Sanctions on Iran and North Korea: An Implementation Manual," New York: International Peace Institute. March 2014.

INDUSTRIAL EQUIPMENT

1.A. EQUIPMENT, ASSEMBLIES, AND COMPONENTS INFCIRC/254/Rev.8/Part2 ANNEX

1.A.1. High-density (lead glass or other) radiation shielding windows, having all of the following characteristics, and specially designed frames therefor:



Source: http://www.sovis-optique.com/en/sovis-optique-radiation-radiation-shielding-windows.html
High-density (lead glass or other) radiation shielding windows, having all of the following characteristics, and specially designed frames therefor:

(a) A "cold area" greater than 0.09 m^2
(b) A density greater than 3 g/cm^3
(c) A thickness of 100 mm or greater.

Note: the term "cold area" means the viewing area of the window exposed to the lowest level of radiation in the design application..

SCHOTT (www.schott.com) and Sovis Glass Solutions (www.sovis-optique.com) both manufacture radiation-shielding glass. Other producers likely include other materials companies specializing in glass of various kinds.

1.A.2. Radiation-hardened TV cameras, or lenses therefor, specially designed or rated as radiation hardened to withstand a total radiation dose greater than 5 x 104 Gy (silicon) without operational degradation.

Radiation-hardened TV cameras, or lenses therefor, especially designed or rated as radiation hardened to withstand a total radiation dose of greater than 5 x 10^4 Gy (silicon) without operational degradation. Note: The term Gy (silicon) refers to the energy in joules

per kilogram absorbed by an unshielded silicon sample when exposed to ionizing radiation. Image: http://www.ahlberg-electronics.com/products/product/u/Color-MRAD-S-PTZ?cat=12 Ahlberg Electronics is a supplier of radiation-resistant electronic equipment for more than 25% of nuclear power plants worldwide. Other electronics companies also have radiation-resistant products designed for nuclear use.

1.A.3. "Robots," "end-effectors," and control units

Source: http://sine.ni.com/cs/app/doc/p/id/cs-15678

"Robots," "end-effectors," and control units as follows:

(a) "Robots" or "end-effectors" having either of the following characteristics:
    1. Specially designed to comply with national safety standards applicable to handling high explosives (e.g., meeting electrical code ratings for high explosives) or
    2. Specially designed or rated as radiation hardened to withstand a total radiation dose greater than 5×10^4 Gy (silicon) without operational degradation.

    Technical Note: The term Gy (silicon) refers to the energy in joules per kilogram absorbed by an unshielded silicon sample when exposed to ionizing radiation.

(b) Control units specially designed for any of the "robots" or "end-effectors" specified in this section.

Note: this does not affect control robots especially designed for non-nuclear industrial applications, e.g., automobile paint-spraying robots.

Technical Notes: "robot" in this entry refers to a manipulation mechanism, which may be of the continuous path or of the point-to-point variety, which may use "sensors," and has all of the following characteristics:

(a) is multifunctional
(b) is capable of positioning or orienting material parts, tools, of special devices through variable movements in three-dimensional space
(c) incorporates three or more closed or open loop servo-devices which may include stepping motors,

(d) has "user-accessible programmability" by means of teach/playback method or by means of an electronic computer which may be a programmable logic controller—i.e., without mechanical intervention.

(NB1) In the above definition, "sensors" means detectors of a physical phenomenon, the output of which (after conversion into a signal that can be interpreted by a control unit) is able to generate "programs" or modify programmed instructions or numerical "program" data. This includes "sensors" with machine vision, infrared imaging, acoustical imaging, tactile feel, inertial position measuring, optical or acoustic ranging or force and torque measuring capabilities.

(NB2) In the above definition, "user-accessible programming" means the facility allowing a user to insert, modify, or replace "programs" by means other than:
(a) a physical change in wiring or interconnections or
(b) the setting of function controls including entry of parameters.

(NB3) The above definition does not include the following devices:
(a) Manipulation mechanisms which are only manually/teleoperator controllable.
(b) Fixed sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by the fixed stops, such as pins of cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic, or electrical means.
(c) Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by fixed, but adjustable, stops such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed "program" pattern. Variations or modifications of the "program" pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations.
(d) Non-servo controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The "program" is variable but the sequence proceeds only from the binary signal from mechanically fixed electrical binary devices or adjustable stops.
(e) Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval. "End-effectors": "end-effectors" are grippers, "active tooling units," and any other tooling that is attached to the baseplate on the end of a "robot" manipulator arm.

(NB) In the above definition, "active tooling units" is a device for applying motive power, process energy, or sensing to the workpiece.

1.A.4. Remote manipulators that can be used to provide remote actions in radiochemical separation operations or hot cells

Source: http://www.rri.kyoto-u.ac.jp/en/facilities/hl

Source: http://en.wikipedia.org/wiki/Remote_manipulator

Remote manipulators that can be used to provide remote actions in radiochemical separation operations or hot cells, having either of the following characteristics:

(a) A capability of penetrating .6 m or more of a hot cell wall (through-the-wall operation)
(b) A capability of bridging over the top of a hot cell wall with a thickness of 0.6 m or more (over-the-wall operation).

Technical Note: Remote manipulators provide translation of human operator actions to a remote operating arm and terminal fixture. They may be of a master/slave type or operated by joystick and keypad.

Companies involved in the production of remote manipulators for nuclear use include Kraft Telerobotics, James Fisher Nuclear, Cavendish Nuclear, and PaR Nuclear. Companies involved in the manufacture of nuclear-level remote manipulators may be subsidiaries or branches of companies that create robotic manipulators for non-nuclear use.

INDUSTRIAL EQUIPMENT

1.B. TEST AND PRODUCTION EQUIPMENT INFCIRC/254/Rev.8/Part2 ANNEX

1.B.1. Flow-Forming Machines, Spin-Forming Machines Capable of Flow-Forming Functions, and Mandrels

Flow-forming machines, spin-forming machines capable of flow-forming functions, and mandrels, as follows:

(a) Machines having both of the following characteristics:
   1. Three or more rollers (active or guiding); and
   2. According to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control.

(b) Rotor-forming mandrels designed to form cylindrical rotors of inside diameter between 75 and 400 mm.

Photo Source: http://pollack.armscontrolwonk.com/archive/4026/north-korean-flow-forming-lathes

Note: These definition(s) include machines that have only a single roller designed to deform metal plus two auxiliary rollers which support the mandrel, but do not directly participate in the deformation process.

1.B.2. Machine tools and any combination thereof, for removing or cutting metals, ceramics, or composites, which, according to the manufacturer's technical specifications, can be equipped with electronic devices for simultaneous "contouring control" in two or more axes

Machine tools, as follows, and any combination thereof, for removing or cutting metals, ceramics, or composites, which, according to the manufacturer's technical specifications, can be equipped with electronic devices for simultaneous "contouring control" in two or more axes. (NB) For "numerical control" units controlled by their associated software, see Item 1.D.3. on this sheet.

(a) Machine tools for turning, that have "positioning accuracies" with all compensations available better (less) than 6 μm according to ISO 320/2 (1998) along any linear axes (overall positioning) for machines capable of machining diameters greater than 35 mm.
   Note: Item 1.B.2.a does not control bar machines (Swissturn) limited to machining only bar feed thru, if maximum bar diameter is equal to or less than 42 mm and there has no capability of mounting chucks. Machines may have drilling and/or milling capabilities for machining parts with diameters less than 42 mm.

(b) Machine tools for milling, having any of the following characteristics:
  (1) "Positioning accuracies" with all compensations available better (less) than 6 μm according to ISO 320/2 (1998) along any linear axes (overall positioning)
  (2) Two or more contouring rotary
  (3) Five or more axes which can be coordinated simultaneously for "contouring control."
  Note: Item 1.B.2.b. does not control milling machines having both of the following characteristics:
    (1) X-axis travel greater than 2
    (2) Overall "positioning accuracy" on the x-axis worse (more) than 30 μm according to ISO 230/2 (1988).

(c) Machine tools for grinding, having any of the following characteristics:
  (1) "Positioning accuracies" with all compensations available better (less) than 4 μm according to ISO 230/2 (1988) along any linear axis (overall positioning)
  (2) Two or more contouring rotary axes
  (3) Five or more axes which can be coordinated simultaneously for "contouring control."
  Note: Item 1.B.2.c. does not control grinding machines as follows:
    (1) Cylindrical external, internal, and external-internal grinding machines having all the following characteristics: Limited to a maximum workpiece capacity of 150 mm outside diameter or length and axes limited to x, z, and c.
    (2) Jig grinders that do not have a z-axis or a w-axis with an overall positioning accuracy of less (better) than 4 microns. Positioning accuracy is according to ISO 230/2 (1988).

(d) Non-wire type Electrical Discharge Machines (EDM) that have two or more contouring rotary axes and can be coordinated simultaneously for "contouring control."

Notes:

(1) Stated "positioning accuracy" levels derived under procedures from measurements according to ISO 230/2 (1988) or national equivalents may be used for each machine tool model if provided to, and accepted by, national authorities instead of individual machine tests. [See ISO 230/2 for positioning accuracy derivation protocol].

(2) Item 1.B.2 does not control special purpose machine tools limited to the manufacture of any of the following parts: Gears, crankshafts or cam shafts, tools or cutters, extruder worms.

Technical Notes:

(1) Axis nomenclature shall be in accordance with International Standard ISO 841, "Numerical Control Machines - Axis and Motion Nomenclature."

(2) Not counted in the total number of contouring axes are secondary parallel contouring axes (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centerline of which is parallel to the primary rotary axis).

(3) Rotary axes do not necessarily have to rotate over 360 degrees. A rotary axis can be driven by a linear device, e.g., a screw or a rack-and-pinion.

(4) For the purposes of 1.B.2. the number of axes which can be coordinated simultaneously for "contouring control" is the number of axes along or around with, during processing of the workpiece, simultaneous and interrelated motions are performed between the workpiece and a

rool. This does not include any additional axes along or around which other relative motions within the machine are performed, such as:

(a) Wheel-dressing systems in grinding machines;
(b) Parallel rotary axes designed for mounting of separate workpieces
(c) Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.

(5) A machine tool having at least 2 of the 3 turning, milling, or grinding capabilities (e.g., a turning machine with milling capability) must be evaluated against each applicable entry, 1.B.2.a, 1.B.2.b, and 1.B.2.c.
(6) Items 1.B.2.b.3 and 1.B.2.c.3 include machines based on a parallel linear kinematic design (e.g., hexapods) that have 5 or more axes none of which are rotary axes.

1.B.3. Dimensional Inspection Machines, Instruments, or Systems

Dimensional inspection machines, instruments, or systems, as follows:

(a) Computer controlled or numerically controlled coordinate measuring machines (CMM) having both of the following characteristics:
  (1) Two or more axes and
  (2) A maximum permissible error of length measurement (E0, MPE) along any axis (one dimensional), identified as E0x, E0y, or E0z, equal to or less (better) than 1.25 + L/1000 μm (where L is the measured length in mm) at any point within the operating range of the machine (i.e., within the length of the axis), tested according to ISO 10360-2(2009).
(b) Linear displacement measuring instruments as follows:
  (1) Non-contact type measuring systems with a "resolution" equal to or better (less) than 0.2 μm within a measuring range up to 0.2 mm;
  (2) Linear variable differential transformer (LVDT) systems having both of the following characteristics:
    (a) "Linearity" equal to or better (less) than 0.1% within a measuring range up to 5 mm;
    (b) Drift equal to or better (less) than 0.1% per day at a standard ambient test room temperature ± 1 K
  (3) Measuring systems having both of the following characteristics:
    (a) Contain a laser and
    (b) Maintain for at least 12 hours, over a temperature range of ± 1 K around a standard temperature and a standard pressure:
      (1) A "resolution" over their full scale of 0.1 μm or better;
      (2) With a "measurement uncertainty" equal to or better (less) than 0.2 + L/2000 μm (L is the measured length in millimeters).

  Note: Item 1.B.3.b.3. does not control measuring interferometer systems, without closed or open loop feedback, containing a laser to measure slide movement errors of machine tools, dimensional inspection machines, or similar equipment.

  Technical Note: In Item 1.B.3.b. "linear displacement" means the change of distance between the measuring probe and the measured object.

(c) Angular displacement measuring instruments having an "angular position deviation" equal to or better (less) than 0.00025°.
Note: Item 1.B.3.c. does not control optical instruments, such as autocollimators, using collimated light (e.g., laser light) to detect angular displacement of a mirror.
(d) Systems for simultaneous linear angular inspection of hemishells, having both of the following characteristics:
(1) "Measurement uncertainty" along any linear axis equal to or better (less) than 3.5 μm per 5 mm; and
(2) "Angular position deviation" equal to or less than 0.02°.

Note:
(1) Item 1.B.3. includes machine tools that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function.
(2) Machines described in Item 1.B.3. are controlled if they exceed the threshold specified anywhere within their operating range.

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

1.B.4. Controlled Atmosphere (Vacuum or Inert Gas) Induction Furnaces and Power Supplies

Controlled atmosphere (vacuum or inert gas) induction furnaces, and power supplies therefor, as follows:

(a) Furnaces having all of the following characteristics:
(1) Capable of operation at temperatures above 1123 K (850° C);
(2) Induction coils 600 mm or less in diameter and
(3) Designed for power inputs of kW or more
Note: Item 1.B.4.a does not control furnaces designed for the processing of semiconductor wafers.
(b) Power supplies, with a specified power output of 5 kW or more, specially designed for furnaces specified in Item 1.b.4.a

Retech Systems LLC is one company that produces controlled-atmosphere metallurgy-related products, and is a (self-described) global leader in the field. Other companies involved in the vacuum metallurgy field include Edwards Vacuum and PVA TePla.

1.B.5. Isostatic Presses and Related Equipment

"Isostatic presses," and related equipment, as follows:
(a) "Isostatic presses" having both of the following characteristics:
(1) Capable of achieving a maximum working pressure of 69 MPa or greater; and
(2) A chamber cavity with an inside diameter in excess of 152 mm;

(b) Dies, molds, and controls specially designed for the "isostatic presses" specified in Item 1.B.5.a. Technical Notes:
   (1) In Item 1.B.5. "Isostatic presses" means equipment capable of pressurizing a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal pressure in all directions within the cavity upon a workpiece or material.
   (2) In Item 1.B.5. the inside chamber dimension is that of the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other.

Image: http://nanfang-crown.en.made-in-china.com/productimage/SbzxwjWdGuVs-2f1j00SCDtwFodPIqO/China-Isostatic-Pressing-Machine.html

1.B.6. Vibration Test Systems, Equipment, and Components

Vibration test systems, equipment, and components as follows:

(a) Electrodynamic vibration test systems, having all of the following characteristics:
   (1) Employing feedback or closed loop control techniques and incorporating a digital control unit;
   (2) Capable of vibrating at 10 g RMS or more between 20 and 2000 Hz; and
   (3) Capable of imparting forces of 50 kN or greater measured "bare table"
(b) Digital control units, combined with "software" specially designed for vibration testing, with a real-time bandwidth greater than 5 kHz and being designed for a system specified in Item 1.B.6.a.
(c) Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force of 50 kN or greater measured "bare table," which are usable for the systems specified in Item 1.B.6.a.
(d) Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force of 50 kN or greater, measured "bare table" which are usable for the systems specified in Item 1.B.6.a.

Technical Note: In Item 1.B.6. "bare table" means a flat table, or surface, with no fixtures or fittings.

1.B.7. Vacuum or Other Controlled Atmosphere Metallurgical Melting and Casting Furnaces and Related Equipment

Vacuum or other controlled atmosphere metallurgical melting and casting furnaces and related equipment, as follows:

(a) Arc remelt and casting furnaces having both of the following characteristics:
  (1) Consumable electrode capacities between 1000 and 20000 cm3; and
  (2) Capable of operating with melting temperatures above 1973 K (1700° C).
(b) Electron beam melting furnaces and plasma atomization and melting furnaces, having both of the following characteristics:
  (1) A power of 50 kW or greater; and
  (2) Capable of operating with melting temperatures above 1473 K (1200° C)
(c) Computer control and monitoring systems specially configured for any of the furnaces specified in Item 1.B.7.a. or 1.B.7.b.

Image: http://www.hellotrade.com/seco-warwick/vacuum-induction-melting-vim.html.

Retech Systems LLC is a company that produces controlled-atmosphere metallurgy-related products, and is a (self-described) global leader in the field. Other companies involved in the vacuum metallurgy field includes Edwards Vacuum and PVA TePla.

INDUSTRIAL EQUIPMENT

1.D. SOFTWARE INFCIRC/254/Rev.8/Part2 ANNEX

1.D.1. "Software" Specially Designed for the "Use" of Equipment Specified in Item 1.A.3., 1.B.1., 1.B.3., 1.B.5., 1.B.6.a., 1.B.6.b., 1.B.6.d. or 1.B.7.

Note: "Software" specially designed for systems specified in Item 1.B.3.d. includes "software" for simultaneous measurements of wall thickness and contour.

1.D.2. "Software" Specially Designed or Modified for the "Development," "Production" or "Use" of Equipment Specified in Item 1.B.2.

1.D.3. "Software" For Any Combination of Electronic Devices or System Enabling Such Device(s) To Function As A "Numerical Control" Unit Capable Of Controlling Five Or More Interpolating Axes That Can Be Coordinated Simultaneously For "Contouring Control."

Notes:

(1) "Software" is controlled whether exported separately or residing in a "numerical control" unit or any electronic device or system.
(2) Item 1.D.3. does not control "software" specially designed or modified by the manufacturers of the control unit or machine tool to operate a machine tool that is not specified in Item 1.B.2.

INDUSTRIAL EQUIPMENT

1.E. TECHNOLOGY INFCIRC/254/Rev.8/Part2 ANNEX

1.E.1. "Technology" According to the Technology Controls for the "Development," "Production" or "Use" of Equipment, Material or "Software" Specified in 1.A. Through 1.D.

No further information.

MATERIALS

2.A. EQUIPMENT, ASSEMBLIES, AND COMPONENTS INFCIRC/254/Rev.8/Part2 ANNEX

2.A.1. Crucibles Made of Materials Resistant to Liquid Actinide Metals

(a) Crucibles having both of the following characteristics:
  (1) A volume of between 150 cm^3 (150 ml) and 8000 cm^3 (8 liters); and
  (2) Made of or coated with any of the following materials, having a purity of 98% or greater by weight:
    (a) Calcium fluoride (CaF2)
    (b) Calcium zirconate (metazirconate) (CaZrO3)
    (c) Cerium sulfide (Ce2S3)
    (d) Erbium oxide (erbia) (Er2O3)
    (e) Hafnium oxide (hafnia) (HfO2)
    (f) Magnesium oxide (MgO)
    (g) Nitrided niobium-titanium-tungsten alloy (approximately 50% Nb, 30% Ti, 20% W)
    (h) Yttrium oxide (yttria) (Y2O3); or
    (i) Zirconium oxide (zirconia) (ZrO2)
(b) Crucibles having both of the following characteristics:
  (1) A volume of between 50 cm^3 (50 ml) and 2000 cm^3 (2 liters); and
  (2) Made of or lined with tantalum, having a purity of 99.9% or greater by weight
(c) Crucibles having all of the following characteristics:
  (1) A volume of between 50 cm^3 (50 ml) and 2000 cm^3 (2 liters);
  (2) Made of or lined with tantalum, having a purity of 98% or greater by weight; and
  (3) Coated with tantalum carbide, nitride, boride, or any combination thereof.

Generally produced by materials and metal technology companies. These include MTI Albany and American Elements, among others.

One company, MTI Albany, lists a tantalum laboratory crucible with 1000 ml capacity at $1536, with the crucible covering costing another $563.

2.A.2. Platinized catalysts specially designed or prepared for promoting the hydrogen isotope exchange reaction between hydrogen and water for the recovery of tritium from heavy water or for the production of heavy water.

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

2.A.3. Composite structures in the form of tubes having both of the following characteristics

Composite structures in the form of tubes having both of the following characteristics:

(a) An inside diameter of between 75 and 400 mm;
(b) Made with any of the "fibrous or filamentary materials" specified in Item 2.C.7.a. or carbon prepreg materials specified in Item 2.C.7.c.

MATERIALS

2.B. TEST AND PRODUCTION EQUIPMENT INFCIRC/254/Rev.8/Part2 ANNEX

2.B.1. Tritium Facilities or Plants, and Equipment

Source:
http://commons.wikimedia.org/wiki/File:Tritium_processing_at_the_National_Ignition_Facility.jpg

Tritium facilities or plants, and equipment therefor, as follows:

(a) Facilities or plants for the production, recovery, extraction, concentration, or handling of tritium.
(b) Equipment for tritium plants or facilities or plants, as follows:
    (1) Hydrogen or helium refrigeration units capable of cooling to 23 K (-250° C) or less, with heat removal capacity greater than 150 W;

(2) Hydrogen isotope storage or purification systems using metal hydrides as the storage or purification medium.

2.B.2. Lithium Isotope Separation Facilities or Plants, and Equipment

Lithium isotope separation facilities or plants, and equipment therefore, as follows:

(a) Facilities or plants for the separation of lithium isotopes;
(b) Equipment for the separation of lithium isotopes, as follows:
  (1) Packed liquid-liquid exchange columns specially designed for lithium amalgams;
  (2) Mercury or lithium amalgam pumps;
  (3) Lithium amalgam electrolysis cells;
  (4) Evaporators for concentrated lithium hydroxide solution.

MATERIALS

2.C. MATERIALS INFCIRC/254/Rev.8/Part2 ANNEX

2.C.1. Aluminum Alloys

Aluminum Alloy Ingot
Source: http://www.metchem.com.pk/products4_02.html

Source: http://www.made-in-china.com/showroom/product-images/China-Free-Cutting-Extrusion-Aluminium-Alloy-HdrZXZpbgc-gerxivsUgHWp.html
Aluminum alloys having both of the following characteristics:

(a) "Capable of" an ultimate tensile strength of 460 MPa or more at 293 K (20° C);
(b) In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.

Technical Note: In Item 2.C.1. the phrase "capable of" encompasses aluminum alloys before or after heat treatment.

There are many aluminum alloy manufacturers worldwide who could produce aluminum and aluminum alloys of the type described above. These are typically materials companies. Some examples include Smith Advanced Metals, and Kaiser Aluminum. Note that aluminum meeting the tensile strength and heat-resistance characteristics is often used in the aerospace industry.

2.C.2. Beryllium Metal, Alloys Containing More Than 50% Beryllium by Weight, Beryllium Compounds, Manufactures Thereof

Beryllium
Source: http://www.daviddarling.info/encyclopedia/B/beryllium.html

Beryllium copper alloy bars. Source:
http://www.diytrade.com/china/pd/10055750/UNS_C17200_beryllium_copper_square_bar.html

Beryllium metal, alloys containing more than 50% beryllium by weight, beryllium compounds, manufactures thereof, and waste or scrap of any of the former. Note: Item 2.C.2. does not control the following:

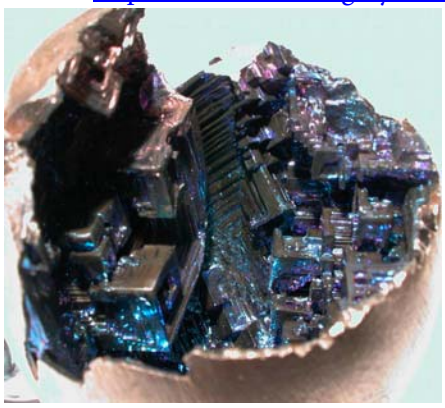
(a) Metal windows for X-ray machines or for bore-hole logging devices;
(b) Oxide shapes in fabricated or semi-fabricated forms specially designed for electronic component parts or as substrates for electronic circuits;
(c) (c) Beryl (silicate of beryllium and aluminum) in the form of emeralds or aquamarines.

Image: Raw Beryllium ore. Source: periodictable.com

As with many other high-purity elements /element compounds in section 2.C, the primary producers of these products are materials companies or companies with significant resources invested in rare earth elements. Individual companies will vary based on the specific material. The price for vacuum-cast beryllium ingots on the American market was ~$745/kilo in 2001 (via US geological survey).

2.C.3. Bismuth

Source: http://www.theodoregray.com/periodictable/Elements/083/index.s14.html#sample1



Source: http://www.theodoregray.com/periodictable/Elements/083/index.s14.html#sample2

Bismuth having both of the following characteristics:

(a) A purity of 99.99% or greater by weight,

(b) and (b) Containing less than 10 parts per million by weight of silver.

Image: High-purity bismuth image from periodictable.com

As with many other high-purity element /element compounds in section 2.C, the primary producers of these products are materials companies or companies with significant resources invested in rare earth elements. Individual companies will vary based on the specific material.

2.C.4. Boron Enriched In the Boron-10 (10b) Isotope to Greater Than Its Natural Isotopic Abundance, As Follows: Elemental Boron, Compounds, Mixtures Containing Boron, Manufactures Thereof

Boron enriched in the boron-10 (10B) isotope to greater than its natural isotopic abundance, as follows: elemental boron, compounds, mixtures containing boron, manufactures thereof, waste or scrap of any of the former.

Note: In Item 2.C.4. mixtures containing boron include boron loaded materials.

Technical Note: The natural isotopic abundance of boron-10 is approximately 18.5 weight % (20 atom %).

As with many other high-purity element /element compounds in section 2.C, the primary producers of these products are chemical or materials companies or companies with significant resources invested in rare earth elements. Individual companies will vary based on the specific material.

2.C.5. Calcium

Calcium having both of the following characteristics:

(a) Containing less than 1000 parts per million by weight of metallic impurities other than magnesium, and
(b) Containing less than 10 parts per million by weight of boron. Image: high-purity calcium

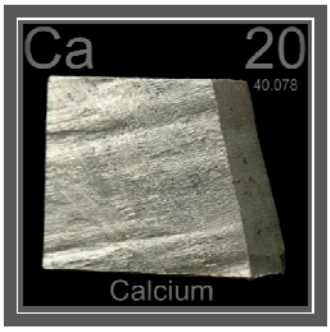


Image from periodictable.com

As with many other high-purity element /element compounds in section 2.C, the primary producers of these products are chemical or materials companies or companies with significant resources invested in rare earth elements. Individual companies will vary based on the specific material.

2.C.6. Chlorine Trifluoride (ClF3).

2.C.7. "Fibrous or Filamentary Materials" and Prepregs

Fibrous or filamentary materials, and prepregs (cloth-like material made of fibers and impregnated with resins), as follows:

(a) Carbon or aramid "fibrous or filamentary materials" having either of the following characteristics:
  (1) A "specific modulus" of 12.7 x 10^6 m or greater; or
  (2) A "specific tensile strength" of 23.5 x10^4 m or greater;
  Note: Item 2.C.7.a. does not control aramid "fibrous or filamentary materials" having 0.25% or more by weight of an ester based fiber surface modifier.

(b) Glass "fibrous or filamentary materials" having both of the following characteristics:

(c) (1) A "specific modulus" of 3.18 x 10^6 m or greater, and (2) A "specific tensile strength" of 7.62 x 10^4 m or greater.

(d) Thermoset resin impregnated continuous "yarns," "rovings," "tows" or "tapes" with a width of 15 mm or less (prepregs), made from carbon or glass "fibrous or filamentary materials" specified in Item 2.C.7.a. or Item 2.C.7.b.
  Technical Note: The resin forms the matrix of the composite.
  Technical Note 1: In Item 2.C.7. "Specific modulus" is the Young´s modulus in N/m^2 divided by the specific weight in N/m^3 when measured at a temperature of 296 ± 2 K (23 ± 2° C) and a relative humidity of 50 ± 5%.
  Technical Note 2: In Item 2.C.7. "Specific tensile strength" is the ultimate tensile strength in N/m^2 divided by the specific weight in N/m^3 when measured at a temperature of 296 ± 2 K (23 ± 2° C) and a relative humidity of 50 ± 5%.

2.C.8. Hafnium Metal, Alloys Containing More Than 60% Hafnium by Weight, Hafnium Compounds Containing More Than 60% Hafnium by Weight, Manufactures Thereof

Source: http://www.atimetals.com/Documents/hafnium_v1.pdf

Source: http://www.atimetals.com/products/Pages/hafnium-alloy-addition.aspx#ChipsSpecs

Hafnium metal, alloys containing more than 60% hafnium by weight, hafnium compounds containing more than 60% hafnium by weight, manufactures thereof, and waste or scrap of any of the former.

Image: high-purity hafnium from periodictable.com

As with many other high-purity element/element compounds in section 2.C, the primary producers of these products are chemical or materials companies or companies with significant resources invested in rare earth elements. Individual companies will vary based on the specific material.

2.C.9. Lithium Enriched In the Lithium-6 (6li) Isotope to Greater Than Its Natural Isotopic Abundance and Products or Devices Containing Enriched Lithium, as Follows: Elemental Lithium, Alloys, Compounds, Mixtures Containing Lithium, Manufactures Thereof

Source for both pictures: http://www.webelements.com/lithium/pictures.html

Lithium enriched in the lithium-6 (6Li) isotope to greater than its natural isotopic abundance and products or devices containing enriched lithium, as follows: elemental lithium, alloys, compounds, mixtures containing lithium, manufactures thereof, waste or scrap of any of the former.

Note: Item 2.C.9. does not control thermo-luminescent dosimeters.

Technical Note: The natural isotopic abundance of lithium-6 is approximately 6.5 weight % (7.5 atom %).

2.C.10. Magnesium

Source: http://www.911metallurgist.com/blog/wp-content/uploads/2013/09/3680979_orig.jpg

Magnesium having both of the following characteristics:

(a) Containing less than 200 parts per million by weight of metallic impurities other than calcium and
(b) Containing less than 10 parts per million by weight of boron.

Image: high-purity magnesium from periodictable.com

As with many other high-purity elements/element compounds in section 2.C, the primary producers of these products are chemical or materials companies or companies with significant resources invested in rare earth elements. Individual companies will vary based on the specific material.

2.C.11. Maraging Steel "Capable Of" an Ultimate Tensile Strength Of 2050 MPa Or More At 293 K (20° C)

Source: am.ru/index.php?id_page=52&language=en

Source: http://trade.indiamart.com/details.mp?offer=3874174548

Maraging steel "capable of" an ultimate tensile strength of 2050 MPa or more at 293 K (20° C).

Note: Item 2.C.11. does not control forms in which all linear dimensions are 75 mm or less.

Technical Note: In Item 2.C.11. the phrase "capable of" encompasses maraging steel before or after heat treatment.

2.C.12. Radium-226 (226ra), Radium-226 Alloys, Radium-226 Compounds, Mixtures Containing Radium-226, Manufactures Thereof

Source: http://commons.wikimedia.org/wiki/File:Radium-226.jpg

Radium-226 (226Ra), radium-226 alloys, radium-226 compounds, mixtures containing radium-226, manufactures thereof, and products or devices containing any of the former.

Note: Item 2.C.12. does not control the following:

(a) Medical applicators;

(b) A product or device containing less than 0.37 GBq of radium-226.

2.C.13. Titanium Alloys

Source: http://www.globalsources.com/gsol/I/Titanium-pipe/p/sm/1065767573.htm#1065767573

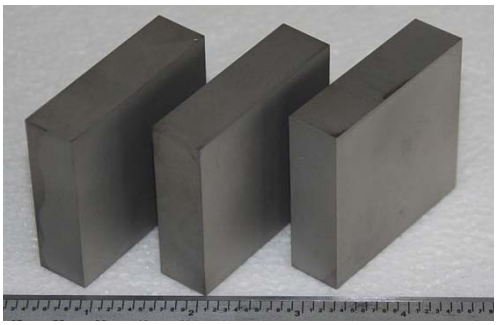
Source: http://news.thomasnet.com/fullstory/Carbide-End-Mills-cut-ferrous-high-temperature-and-titanium-alloys-15845

Titanium alloys having both of the following characteristics:

(a) "Capable of" an ultimate tensile strength of 900 MPa or more at 293 K (20° C);
(b) In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.

Technical Note: In Item 2.C.13. the phrase "capable of" encompasses titanium alloys before or after heat treatment.

2.C.14. Tungsten, Tungsten Carbide, And Alloys Containing More Than 90% Tungsten By Weight



Source: http://commons.wikimedia.org/wiki/File:Tungsten_Carbide_Block.jpg

Source: http://www.best-carbide.com/Tungsten-carbide-rods-21.html

Tungsten, tungsten carbide, and alloys containing more than 90% tungsten by weight, having both of the following characteristics:

(a) In forms with a hollow cylindrical symmetry (including cylinder segments) with an inside diameter between 100 and 300 mm, and
(b) A mass greater than 20 kg.

Note: Item 2.C.14. does not control manufactures specially designed as weights or gamma-ray collimators.

2.C.15. Zirconium with a Hafnium Content Of Less Than 1 Part Hafnium To 500 Parts Zirconium By Weight, As Follows: Metal, Alloys Containing More Than 50% Zirconium By Weight, Compounds, Manufactures Thereof

Source: http://en.wikipedia.org/wiki/File:Zirconium_crystal_bar_and_1cm3_cube.jpg

Zirconium with a hafnium content of less than 1 part hafnium to 500 parts zirconium by weight, as follows: metal, alloys containing more than 50% zirconium by weight, compounds, manufactures thereof, waste of or scrap of any of the former. Note: Item 2.C.15. does not control zirconium in the form of foil having a thickness of 0.10 mm or less.

2.C.16. Nickel Powder And Porous Nickel Metal

Source: http://www.natureer.com/Organic-compounds/Nickel-powder.html

Nickel powder and porous nickel metal as follows: (NB) For nickel powders which are especially prepared for the manufacture of gaseous diffusion barriers see INFCIRC/254/Part 1 (as amended).

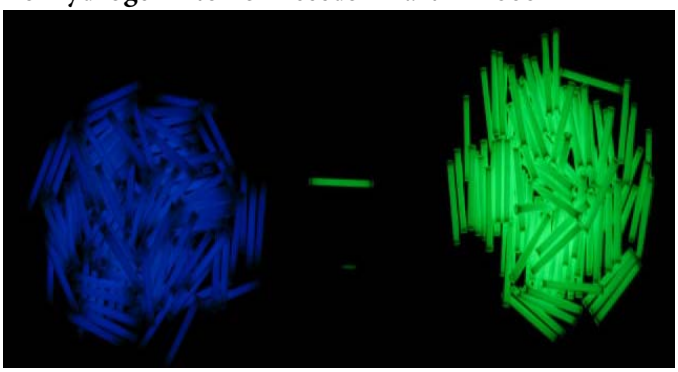
(a) Nickel powder having the following characteristics:
    (1) A nickel purity content of 99.0% or greater by weight; and
    (2) A mean particle size of less than 10 μm measured by the ASTM B 330 standard.
(b) Porous nickel metal produced from materials specified in Item 2.C.16.a.

Note: Item 2.C.16. does not control the following:

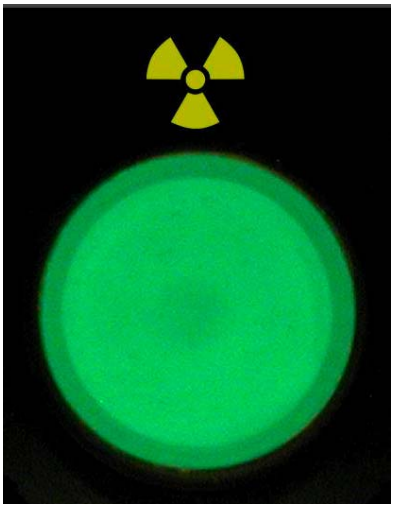
(a) Filamentary nickel powders;
(b) Single porous nickel metal sheets with an area of 1000cm^2 per sheet or less.

Technical Note: Item 2.C.16.b. refers to porous metal formed by compacting and sintering the material in Item 2.C.16.a. to form a metal material with fine pores interconnected throughout the structure.

2.C.17. Tritium, Tritium Compounds, Mixtures Containing Tritium In Which The Ratio Of Tritium To Hydrogen Atoms Exceeds 1 Part In 1000



Source: http://www.cpfmarketplace.com/mp/showthread.php?170374-For-Sale-Tritium-Vials



Source: http://periodictable.com/Items/001.13/index.html

Tritium, tritium compounds, mixtures containing tritium in which the ratio of tritium to hydrogen atoms exceeds 1 part in 1000, and products or devices containing any of the former. Note: Item 2.C.17. does not control a product or device containing less than 1.48 x 10^3 GBq of tritium.

2.C.18. Helium-3 (3he), Mixtures Containing Helium-3

2.C.18. Helium-3 (3He), mixtures containing helium-3, and products or devices containing any of the former. Note: Item 2.C.18. does not control a product or device containing less than 1 g of helium-3.

2.C.19. Alpha-Emitting Radionuclides Having An Alpha Half-Life Of 10 Days Or Greater But Less Than 200 Years

Alpha-emitting radionuclides having an alpha half-life of 10 days or greater but less than 200 years, in the following forms:

(a) Elemental
(b) Compounds having a total alpha activity of 37 GBq per kg or greater;
(c) Mixtures having a total alpha activity of 37 GBq per kg or greater;
(d) Products or devices containing any of the former.

Note: Item 2.C.19. does not control a product or device containing less than 3.7 GBq of alpha activity.

MATERIALS

2.E. TECHNOLOGY INFCIRC/254/Rev.8/Part2 ANNEX

2.E.1. "Technology" According To The Technology Controls For The "Development," "Production," Or "Use" Of Equipment, Material Or "Software" Specified In 2.A. Through 2.D.

No further information.

URANIUM ISOTOPE SEPARATION EQUIPMENT AND COMPONENTS

(Other Than Trigger List Items)

3.A. EQUIPMENT, ASSEMBLIES, AND COMPONENTS INFCIRC/254/Rev.8/Part2 ANNEX

3.A.1. Frequency Changers or Generators

Frequency changers or generators having all of the following characteristics:

(NB) Frequency changers and generators especially designed or prepared for the gas centrifuge process are controlled under INFCIRC/254/Part 1 (as amended).

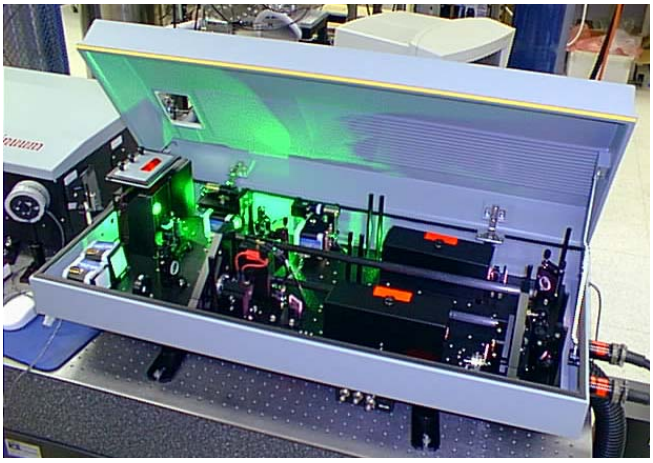
(a) Multiphase output capable of providing a power of 40 W or greater;
(b) Capable of operating in the frequency range between 600 and 2000 Hz;
(c) Total harmonic distortion better (less) than 10%; and
(d) Frequency control better (less) than 0.1%

Technical Note: Frequency changers in Item 3.A.1. are also known as converters or inverters.

3.A.2. Lasers, Laser Amplifiers, and Oscillators

Copper vapor laser
Source: http://www.laserfx.com/Works/Works2.html

Argon ion laser
Source: http://www.laserresale.com/?fa=app.view&it=5548



Neodymium-doped lasers
Source: http://en.wikipedia.org/wiki/File:Powerlite_NdYAG.jpg

Pulsed carbon dioxide lasers

Source: http://www.edinburghphotonics.com/files/image/large-product-images/CO-CO2Lasers.jpg

Pulsed excimer lasers

Source: http://www.photonicsolutions.co.uk/product.asp?prodid=lasEXlaser

Laser, laser amplifiers, and oscillators as follows:

(a) Copper vapor lasers having both of the following characteristics:
  (1) Operating at wavelengths between 500 and 600 nm; and
  (2) An average output power equal to or greater than 40 W;

(b) Argon ion lasers having both of the following characteristics:
  (1) Operating at wavelengths between 400 and 515 nm; and
  (2) An average output power greater than 40 W;

(c) Neodymium-doped (other than glass) lasers with an output wavelength between 1000 and 1100 nm having either of the following:
  (1) Pulse-excited and Q-switched with a pulse duration equal to or greater than 1 ns, and having either of the following:
    (a) A single-transverse mode output with an average output power greater than 40 W; or
    (b) A multiple-transverse mode output with an average output power greater than 50 W; or
  (2) Incorporating frequency doubling to give an output wavelength between 500 and 550 nm with an average output power of greater than 40 W;

(d) Tunable pulsed single-mode dye laser oscillators having all of the following characteristics:
  (1) Operating at wavelengths between 300 and 800 nm;
  (2) An average output power greater than 1 W;
  (3) A repetition rate greater than 1 kHz; and (4) Pulse width less than 100 ns

(e) Tunable pulsed dye laser amplifiers and oscillators having all of the following characteristics:
  (1) Operating at wavelengths between 300 and 800 nm;
  (2) An average output power greater than 30 W;
  (3) A repetition rate greater than 1 kHz; and
  (4) Pulse width less than 100 ns,
  Note: Item 3.A.2.e. does not control single mode oscillators.

(f) Alexandrite lasers having all of the following characteristics:

(1) Operating at wavelengths between 720 and 800 nm;
(2) A bandwidth of 0.005 nm or less;
(3) A repetition rate greater than 125 Hz; and
(4) An average output power greater than 30 W;

(g) Pulsed carbon dioxide lasers having all of the following characteristics:
(1) Operating at wavelengths between 9000 and 11000 nm;
(2) A repetition rate greater than 250 Hz;
(3) An average output power greater than 500 W; and
(4) Pulse width of less than 200 ns;

Note: Item 3.A.2.g. does not control the higher power (typically 1 to 5 kW) industrial CO2 lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width greater than 200 ns.

(h) Pulsed excimer lasers (XeF, XeCl, KrF) having all of the following characteristics:
(1) Operating at wavelengths between 240 and 360 nm;
(2) A repetition rate greater than 250 Hz; and
(3) An average output power greater than 500 W;

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

3.A.3. Valves

Valves having all of the following characteristics:

(a) A nominal size of 5 mm or greater
(b) Having a bellows seal; and
(c) Wholly made of or lined with aluminum, aluminum alloy, nickel, or nickel alloy containing more than 60% nickel by weight.

Technical Note: For valves with different inlet and outlet diameter, the nominal size parameter in Item 3.A.3.a. refers to the smallest diameter.

Image: Range of metal bellows valves. Source: http://en.wikipedia.org/wiki/File:Metal_bellows.jpg

3.A.4. Superconducting Solenoid Electromagnets

Source: http://en.wikipedia.org/wiki/File:Modern_3T_MRI.JPG

Superconducting solenoidal electromagnets having all of the following characteristics:

(a) Capable of creating magnetic fields greater than 2 T;
(b) A ratio of length to inner diameter greater than 2;
(c) Inner diameter greater than 300 mm; and
(d) Magnetic field uniform to better than 1% over the central 50% of the inner volume.

Note: Item 3.A.4. does not control magnets specially designed for and exported as part of medical nuclear magnetic resonance (NMR) imaging systems.

NB: As part of, does not necessarily mean physical part in the same shipment. Separate shipments from different sources are allowed, provided the related export documents clearly specify the as part of relationship.

Image: Diagram of a basic solenoid magnet design. Note that in order to meet specifications above, materials and size may vary.

Note the minimum inner diameter (300 mm) and ratio of length to inner diameter (2:1) above for minimum dimensions of individual units.

3.A.5. High-Power Direct Current Power Supplies

Source: http://www.lesker.com/newweb/ped/components.cfm

High-power direct current power supplies having both of the following characteristics:

(a) Capable of continuously producing, over a time period of 8 hours, 100 V or greater with current output of 500 A or greater; and
(b) Current or voltage stability better than 0.1% over a time period of 8 hours.

Power companies, generally, will be the primary producers of this type of product.

3.A.6. High-Voltage Direct Current Power Supplies

Source: http://www.keithley.com/products/dcac/highspeedpower/highvoltage/?mn=248

High-voltage direct current power supplies having both of the following characteristics:

(a) Capable of continuously producing, over a time period of 8 hours, 20 kV or greater with current output of 1 A or greater; and
(b) Current or voltage stability better than 0.1% over a time period of 8 hours.

Power companies, generally, will be the primary producers of this type of product.

3.A.7. Pressure Transducers Capable Of Measuring Absolute Pressures at Any Point in the Range 0 To 13 kPa

Pressure transducers capable of measuring absolute pressures at any point in the range 0 to 13 kPa and having both of the following characteristics:

(a) Pressure sensing elements made of or protected by aluminum, aluminum alloy, nickel, or nickel alloy with more than 60% nickel by weight; and
(b) Having either of the following characteristics:
    (1) A full scale of less than 13 kPa and an "accuracy" of better than ± 1% of full scale;
    (2) A full scale of 13 kPa or greater and an "accuracy" of better than ± 130 Pa.
    Technical Note 1: In Item 3.A.7. pressure transducers are devices that convert pressure measurements into an electrical signal.
    Technical Note 2: In Item 3.A.7. "accuracy" includes non-linearity, hysteresis and repeatability at ambient temperature.

3.A.8. Vacuum Pumps

Vacuum pumps having all of the following characteristics:

(a) Input throat size equal to or greater than 380 mm;
(b) Pumping speed equal to or greater than 15m^3/s; and
(c) Capable of producing an ultimate vacuum better than 13.3 mPa.

Technical Note 1: The pumping speed is determined at the measurement point with nitrogen gas or air.

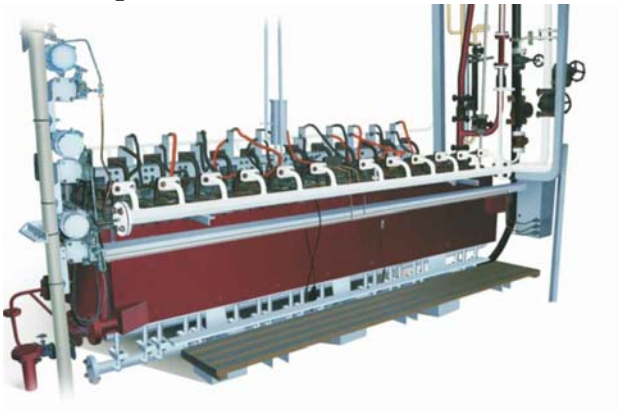
Technical Note 2: The ultimate vacuum is determined at the input of the pump with the input of the pump blocked off.

URANIUM ISOTOPE SEPARATION EQUIPMENT AND COMPONENTS

(Other Than Trigger List Items)

3.B. TEST AND PRODUCTION EQUIPMENT INFCIRC/254/Rev.8/Part2 ANNEX

3.B.1. Electrolytic Cells for Fluorine Production with an Output Capacity Greater Than 250 g of Fluorine per Hour



Source: http://www.essentialchemicalindustry.org/chemicals/hydrogen-fluoride.html

Electrolytic cells for fluorine production with an output capacity greater than 250 g of fluorine per hour.

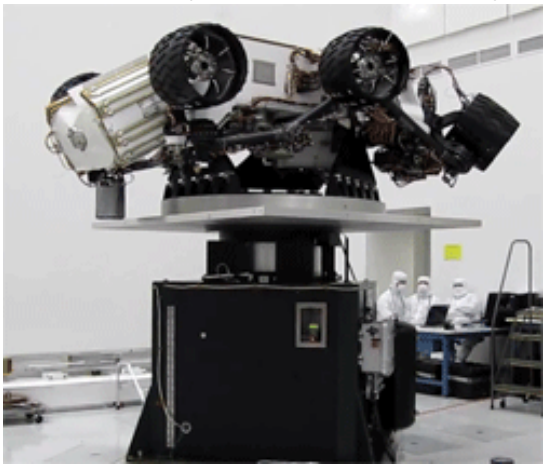
3.B.2. Rotor Fabrication or Assembly Equipment, Rotor Straightening Equipment, Bellows-Forming Mandrels and Dies

3.B.2. Rotor fabrication or assembly equipment, rotor straightening equipment, bellows-forming mandrels and dies, as follows:

(a) Rotor assembly equipment for assembly of gas centrifuge rotor tube sections, baffles, and end caps;
Note: Item 3.B.2.a. includes precision mandrels, clamps, and shrink fit machines.

(b) Rotor straightening equipment for alignment of gas centrifuge rotor tube sections to a common axis;
Technical Note: In Item 3.B.2.b. such equipment normally consists of precision measuring probes linked to a computer that subsequently controls the action of, for example, pneumatic rams used for aligning the rotor tube sections.
(c) Bellows-forming mandrels and dies for producing single-convolution bellows.
Technical Note: The bellows referred to in Item 3.B.2.c. have all of the following characteristics:
(1) Inside diameter between 75 and 400 mm;
(2) Length equal to or greater than 12.7 mm;
(3) Single convolution depth greater than 2 mm; and
(4) Made of high-strength aluminum alloys, maraging steel, or high strength "fibrous or filamentary materials."

3.B.3. Centrifugal Multi-plane Balancing Machines, Fixed or Portable, Horizontal or Vertical



Source: http://www.space-electronics.com/Products/spin.php

Centrifugal multi-plane balancing machines, fixed or portable, horizontal or vertical, as follows:

(a) Centrifugal balancing machines designed for balancing flexible rotors having a length of 600 mm or more and having all of the following characteristics:
(1) Swing or journal diameter greater than 75 mm;
(2) Mass capability of from 0.9 to 23 kg; and
(3) Capable of balancing speed of revolution greater than 5000 rpm;
(b) Centrifugal balancing machines designed for balancing hollow cylindrical rotor components and having all of the following characteristics:
(1) Journal diameter greater than 75 mm;
(2) Mass capability of from 0.9 to 23 kg;
(3) Capable of balancing to a residual imbalance equal to or less than 0.010 kg x mm/kg per plane; and
(4) Belt drive type.

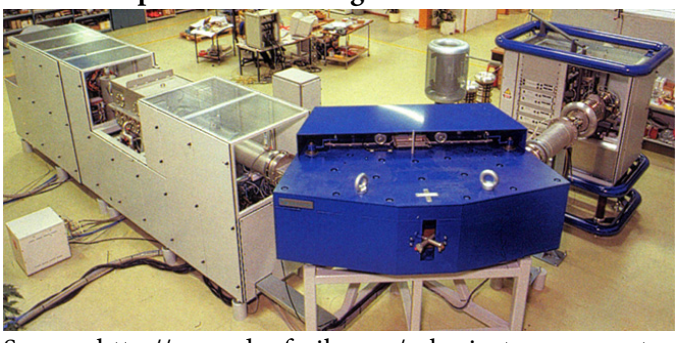
3.B.4. Filament Winding Machines and Related Equipment

Source: http://www.cadfil.com/filamentwindingprocess.html

Filament winding machines and related equipment, as follows:

(a) Filament winding machines having all of the following characteristics:
  (1) Having motions for positioning, wrapping, and winding fibers coordinated and programmed in two or more axes;
  (2) Specially designed to fabricate composite structures or laminates from "fibrous or filamentary materials"; and
  (3) Capable of winding cylindrical rotors of diameter between 75 and 400 mm and lengths of 600 mm or greater;
(b) Coordinating and programming controls for the filament winding machines specified in Item 3.B.4.a.;
(c) Precision mandrels for the filament winding machines specified in Item 3.B.4.a.

3.B.5. Electromagnetic Isotope Separators Designed for, or Equipped with, Single or Multiple Ion Sources Capable of Providing a Total Ion Beam Current of 50 Ma or Greater



Source: http://www.danfysik.com/saha-isotope-separator-and-ion-implanter/26623

Electromagnetic isotope separators designed for, or equipped with, single or multiple ion sources capable of providing a total ion beam current of 50 mA or greater. Note1: Item 3.B.5. includes separators capable of enriching stable isotopes as well as those for uranium. (NB) A separator capable of separating the isotopes of lead with a one-mass unit difference is inherently capable of enriching the isotopes of uranium

with a three-unit mass difference. Note2: Item 3.B.5. includes separators with the ion sources and collectors both in the magnetic field and those configurations in which they are external to the field. Technical Note: A single 50 mA ion source cannot produce more than 3 g of separated highly enriched uranium (HEU) per year from natural abundance feed.

3.B.6. Mass Spectrometers Capable of Measuring Ions of 230 Atomic Mass Units or Greater and Having a Resolution of Better Than 2 Parts in 230, as Follows, and Ion Sources Therefor

Mass spectrometers capable of measuring ions of 230 atomic mass units or greater and having a resolution of better than 2 parts in 230, as follows, and ion sources therefor: (NB) Mass spectrometers especially designed or prepared for analyzing on-line samples of uranium hexafluoride (UF6) are controlled under INFCIRC/254/Part 1 (as amended).

(a) Inductively coupled plasma mass spectrometers (ICP/MS);
(b) Glow discharge mass spectrometers (GDMS);
(c) Thermal ionization mass spectrometers (TIMS);
(d) Electron bombardment mass spectrometers which have a source chamber constructed from, lined with or plated with materials resistant to UF6;
(e) Molecular beam mass spectrometers having either of the following characteristics:
    (1) A source chamber constructed from, lined with or plated with stainless steel or molybdenum, and equipped with a cold trap capable of cooling to 193 K (-80° C) or less; or
    (2) A source chamber constructed from, lined with or plated with materials resistant to UF6;
(f) Mass spectrometers equipped with a microfluorination ion source designed for actinides or actinide fluorides.

URANIUM ISOTOPE SEPARATION EQUIPMENT AND COMPONENTS

(Other Than Trigger List Items)

3.D. SOFTWARE INFCIRC/254/Rev.8/Part2 ANNEX

3.D.1. "Software" Specially Designed for the "Use" of Equipment Specified in Item 3.B.3. Or 3.B.4.

Software specially designed for the "use" of equipment specified in Item 3.B.3. or 3.B.4.

URANIUM ISOTOPE SEPARATION EQUIPMENT AND COMPONENTS

(Other Than Trigger List Items)

3.E. TECHNOLOGY INFCIRC/254/Rev.8/Part2 ANNEX

3.E.1. "Technology" According to the Technology Controls for the "Development," "Production," or "Use" of Equipment, Material or "Software" Specified in 3.A. Through 3.D.

"Technology" according to the Technology Controls for the "development," "production," or "use" of equipment, material or "software" specified in 3.A. through 3.D.

HEAVY WATER PRODUCTION PLANT RELATED EQUIPMENT

(Other Than Trigger List Items)

4.A. EQUIPMENT, ASSEMBLIES, AND COMPONENTS INFCIRC/254/Rev.8/Part2 ANNEX

4.A.1. Specialized Packing Which May Be Used in Separating Heavy Water from Ordinary Water

Specialized packing which may be used in separating heavy water from ordinary water, having both of the following characteristics:

(a) Made of phosphor bronze mesh chemically treated to improve wettability; and
(b) Designed to be used in vacuum distillation towers.

4.A.2. Pumps Capable of Circulating Solutions of Concentrated or Dilute Potassium Amide Catalyst in Liquid Ammonia (KNH2/NH3)

Pumps capable of circulating solutions of concentrated or dilute potassium amide catalyst in liquid ammonia (KNH2/NH3), having all of the following characteristics:

(a) Airtight (i.e., hermetically sealed)
(b) A capacity greater than 8.5m^3/h; and
(c) Either of the following characteristics:
    (1) For concentrated potassium amide solutions (1% or greater), an operating pressure of 1.5 to 60 MPa;
    (2) For dilute potassium amide solutions (less than 1%), an operating pressure of 20 to 60 MPa.

4.A.3. Turboexpanders or Turboexpander-Compressor Sets

Turboexpanders or turboexpander-compressor sets having both of the following characteristics:

(a) Designed for operation with an outlet temperature of 35 K (- 238 ° C) or less; and
(b) Designed for a throughput of hydrogen gas of 1000 kg/h or greater.

HEAVY WATER PRODUCTION PLANT RELATED EQUIPMENT

(Other Than Trigger List Items)

4.B. TEST AND PRODUCTION EQUIPMENT INFCIRC/254/Rev.8/Part2 ANNEX

4.B.1. Water-Hydrogen Sulfide Exchange Tray Columns and Internal Contactors

Water-hydrogen sulfide exchange tray columns and internal contactors, as follows:

(NB) For columns which are especially designed or prepared for the production of heavy water, see INFCIRC/254/Part 1 (as amended).

(a) Water-hydrogen sulfide exchange tray columns, having all of the following characteristics:
  (1) Can operate at pressures of 2 MPa or greater;
  (2) Constructed of carbon steel having an austenitic ASTM (or equivalent standard) grain size number of 5 or greater; and
  (3) With a diameter of 1.8 m or greater;
(b) Internal contactors for the water-hydrogen sulfide exchange tray columns specified in Item 4.B.1.a.

Technical Note: Internal contactors of the columns are segmented trays which have an effective assembled diameter of 1.8 m or greater; are designed to facilitate countercurrent contacting and are constructed of stainless steels with a carbon content of 0.03% or less. These may be sieve trays, valve trays, bubble cap trays, or turbogrid trays.

4.B.2. Hydrogen-Cryogenic Distillation Columns

Hydrogen-cryogenic distillation columns having all of the following characteristics:

(a) Designed for operation at internal temperatures of 35 K (-238 ° C) or less;
(b) Designed for operation at internal pressures of 0.5 to 5 Mpa;
(c) Constructed of either:
  (1) Stainless steel of the 300 series with low sulfur content and with an austenitic ASTM (or equivalent standard) grain size number of 5 or greater; or
  (2) Equivalent materials which are both cryogenic and H2-compatible; and
(d) With internal diameters of 1 m or greater and effective lengths of 5 m or greater.

4.B.3. Ammonia Synthesis Converters or Synthesis Units, in which the Synthesis Gas (Nitrogen and Hydrogen) is Withdrawn From an Ammonia/Hydrogen High-Pressure Exchange Column and the Synthesized Ammonia is Returned to the Column

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

HEAVY WATER PRODUCTION PLANT RELATED EQUIPMENT

(Other Than Trigger List Items)

4.E. TECHNOLOGY INFCIRC/254/Rev.8/Part2 ANNEX

4.E.1. "Technology" According to the Technology Controls for the "Development," "Production" or "Use" of Equipment, Material or "Software" Specified in 4.A. Through 4.D.

No further information.

TEST AND MEASUREMENT EQUIPMENT FOR THE DEVELOPMENT OF NUCLEAR EXPLOSIVE DEVICES

5.A. EQUIPMENT, ASSEMBLIES, AND COMPONENTS INFCIRC/254/Rev.8/Part2 ANNEX

5.A.1. Photomultiplier Tubes

Photomultiplier tubes having both of the following characteristics:

(a) Photocathode area of greater than 20 cm^2; and
(b) Anode pulse rise time of less than 1 ns.

Image source: Optical Microscopy Division of the National High Magnetic Field Laboratory, "Concepts in Digital Imaging Technology: Photomultiplier Tubes," available at http://micro.magnet.fsu.edu/primer/digitalimaging/concepts/photomultipliers.html .

TEST AND MEASUREMENT EQUIPMENT FOR THE DEVELOPMENT OF NUCLEAR EXPLOSIVE DEVICES

5.B. TEST AND PRODUCTION EQUIPMENT INFCIRC/254/Rev.8/Part2 ANNEX

5.B.1. Flash X-Ray Generators or Pulsed Electron Accelerators

Flash X-ray generators or pulsed electron accelerators having either of the following sets of characteristics:

(a) (1) An accelerator peak electron energy of 500 keV or greater but less than 25 MeV; and
(2) With a figure of merit (K) of 0.25 or greater; or
(b) (1) An accelerator peak electron energy of 25 MeV or greater; and
(2) A peak power greater than 50 MW.

Note: Item 5.B.1. does not control accelerators that are component parts of devices designed for purposes other than electron beam or X-ray radiation (electron microscopy, for example) nor those designed for medical purposes.

Technical Note 1: The figure of merit K is defined as: $K = 1.7 \times 10^3 \times (V^{2.65}) \times Q$. V is the peak electron energy in million electron volts. If the accelerator beam pulse duration is less than or equal to 1 μs,

then Q is the total accelerated charge in Coulombs. If the accelerator beam pulse duration is greater than 1 μs, then Q is the maximum accelerated charge in 1 μs. Q equals the integral of i with respect to t, over the lesser of 1 μs or the time duration of the beam pulse ($Q= \int idt$) where i is beam current in amperes and t is the time in seconds.

Technical Note 2: Peak power = (peak potential in volts) x (peak beam current in amperes).
Technical Note 3: In machines based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1 μs or the duration of the bunched beam packet resulting from one microwave modulator pulse.

Technical Note 4: In machines based on microwave accelerating cavities, the peak beam current is the average current in the time duration of a bunched beam packet.

5.B.2. Multistage Light Gas Guns or Other High-Velocity Gun Systems (Coil, Electromagnetic, and Electrothermal Types, and Other Advanced Systems) Capable of Accelerating Projectiles to 2 Km/S or Greater

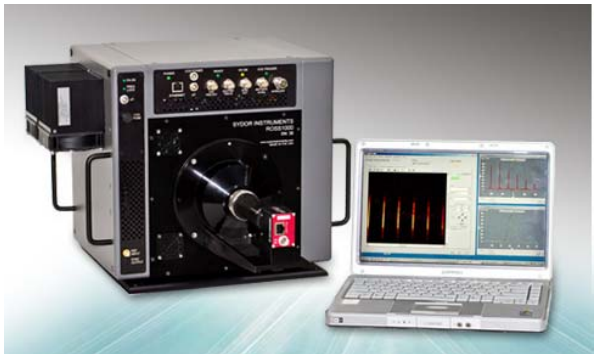
Multistage light gas guns or other high-velocity gun systems (coil, electromagnetic, and electrothermal types, and other advanced systems) capable of accelerating projectiles to 2 km/s or greater.

5.B.3. Mechanical Rotating Mirror Cameras

Mechanical rotating mirror cameras, as follows, and specially designed components therefor:

(a) Framing cameras with recording rates greater than 225,000 frames per second;
(b) Streak cameras with writing speeds greater than 0.5 mm/μs.
Note: In Item 5.B.3. components of such cameras include their synchronizing electronics units and rotor assemblies consisting of turbines, mirrors, and bearings.

5.B.4. Electronic Streak Cameras, Electronic Framing Cameras, Tubes and Devices



Source: http://www.sydorinstruments.com/products_streak.asp

Electronic streak cameras, electronic framing cameras, tubes and devices, as follows:
(a) Electronic streak cameras capable of 50 ns or less time resolution;

(b) Streak tubes for cameras specified in Item 5.B.4.a.;
(c) Electronic (or electronically shuttered) framing cameras capable of 50 ns or less frame exposure time;
(d) Framing tubes and solid-state imaging devices for use with cameras specified in Item 5.B.4.c., as follows:
    (1) Proximity focused image intensifier tubes having the photocathode deposited on a transparent conductive coating to decrease photocathode sheet resistance;
    (2) Gate silicon intensifier target (SIT) vidicon tubes, where a fast system allows gating the photoelectrons from the photocathode before they impinge on the SIT plate;
    (3) Kerr or Pockels cell electro-optical shuttering;
    (4) Other framing tubes and solid-state imaging devices having a fast image gating time of less than 50 ns specially designed for cameras specified in Item 5.B.4.c.

5.B.5. Specialized Instrumentation for Hydrodynamic Experiments

Specialized instrumentation for hydrodynamic experiments, as follows:

(a) Velocity interferometers for measuring velocities exceeding 1 km/s during time intervals of less than 10 μs;
(b) Manganin gauges for pressures greater than 10 GPa;
(c) Quartz pressure transducers for pressures greater than 10 GPa.

Note: Item 5.B.5.a. includes velocity interferometers such as VISARs (Velocity interferometer systems for any reflector) and DLIs (Doppler laser interferometers).

5.B.6. High-Speed Pulse Generators

Source: http://www.eeweb.com/company-news/ixys/high-speed-daypulse-generator/
High-speed pulse generators having the following characteristics:

(a) Output voltage greater than 6 V into a resistive load of less than 55 ohms; and
(b) "Pulse transition time" less than 500 ps.

Technical Note: In Item 5.B.6.b. "pulse transition time" is defined as the time interval between 10% and 90% voltage amplitude.

TEST AND MEASUREMENT EQUIPMENT FOR THE DEVELOPMENT OF NUCLEAR EXPLOSIVE DEVICES

5.E. TECHNOLOGY INFCIRC/254/Rev.8/Part2 ANNEX

5.E.1. "Technology" According to the Technology Controls for the "Development," "Production" or "Use" of Equipment, Material or "Software" Specified in 5.A. Through 5.D.

No further information.

COMPONENTS FOR NUCLEAR EXPLOSIVE DEVICES

6.A. EQUIPMENT, ASSEMBLIES, AND COMPONENTS INFCIRC/254/Rev.8/Part2 ANNEX

6.A.1. Detonators and Multipoint Initiation Systems

Detonators and multipoint initiation systems, as follows:

(a) Electrically driven explosive detonators, as follows:
  (1) Exploding bridge (EB);
  (2) Exploding bridge wire (EBW);
  (3) Slapper,
  (4) Exploding foil initiators (EFI);
(b) Arrangements using single or multiple detonators designed to nearly simultaneously initiate an explosive surface over an area greater than 5000 mm^2 from a single firing signal with an initiation timing spread over the surface of less than 2.5 μs.

Note: Item 6.A.1. does not control detonators using only primary explosives, such as lead azide.
Technical Note: In Item 6.A.1. the detonators of concern all utilize a small electrical conductor (bridge, bridge wire, or foil) that explosively vaporizes when a fast, high-current electrical pulse is passed through it. In nonslapper types, the exploding conductor starts a chemical detonation in a contacting high-explosive material such as PETN (pentaerythritoltetranitrate). In slapper detonators, the explosive vaporization of the electrical conductor drives a flyer or slapper across a gap, and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by magnetic force. The term exploding foil detonator may refer to either an EB or a slapper-type detonator. Also, the word initiator is sometimes used in place of the word detonator.

6.A.2. Firing Sets and Equivalent High-Current Pulse Generators

Firing sets and equivalent high-current pulse generators, as follows:

(a) Explosive detonator firing sets designed to drive multiple controlled detonators specified by Item 6.A.1.
(b) Modular electrical pulse generators (pulsers) having all of the following characteristics:
    (1) Designed for portable, mobile, or ruggedized-use;
    (2) Enclosed in a dust-tight enclosure;
    (3) Capable of delivering their energy in less than 15 μs;
    (4) Having an output greater than 100 A;
    (5) Having a "rise time" of less than 10 μs into loads of less than 40 ohms;
    (6) No dimension greater than 25.4 cm;
    (7) Weight less than 25 kg ; and
    (8) Specified to operate over an extended temperature range of 223 to 373 K (-50 ° C to 100 ° C) or specified as suitable for aerospace applications.

Note: Item 6.A.2.b. includes xenon flashlamp drivers.

Technical Note: In Item 6.A.2.b.5. "rise time" is defined as the time interval from 10% to 90% current amplitude when driving a resistive load.

Image: http://en.wikipedia.org/wiki/File:Pulse_generators.jpg

6.A.3. Switching Devices

Switching devices as follows:

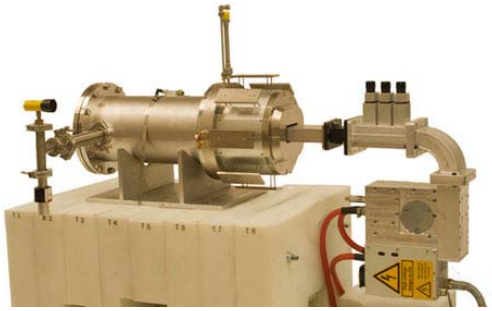
(a) Cold-cathode tubes, whether gas filled or not, operating similarly to a spark gap, having all of the following characteristics:
    (1) Containing three or more electrodes;
    (2) Anode peak voltage rating of 2.5 kV or more;
    (3) Anode peak current rating of 100 A or more; and
    (4) Anode delay time of 10 μs or less;
    Note: Item 6.A.3.a. includes gas krytron tubes and vacuum sprytron tubes.
(b) Triggered spark-gaps having both of the following characteristics:
    (1) Anode delay time of 15 μs or less; and
    (2) Rated for a peak current of 500 A or more;
(c) Modules or assemblies with a fast switching function having all of the following characteristics:
    (1) Anode peak voltage rating greater than 2 kV;
    (2) Anode peak current rating of 500 A or more; and
    (3) Turn-on time of 1 μs or less.

6.A.4. Pulse Discharge Capacitors

Pulse discharge capacitors having either of the following sets of characteristics:

(a) (1) Voltage rating greater than 1.4 kV;
    (2) Energy storage greater than 10 J;
    (3) Capacitance greater than 0.5 μF; and
    (4) Series inductance less than 50 nH; or
(b) (1) Voltage rating greater than 750 V;
    (2) Capacitance greater than 0.25 μF; and
    (3) Series inductance less than 10 nH.

6.A.5. Neutron Generator Systems, Including Tubes



Source: http://www.adelphitech.com/products/dd109.html

Neutron generator systems, including tubes, having both of the following characteristics:

(a) Designed for operation without an external vacuum system; and
(b) Utilizing electrostatic acceleration to induce a tritium-deuterium nuclear reaction.

COMPONENTS FOR NUCLEAR EXPLOSIVE DEVICES

6.C. MATERIALS INFCIRC/254/Rev.8/Part2 ANNEX

6.C.1. High Explosive Substances or Mixtures, Containing More Than 2 % by Weight of Any of The Following (See Articles A, B, C, D, and E)

High explosive substances or mixtures, containing more than 2% by weight of any of the following:

(a) Cyclotetramethylenetetranitramine (HMX) (CAS 2691-41-0);
(b) Cyclotrimethylenetrinitramine (RDX) (CAS 121-82-4);

(c) Triaminotrinitrobenzene (TATB) (CAS 3058-38-6);
(d) Hexanitrostilbene (HNS) (CAS 20062-22-0); or
(e) Any explosive with a crystal density greater than 1.8 g/cm^3 and having a detonation velocity greater than 8000 m/s.

COMPONENTS FOR NUCLEAR EXPLOSIVE DEVICES

6.D. SOFTWARE INFCIRC/254/Rev.8/Part2 ANNEX

6.D.1. "Software" Specially Designed for the "Use" of Equipment

High explosive substances or mixtures, containing more than 2% by weight of any of the following:

(a) Cyclotetramethylenetetranitramine (HMX) (CAS 2691-41-0);
(b) Cyclotrimethylenetrinitramine (RDX) (CAS 121-82-4);
(c) Triaminotrinitrobenzene (TATB) (CAS 3058-38-6);
(d) Hexanitrostilbene (HNS) (CAS 20062-22-0); or
(e) Any explosive with a crystal density greater than 1.8 g/cm^3 and having a detonation velocity greater than 8000 m/s.

COMPONENTS FOR NUCLEAR EXPLOSIVE DEVICES

6.E. TECHNOLOGY INFCIRC/254/Rev.8/Part2 ANNEX

6.E.1. "Technology" According to the Technology Controls for the "Development," "Production," or "Use" of Equipment, Material or "Software" Specified in 6.A. Through 6.D.

Technology according to the Technology Controls for the "development," "production," or "use" of equipment, material or "software" specified in 6.A. through 6.D.