Foreign Affairs and International Trade Canada
Affaires étrangères et Commerce international Canada

A Guide To

CANADA'S EXPORT CONTROLS

2007

Canada

Introduction

The issuance of export permits is administered by the Export Controls Division (TIE) of Foreign Affairs and International Trade Canada (DFAIT). TIE provides assistance to exporters in determining if export permits are required. It also publishes brochures and Notices to Exporters that are freely available on request and on our website www.exportcontrols.gc.ca.

How to contact us:

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For information on how to apply for an export permit and additional information on export controls please refer to our website.

To enquire on the status of an export permit application:

Recognized EXCOL users can check the status of an export permit application on-line. Non-recognized users can call (613) 996-2387 or email tie.reception@international.gc.ca and quote your export permit application identification
(ref ID) number.

Export Controls Division website: www.exportcontrols.gc.ca

This Guide, at time of publication, encompasses the list of items enumerated on the Export Control List (ECL) that are controlled for export in accordance with Canadian foreign policy, including Canada's participation in multilateral export control regimes and bilateral agreements. Unless otherwise specified, the export controls contained in this Guide apply to all destinations except the United States.

Canada's Export Control List can be found at the Department of Justice website at http://canada.justice.gc.ca/. The most recent versions of each multilateral export control regime's control lists included in the ECL are:

Export Control Regimes	Latest Controls Incorporated into ECL
Wassenaar Arrangement	December 2006
Nuclear Suppliers Group	November 2007
Missile Technology Control Regime	December 2006
Australia Group	June 2007

Contents

Group 1 - Dual-Use List

Note:
Terms in "quotations" are defined terms. Refer to 'Definitions of Terms used in these Lists' annexed to this List, at the end of Group 2. References to the "Dual-Use List" and "Munitions Lists" within Groups 1 and 2 refer to the "Group 1 – Dual-Use List" and the "Group 2 – Munitions List" respectively.

General Technology Note:
The export of "technology" which is "required" for the "development", "production" or "use" of items controlled in the Dual-Use List is controlled according to the provisions in each Category. This "technology" remains under control even when applicable to any uncontrolled item.

Controls do not apply to that "technology" which is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which are not controlled or whose export has been authorised.

Note:
This does not release such "technology" controlled in entries 1-1.E.2.e. & 1-1.E.2.f. and 1-8.E.2.a. & 1-8.E.2.b.

Controls do not apply to "technology" "in the public domain", to "basic scientific research" or to the minimum necessary information for patent applications.

General Software Note:
The Lists do not control "software" which is either:

1. Generally available to the public by being:
   a. Sold from stock at retail selling points, without restriction, by means of:
      1. Over-the-counter transactions;
      2. Mail order transactions;
      3. Electronic transactions; **or**
      4. Telephone call transactions; **and**
   b. Designed for installation by the user without further substantial support by the supplier; **or**

   Note:
   Entry 1 of the General Software Note does not release "software" controlled by Category 5 - Part 2 ("Information Security").
2. "In the public domain".

Category 1: Advanced Materials

1-1.A. Systems, Equipment and Components

1. Components made from fluorinated compounds, as follows:
   a. Seals, gaskets, sealants or fuel bladders specially designed for "aircraft" or aerospace use made from more than 50 % by weight of any of the materials controlled by 1-1.C.9.b. or 1-1.C.9.c.;
   b. Piezoelectric polymers and copolymers made from vinylidene fluoride materials controlled by 1-1.C.9.a.:
      1. In sheet or film form; **and**
      2. With a thickness exceeding 200 µm;
   c. Seals, gaskets, valve seats, bladders or diaphragms made from fluoroelastomers containing at least one vinylether group as a constitutional unit, specially designed for "aircraft", aerospace or missile use.
2. "Composite" structures or laminates, having any of the following:
   a. Consisting of an organic "matrix" and materials controlled by 1-1.C.10.c., 1-1.C.10.d. or 1-1.C.10.e.; **or**

   Note:
   1-1.A.2.a does not control finished or semi-finished items specially designed for purely civilian applications as follows:
   a. Sporting goods;
   b. Automotive industry;
   c. Machine tool industry;
   d. Medical applications.

   b. Consisting of a metal or carbon "matrix" and any of the following:
      1. Carbon "fibrous or filamentary materials" with:
         a. A specific modulus exceeding 10.15×10^6 m; **and**
         b. A specific tensile strength exceeding 17.7×10^4 m; **or**
      2. Materials controlled by 1-1.C.10.c.

   Note:
   1-1.A.2.b. does not control finished or semi-finished items specially designed for purely civilian applications as follows:
   a. Sporting goods;
   b. Automotive industry;
   c. Machine tool industry;
   d. Medical applications.

   Technical Notes:
   1. Specific modulus: Young's modulus in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.
   2. Specific tensile strength: ultimate tensile strength in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

   Note:
   1-1.A.2. does not control composite structures or laminates made from epoxy resin impregnated carbon "fibrous or filamentary materials" for the repair of "civil aircraft" structures or laminates, provided the size does not exceed 100 cm x 100 cm.
3. Manufactures of non-fluorinated polymeric substances controlled by 1-1.C.8.a.3., in film, sheet, tape or ribbon form:
   a. With a thickness exceeding 0.254 mm; **or**
   b. Coated or laminated with carbon, graphite, metals or magnetic substances.

   Note:
   1-1.A.3. does not control manufactures when coated or laminated with copper and designed for the production of electronic printed circuit boards.
4. Protective and detection equipment and components not specially designed for military use, as follows:
   a. Gas masks, filter canisters and decontamination equipment therefor designed or modified for defence against biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents and specially designed components therefor;
   b. Protective suits, gloves and shoes specially designed or modified for defence against biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents;
   c. Nuclear, biological and chemical (NBC) detection systems specially designed or modified for detection or identification of biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents and specially designed components therefor.

   Note:
   1-1.A.4. does not control :
   a. Personal radiation monitoring dosimeters;
   b. Equipment limited by design or function to protect against hazards specific to civil industries, such as mining, quarrying, agriculture, pharmaceuticals, medical, veterinary, environmental, waste management, or to the food industry.
5. Body armour, and specially designed components therefor, not manufactured to military standards or specifications, nor to their equivalents in performance.

N.B.:
For "fibrous or filamentary materials" used in the manufacture of body armour, see entry 1-1.C.10.
Note 1:
1-1.A.5. does not control individual suits of body armour or protective garments when accompanying their user for the user's own personal protection.
Note 2:
1-1.A.5. does not control body armour designed to provide frontal protection only from both fragment and blast from non-military explosive devices.

1-1.B. Test, Inspection and Production Equipment

1. Equipment for the production of fibres, prepregs, preforms or "composites" controlled by 1-1.A.2. or 1-1.C.10., as follows, and specially designed components and accessories therefor:
   a. Filament winding machines of which the motions for positioning, wrapping and winding fibres are coordinated and programmed in three or more axes, specially designed for the manufacture of "composite" structures or laminates from "fibrous or filamentary materials";
   b. Tape-laying or tow-placement machines of which the motions for positioning and laying tape, tows or sheets are coordinated and programmed in two or more axes, specially designed for the manufacture of "composite" airframe or missile structures;
   c. Multidirectional, multidimensional weaving machines or interlacing machines, including adapters and modification kits, for weaving, interlacing or braiding fibres to manufacture "composite" structures;
   Technical Note:
   For the purposes of 1-1.B.1.c. the technique of interlacing includes knitting.
   Note:
   1-1.B.1.c. does not control textile machinery not modified for the above end-uses.
   d. Equipment specially designed or adapted for the production of reinforcement fibres, as follows:
      1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, pitch or polycarbosilane) into carbon fibres or silicon carbide fibres, including special equipment to strain the fibre during heating;
      2. Equipment for the chemical vapour deposition of elements or compounds on heated filamentary substrates to manufacture silicon carbide fibres;
      3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);
      4. Equipment for converting aluminium containing precursor fibres into alumina fibres by heat treatment;
   e. Equipment for producing prepregs controlled by 1-1.C.10.e. by the hot melt method;
   f. Non-destructive inspection equipment specially designed for "composite" materials, as follows:
      1. X-ray tomography systems for three dimensional defect inspection;
      2. Numerically controlled ultrasonic testing machines of which the motions for positioning transmitters and/or receivers are simultaneously coordinated and programmed in four or more axes to follow the three dimensional contours of the component under inspection.
2. Equipment for producing metal alloys, metal alloy powder or alloyed materials, specially designed to avoid contamination and specially designed for use in one of the processes specified in Item 1-1.C.2.c.2.
3. Tools, dies, moulds or fixtures, for "superplastic forming" or "diffusion bonding" titanium or aluminium or their alloys, specially designed for the manufacture of:
   a. Airframe or aerospace structures;
   b. "Aircraft" or aerospace engines; **or**
   c. Specially designed components for those structures or engines.

1-1.C. Materials

Technical Note:
Metals and alloys
Unless provision to the contrary is made, the words 'metals' and 'alloys' cover crude and semi-fabricated forms, as follows:

Crude forms
Anodes, balls, bars (including notched bars and wire bars), billets, blocks, blooms, brickets, cakes, cathodes, crystals, cubes, dice, grains, granules, ingots, lumps, pellets, pigs, powder, rondelles, shot, slabs, slugs, sponge sticks;

Semi-fabricated forms (whether or not coated, plated, drilled or punched):
a. Wrought or worked materials fabricated by rolling, drawing, extruding, forging, impact extruding, pressing, graining, atomising, and grinding, i.e.: angles, channels, circles, discs, dust, flakes, foils and leaf, forging, plate, powder, pressings and stampings, ribbons, rings, rods (including bare welding rods, wire rods, and rolled wire), sections, shapes, sheets, strip, pipe and tubes (including tube rounds, squares, and hollows), drawn or extruded wire;
b. Cast material produced by casting in sand, die, metal, plaster or other types of moulds, including high pressure castings, sintered forms, and forms made by powder metallurgy.

The object of the control should not be defeated by the export of non-listed forms alleged to be finished products but representing in reality crude forms or semi-fabricated forms.

1. Materials specially designed for use as absorbers of electromagnetic waves, or intrinsically conductive polymers, as follows:
   a. Materials for absorbing frequencies exceeding 2×10^8 Hz but less than 3×10^{12} Hz;
   Note 1:
   1-1.C.1.a. does not control:
   a. Hair type absorbers, constructed of natural or synthetic fibres, with non-magnetic loading to provide absorption;
   b. Absorbers having no magnetic loss and whose incident surface is non-planar in shape, including pyramids, cones, wedges and convoluted surfaces;
   c. Planar absorbers, having all of the following characteristics:
      1. Made from any of the following:
         a. Plastic foam materials (flexible or non-flexible) with carbon-loading, or organic materials, including binders, providing more than 5% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 450 K (177° C); **or**
         b. Ceramic materials providing more than 20% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 800 K (527°C);

Technical Note:
Absorption test samples for 1-1.C.1.a. Note 1-1.C.1. should be a square at least 5 wavelengths of the centre frequency on a side and positioned in the far field of the radiating element.

2. Tensile strength less than 7 x 10^6 N/m^2; **and**
3. Compressive strength less than 14 x 10^6 N/m^2;

d. Planar absorbers made of sintered ferrite, having**:**
1. A specific gravity exceeding 4.4; **and**
2. A maximum operating temperature of 548 K (275°C).

Note 2:
Nothing in this Note 1 releases magnetic materials to provide absorption when contained in paint.

b. Materials for absorbing frequencies exceeding 1.5 x 10^{14} Hz but less than 3.7 x 10^{14} Hz and not transparent to visible light;

c. Intrinsically conductive polymeric materials with a bulk electrical conductivity exceeding 10,000 S/m (Siemens per metre) or a sheet (surface) resistivity of less than 100 ohms/square, based on any of the following polymers:
1. Polyaniline;
2. Polypyrrole;
3. Polythiophene;
4. Poly phenylene-vinylene; **or**
5. Poly thienylene-vinylene.

Technical Note:
Bulk electrical conductivity and sheet (surface) resistivity should be determined using ASTM D-257 or national equivalents.

2. Metal alloys, metal alloy powder and alloyed materials, as follows:

Note:
1-1.C.2. does not control metal alloys, metal alloy powder and alloyed materials for coating substrates.

Technical Notes:
1. The metal alloys in 1-1.C.2. are those containing a higher percentage by weight of the stated metal than of any other element.
2. Stress-rupture life should be measured in accordance with ASTM Standard E-139 or national equivalents.
3. Low cycle fatigue life should be measured in accordance with ASTM Standard E-606 ‘Recommended Practice for Constant-Amplitude Low-Cycle Fatigue Testing’ or national equivalents. Testing should be axial with an average stress ratio equal to 1 and a stress-concentration factor (K_t) equal to 1. The average stress is defined as maximum stress minus minimum stress divided by maximum stress.

a. Aluminides, as follows:
1. Nickel aluminides containing a minimum of 15 weight percent aluminium, a maximum of 38 weight percent aluminium and at least one additional alloying element;
2. Titanium aluminides containing 10 weight percent or more aluminium and at least one additional alloying element;

b. Metal alloys, as follows, made from material controlled by 1-1.C.2.c.:
1. Nickel alloys with:
   a. A stress-rupture life of 10,000 hours or longer at 923 K (650°C) at a stress of 676 MPa; **or**
   b. A low cycle fatigue life of 10,000 cycles or more at 823 K (550°C) at a maximum stress of 1,095 MPa;
2. Niobium alloys with:
   a. A stress-rupture life of 10,000 hours or longer at 1,073 K (800°C) at a stress of 400 MPa; **or**
   b. A low cycle fatigue life of 10,000 cycles or more at 973 K (700°C) at a maximum stress of 700 MPa;
3. Titanium alloys with:
   a. A stress-rupture life of 10,000 hours or longer at 723 K (450°C) at a stress of 200 MPa; **or**
   b. A low cycle fatigue life of 10,000 cycles or more at 723 K (450°C) at a maximum stress of 400 MPa;
4. Aluminium alloys with a tensile strength of:
   a. 240 MPa or more at 473 K (200°C); **or**
   b. 415 MPa or more at 298 K (25°C);
5. Magnesium alloys with:
   a. a tensile strength of 345 MPa or more; **and**
   b. a corrosion rate of less than 1 mm/year in 3% sodium chloride aqueous solution measured in accordance with ASTM standard G-31 or national equivalents;

c. Metal alloy powder or particulate material, having all of the following characteristics:
1. Made from any of the following composition systems:

   Technical Note:
   X in the following equals one or more alloying elements.

   a. Nickel alloys (Ni-Al-X, Ni-X-Al) qualified for turbine engine parts or components, i.e. with less than 3 non-metallic particles (introduced during the manufacturing process) larger than 100 μm in 10^9 alloy particles;
   b. Niobium alloys (Nb-Al-X or Nb-X-Al, Nb-Si-X or Nb-X-Si, Nb-Ti-X or Nb-X-Ti);
   c. Titanium alloys (Ti-Al-X or Ti-X-Al);
   d. Aluminium alloys (Al-Mg-X or Al-X-Mg, Al-Zn-X or Al-X-Zn, Al-Fe-X or Al-X-Fe); **or**
   e. Magnesium alloys (Mg-Al-X or Mg-X-Al); **and**
2. Made in a controlled environment by any of the following processes:
   a. “Vacuum atomisation”;
   b. “Gas atomisation”;
   c. “Rotary atomisation”;
   d. “Splat quenching”;
   e. “Melt spinning” and “comminution”;
   f. “Melt extraction” and “comminution”; **or**
   g. “Mechanical alloying”;
3. Capable of forming materials controlled by 1-1.C.2.a. or 1-1.C.2.b.;

d. Alloyed materials, having all of the following characteristics:
1. Made from any of the composition systems specified in 1-1.C.2.c.1.;
2. In the form of uncomminuted flakes, ribbons or thin rods; **and**
3. Produced in a controlled environment by any of the following:
   a. “Splat quenching”;
   b. “Melt spinning”; **or**
   c. “Melt extraction”;

3. Magnetic metals, of all types and of whatever form, having any of the following characteristics:

a. Initial relative permeability of 120,000 or more and a thickness of 0.05 mm or less;

Technical Note:
Measurement of initial permeability must be performed on fully annealed materials.

b. Magnetostrictive alloys, having any of the following characteristics:
   1. A saturation magnetostriction of more than 5 x 10^{-4}; **or**
   2. A magnetomechanical coupling factor (k) of more than 0.8; **or**

c. Amorphous or nanocrystalline alloy strips, having all of the following characteristics:
   1. A composition having a minimum of 75 weight percent of iron, cobalt or nickel;
   2. A saturation magnetic induction (B_S) of 1.6 T or more; **and**
   3. Any of the following:
      a. A strip thickness of 0.02 mm or less; **or**
      b. An electrical resistivity of 2 x 10^{-4} ohm cm or more.

   Technical Note:
   ‘Nanocrystalline’ materials in 1-1.C.3.c. are those materials having a crystal grain size of 50 nm or less, as determined by X-ray diffraction.

4. Uranium titanium alloys or tungsten alloys with a “matrix” based on iron, nickel or copper, having all of the following:
   a. A density exceeding 17.5 g/cm^3;
   b. An elastic limit exceeding 880 MPa;
   c. An ultimate tensile strength exceeding 1,270 MPa; **and**
   d. An elongation exceeding 8%.
5. “Superconductive” “composite” conductors in lengths exceeding 100 m or with a mass exceeding 100 g, as follows:
   a. “Superconductive” “composite” conductors containing one or more niobium-titanium filaments, having all of the following:
      1. Embedded in a “matrix” other than a copper or copper-based mixed “matrix”; **and**
      2. Having a cross-section area less than 0.28 x 10^{-4} mm^2 (6 µm in diameter for circular filaments);
   b. “Superconductive” “composite” conductors consisting of one or more “superconductive” filaments other than niobium-titanium, having all of the following:
      1. A “critical temperature” at zero magnetic induction exceeding 9.85 K (-263.31°C); **and**
      2. Remaining in the “superconductive” state at a temperature of 4.2 K (-268.96°C) when exposed to a magnetic field oriented in any direction perpendicular to the longitudinal axis of conductor and corresponding to a magnetic induction of 12 T with critical current density exceeding 1,750 A/mm^2 on overall cross-section of the conductor.
   c. “Superconductive” “composite” conductors consisting of one or more “superconductive” filaments which remain “superconductive” above 115 K (-158.16°C).

   Technical Note:
   For the purpose of 1-1.C.5., filaments may be in wire, cylinder, film, tape or ribbon form.

6. Fluids and lubricating materials, as follows:
   a. Hydraulic fluids containing, as their principal ingredients, any of the following compounds or materials:
      1. Synthetic silahydrocarbon oils, having all of the following:

         Technical Note:
         For the purpose of 1-1.C.6.a.1., silahydrocarbon oils contain exclusively silicon, hydrogen and carbon.

         a. A flash point exceeding 477 K (204°C);
         b. A pour point at 239 K (-34°C) or less;
         c. A viscosity index of 75 or more; **and**
         d. A thermal stability at 616 K (343°C); **or**
      2. Chlorofluorocarbons, having all of the following:

         Technical Note:
         For the purpose of 1-1.C.6.a.2., chlorofluorocarbons contain exclusively carbon, fluorine and chlorine.

         a. No flash point;
         b. An autogenous ignition temperature exceeding 977 K (704°C);
         c. A pour point at 219 K (-54°C) or less;
         d. A viscosity index of 80 or more; **and**
         e. A boiling point at 473 K (200°C) or higher;
   b. Lubricating materials containing, as their principal ingredients, any of the following compounds or materials:
      1. Phenylene or alkylphenylene ethers or thio-ethers, or their mixtures, containing more than two ether or thio-ether functions or mixtures thereof; **or**
      2. Fluorinated silicone fluids with a kinematic viscosity of less than 5,000 mm^2/s (5,000 centistokes) measured at 298 K (25°C);
   c. Damping or flotation fluids with a purity exceeding 99.8%, containing less than 25 particles of 200 µm or larger in size per 100 ml and made from at least 85% of any of the following compounds or materials:
      1. Dibromotetrafluoroethane;
      2. Polychlorotrifluoroethylene (oily and waxy modifications only); **or**
      3. Polybromotrifluoroethylene;
   d. Fluorocarbon electronic cooling fluids, having all of the following characteristics:
      1. Containing 85% by weight or more of any of the following, or mixtures thereof:
         a. Monomeric forms of perfluoropolyalkylether-triazines or perfluoroaliphatic-ethers;
         b. Perfluoroalkylamines;
         c. Perfluorocycloalkanes; **or**
         d. Perfluoroalkanes;
      2. Density at 298 K (25°C) of 1.5 g/ml or more;
      3. In a liquid state at 273 K (0°C); **and**
      4. Containing 60% or more by weight of fluorine.

Technical Note:
For the purpose of 1-1.C.6.:

a. Flash point is determined using the Cleveland Open Cup Method described in ASTM D-92 or national equivalents;
b. Pour point is determined using the method described in ASTM D-97 or national equivalents;
c. Viscosity index is determined using the method described in ASTM D-2270 or national equivalents;
d. Thermal stability is determined by the following test procedure or national equivalents:
   Twenty ml of the fluid under test is placed in a 46 ml type 317 stainless steel chamber containing one each of 12.5 mm (nominal) diameter balls of M-10 tool steel, 52100 steel and naval bronze (60% Cu, 39% Zn, 0.75% Sn);
   The chamber is purged with nitrogen, sealed at atmospheric pressure and the temperature raised to and maintained at 644 ± 6 K (371 ± 6°C) for six hours;
   The specimen will be considered thermally stable if, on completion of the above procedure, all of the following conditions are met:

1. The loss in weight of each ball is less than 10 mg/mm^2 of ball surface;
2. The change in original viscosity as determined at 311 K (38°C) is less than 25%; **and**
3. The total acid or base number is less than 0.40;

e. Autogenous ignition temperature is determined using the method described in ASTM E-659 or national equivalents.

7. Ceramic base materials, non-“composite” ceramic materials, ceramic-“matrix” “composite” materials and precursor materials, as follows:
   a. Base materials of single or complex borides of titanium having total metallic impurities, excluding intentional additions, of less than 5,000 ppm, an average particle size equal to or less than 5 µm and no more than 10% of the particles larger than 10 µm;
   b. Non-“composite” ceramic materials in crude or semi-fabricated form, composed of borides of titanium with a density of 98% or more of the theoretical density;

   Note:
   1-1.C.7.b. does not control abrasives.

   c. Ceramic-ceramic “composite” materials with a glass or oxide-“matrix” and reinforced with fibres having all of the following:
      1. Made from any of the following materials:
         a. Si-N;
         b. Si-C;
         c. Si-Al-O-N; **or**
         d. Si-O-N; **and**
      2. Having a specific tensile strength exceeding 12.7 x 10^3m;
   d. Ceramic-ceramic “composite” materials, with or without a continuous metallic phase, incorporating particles, whiskers or fibres, where carbides or nitrides of silicon, zirconium or boron form the “matrix”;
   e. Precursor materials (i.e., special purpose polymeric or metallo-organic materials) for producing any phase or phases of the materials controlled by 1-1.C.7.c., as follows:
      1. Polydiorganosilanes (for producing silicon carbide);
      2. Polysilazanes (for producing silicon nitride);
      3. Polycarbosilazanes (for producing ceramics with silicon, carbon and nitrogen components);
   f. Ceramic-ceramic “composite” materials with an oxide or glass “matrix” reinforced with continuous fibres from any of the following systems:
      1. Al_2O_3; **or**
      2. Si-C-N.

   Note:
   1-1.C.7.f. does not control “composites” containing fibres from these systems with a fibre tensile strength of less than 700 MPa at 1,273 K (1,000° C) or fibre tensile creep resistance of more than 1% creep strain at 100 MPa load and 1,273 K (1,000° C) for 100 hours.

8. Non-fluorinated polymeric substances, as follows:
   a. 1. Bismaleimides;
      2. Aromatic polyamide-imides;
      3. Aromatic polyimides;
      4. Aromatic polyetherimides having a glass transition temperature (T_g) exceeding 513 K (240° C);

   Note 1:
   1-1.C.8.a. controls the substances in liquid or solid form, including resin, powder, pellet, film, sheet, tape, or ribbon.

   Note 2:
   1-1.C.8.a. does not control non-fusible compression moulding powders or moulded forms.

   b. Thermoplastic liquid crystal copolymers having a heat distortion temperature exceeding 523 K (250°C) measured according to ISO 75-2 (2004), method A or national equivalents, with a load of 1.80 N/mm^2 and composed of:
      1. Any of the following:
         a. Phenylene, biphenylene or naphthalene; **or**
         b. Methyl, tertiary-butyl or phenyl substituted phenylene, biphenylene or naphthalene; **and**
      2. Any of the following acids:
         a. Terephthalic acid;
         b. 6-hydroxy-2 naphthoic acid; **or**
         c. 4-hydroxybenzoic acid;
   c. Deleted
   d. Polyarylene ketones;
   e. Polyarylene sulphides, where the arylene group is biphenylene, triphenylene or combinations thereof;
   f. Polybiphenylenethersulphone having a glass transition temperature (Tg) exceeding 513 K (240° C).

   Technical Note:
   The glass transition temperature (Tg) for 1-1.C.8. materials is determined using the method described in ISO 11357-2 (1999) or national equivalents.

9. Unprocessed fluorinated compounds, as follows:
   a. Copolymers of vinylidene fluoride having 75% or more beta crystalline structure without stretching;
   b. Fluorinated polyimides containing 10% by weight or more of combined fluorine;
   c. Fluorinated phosphazene elastomers containing 30% by weight or more of combined fluorine.
10. “Fibrous or filamentary materials” which may be used in organic “matrix”, metallic “matrix” or carbon “matrix” “composite” structures or laminates, as follows:
   a. Organic “fibrous or filamentary materials”, having all of the following:
      1. A specific modulus exceeding 12.7 x 10^6 m; **and**
      2. A specific tensile strength exceeding 23.5 x 10^4 m;

   Note:
   1-1.C.10.a. does not control polyethylene.

   b. Carbon “fibrous or filamentary materials”, having all of the following:
      1. A specific modulus exceeding 12.7 x 10^6 m; **and**
      2. A specific tensile strength exceeding 23.5 x 10^4 m;

   Technical Note:
   Properties for materials described in 1-1.C.10.b. should be determined using SACMA recommended methods SRM 12 to 17, or national equivalent tow tests, such as Japanese Industrial Standard JIS-R-7601, Paragraph 6.6.2., and based on lot average.

   Note:
   1-1.C.10.b. does not control fabric made from “fibrous or filamentary materials” for the repair of “civil aircraft” structures or laminates, in which the size of individual sheets does not exceed 100 cm x 100 cm.

   c. Inorganic “fibrous or filamentary materials”, having all of the following:
      1. A specific modulus exceeding 2.54 x 10^6 m; **and**
      2. A melting, softening, decomposition or sublimation point exceeding 1,922 K (1,649°C) in an inert environment;

Note:
1-1.C.10.c. does not control:
1. Discontinuous, multiphase, polycrystalline alumina fibres in chopped fibre or random mat form, containing 3 weight percent or more silica, with a specific modulus of less than 10 x 10^6 m;
2. Molybdenum and molybdenum alloy fibres;
3. Boron fibres;
4. Discontinuous ceramic fibres with a melting, softening, decomposition or sublimation point lower than 2,043 K (1,770°C) in an inert environment.

d. “Fibrous or filamentary materials”:
   1. Composed of any of the following:
      a. Polyetherimides controlled by 1-1.C.8.a.; **or**
      b. Materials controlled by 1-1.C.8.b. to 1-1.C.8.f.; **or**
   2. Composed of materials controlled by 1-1.C.10.d.1.a. or 1-1.C.10.d.1.b. and “commingled” with other fibres controlled by 1-1.C.10.a., 1-1.C.10.b. or 1-1.C.10.c.;

e. Resin-impregnated or pitch-impregnated fibres (prepregs), metal or carbon-coated fibres (preforms) or “carbon fibre preforms”, as follows:
   1. Made from “fibrous or filamentary materials” controlled by 1-1.C.10.a., 1-1.C.10.b. or 1-1.C.10.c.;
   2. Made from organic or carbon “fibrous or filamentary materials”:
      a. With a specific tensile strength exceeding 17.7 x 10^4 m;
      b. With a specific modulus exceeding 10.15 x 10^6 m;
      c. Not controlled by 1-1.C.10.a. or 1-1.C.10.b.; **and**
      d. When impregnated with materials controlled by 1-1.C.8. or 1-1.C.9.b., having a glass transition temperature (T_g) exceeding 383 K (110°C) or with phenolic or epoxy resins, having a glass transition temperature (T_g) equal to or exceeding 418 K (145°C).

Notes:
1-1.C.10.e. does not control:
1. Epoxy resin “matrix” impregnated carbon “fibrous or filamentary materials” (prepregs) for the repair of “civil aircraft” structures or laminates, in which the size of individual sheets of prepreg does not exceed 100 cm x 100 cm;
2. Prepregs when impregnated with phenolic or epoxy resins having a glass transition temperature (Tg) less than 433 K (160°C) and a cure temperature lower than the glass transition temperature.

Technical Note:
The glass transition temperature (Tg) for 1-1.C.10.e. materials is determined using the method described in ASTM D 3418 using the dry method. The glass transition temperature for phenolic and epoxy resins is determined using the method described in ASTM D 4065 at a frequency of 1Hz and a heating rate of 2 K (°C) per minute using the dry method.

Technical Notes:
1. Specific modulus: Young’s modulus in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.
2. Specific tensile strength: ultimate tensile strength in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

11. Metals and compounds, as follows:
   a. Metals in particle sizes of less than 60 µm whether spherical, atomised, spheroidal, flaked or ground, manufactured from material consisting of 99% or more of zirconium, magnesium and alloys of these;

Technical Note:
The natural content of hafnium in the zirconium (typically 2% to 7%) is counted with the zirconium.

Note:
The metals or alloys listed in 1-1.C.11.a. are controlled whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.

   b. Boron or boron carbide of 85% purity or higher and a particle size of 60 µm or less;

Note:
The metals or alloys listed in 1-1.C.11.b. are controlled whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.

   c. Guanidine nitrate;
   d. Nitroguanidine (NQ) (CAS 556-88-7).

12. Materials as follows:

Technical Note:
These materials are typically used for nuclear heat sources.

   a. Plutonium in any form with a plutonium isotopic assay of plutonium-238 of more than 50% by weight;

Note:
1-1.C.12.a. does not control:
1. Shipments with a plutonium content of 1 g or less;
2. Shipments of 3 “effective grams” or less when contained in a sensing component in instruments.

   b. “Previously separated” neptunium-237 in any form.

Note:
1-1.C.12.b. does not control shipments with a neptunium-237 content of 1 g or less.

1-1.D. Software

1. “Software” specially designed or modified for the “development”, “production” or “use” of equipment controlled by 1-1.B.
2. “Software” for the “development” of organic “matrix”, metal “matrix” or carbon “matrix” laminates or “composites”.
3. “Software” specially designed or modified to enable equipment to perform the functions of equipment controlled under section 1-1.A.4.c.

1-1.E. Technology

1. “Technology” according to the General Technology Note for the “development” or “production” of equipment or materials controlled by 1-1.A.1.b., 1-1.A.1.c., 1-1.A.2. to 1-1.A.5., 1-1.B. or 1-1.C.
2. Other “technology”, as follows:
   a. “Technology” for the “development” or “production” of polybenzothiazoles or polybenzoxazoles;
   b. “Technology” for the “development” or “production” of fluoroelastomer compounds containing at least one vinylether monomer;
   c. “Technology” for the design or “production” of the following base materials or non-“composite” ceramic materials:
      1. Base materials having all of the following characteristics:
         a. Any of the following compositions:
            1. Single or complex oxides of zirconium and complex oxides of silicon or aluminium;
            2. Single nitrides of boron (cubic crystalline forms);

3. Single or complex carbides of silicon or boron; or
4. Single or complex nitrides of silicon;

b. Total metallic impurities, excluding intentional additions, of less than:
1. 1,000 ppm for single oxides or carbides; or
2. 5,000 ppm for complex compounds or single nitrides; and

c. Being any of the following:
1. Zirconia with an average particle size equal to or less than 1 µm and no more than 10% of the particles larger than 5 µm;2. Other base materials with an average particle size equal to or less than 5 µm and no more than 10% of the particles larger than 10 µm; **or**
3. Having all of the following:
a. Platelets with a length to thickness ratio exceeding 5;
b. Whiskers with a length to diameter ratio exceeding 10 for diameters less than 2 µm; **and**
c. Continuous or chopped fibres less than 10 µm in diameter;

2. Non-“composite” ceramic materials composed of the materials described in 1-1.E.2.c.1.;

Note:
1-1.E.2.c.2. does not control technology for the design or production of abrasives.

d. “Technology” for the “production” of aromatic polyamide fibres;

e. “Technology” for the installation, maintenance or repair of materials controlled by 1-1.C.1.;

f. “Technology” for the repair of “composite” structures, laminates or materials controlled by 1-1.A.2., 1-1.C.7.c. or 1-1.C.7.d.

Note:
1-1.E.2.f. does not control “technology” for the repair of “civil aircraft” structures using carbon “fibrous or filamentary materials” and epoxy resins, contained in aircraft manufacturers’ manuals.

g. Libraries (parametric technical databases) specially designed or modified to enable equipment to perform the functions of equipment controlled under section 1-1.A.4.c.

Technical Note:
For the purpose of 1-1.E.2.g., the term ‘library’ (parametric technical database) means a collection of technical information, reference to which may enhance the performance of relevant equipment or systems.

Category 2: Materials Processing

1-2.A. Systems, Equipment and Components

N.B.:
For quiet running bearings, see Item 2-9 on the Munitions List.

1. Anti-friction bearings and bearing systems, as follows, and components therefor:

Note:
1-2.A.1. does not control balls with tolerances specified by the manufacturer in accordance with ISO 3290 as grade 5 or worse.

a. Ball bearings and solid roller bearings having all tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 4 (or ANSI/ABMA Std 20 Tolerance Class ABEC-7 or RBEC-7, or other national equivalents), or better, and having both rings and rolling elements (ISO 5593) made from monel or beryllium;

Note:
1-2.A.1.a. does not control tapered roller bearings.

b. Other ball bearings and solid roller bearings having all tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or RBEC-9, or other national equivalents), or better;

Note:
1-2.A.1.b. does not control tapered roller bearings.

c. Active magnetic bearing systems using any of the following:
1. Materials with flux densities of 2.0 T or greater and yield strengths greater than 414 MPa;
2. All-electromagnetic 3D homopolar bias designs for actuators; **or**
3. High temperature (450 K (177°C) and above) position sensors.

1-2.B. Test, Inspection and Production Equipment

Technical Notes:

1. Secondary parallel contouring axes, (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centre line of which is parallel to the primary rotary axis) are not counted in the total number of contouring axes. Rotary axes need not rotate over 360°. A rotary axis can be driven by a linear device (e.g., a screw or a rack-and-pinion).
2. For the purposes of 1-2.B, the number of axes which can be co-ordinated simultaneously for “contouring control” is the number of axes along or around which, during processing of the workpiece, simultaneous and interrelated motions are performed between the workpiece and a tool. 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.
3. Axis nomenclature shall be in accordance with International Standard ISO 841, ‘Numerical Control Machines - Axis and Motion Nomenclature’.
4. For the purposes of this Category a “tilting spindle” is counted as a rotary axis.
5. Stated positioning accuracy levels derived from measurements made according to ISO 230/2 (1997) or national equivalents may be used for each machine tool model instead of individual machine tests. Stated positioning accuracy means the accuracy value provided to national licensing authorities as representative of the accuracy of a machine model.
   Determination of Stated Values:
   a. Select five machines of a model to be evaluated;
   b. Measure the linear axis accuracies according to ISO 230/2 (1997);
   c. Determine the A-values for each axis of each machine. The method of calculating the A-value is described in the ISO standard;
   d. Determine the mean value of the A-value of each axis. This mean value Â becomes the stated value of each axis for the model (Âx Ây...);
   e. Since the Category 2 list refers to each linear axis there will be as many stated values as there are linear axes;

f. If any axis of a machine model not controlled by 1-2.B.1.a. to 1-2.B.1.c. has a stated accuracy Â of 5 microns for grinding machines and 6.5 microns for milling and turning machines or better, the builder should be required to reaffirm the accuracy level once every eighteen months.

1. Machine tools and any combination thereof, for removing (or cutting) metals, ceramics or "composites", which, according to the manufacturer's technical specification, can be equipped with electronic devices for "numerical control", and specially designed components as follows:

Note 1:
1-2.B.1. does not control special purpose machine tools limited to the manufacture of gears. For such machines, see Item 1-2.B.3.

Note 2:
1-2.B.1. does not control special purpose machine tools limited to the manufacture of any of the following parts:
a. Crank shafts or cam shafts;
b. Tools or cutters;
c. Extruder worms;
d. Engraved or facetted jewellery parts.

Note 3:
A machine tool having at least two of the three turning, milling or grinding capabilities (e.g., a turning machine with milling capability), must be evaluated against each applicable entry 1-2.B.1.a., 1-2.B.1.b. or 1-2.B.1.c.

a. Machine tools for turning, having all of the following characteristics:
   1. Positioning accuracy with "all compensations available" equal to or less (better) than 4.5 µm according to ISO 230/2 (1997) or national equivalents along any linear axis; **and**
   2. Two or more axes which can be coordinated simultaneously for "contouring control";

   Note:
   1-2.B.1.a. does not control turning machines specially designed for the production of contact lenses, having all of the following characteristics:
   1. Machine controller limited to using ophthalmic based software for part programming data input; **and**
   2. No vacuum chucking.

b. Machine tools for milling, having any of the following characteristics:
   1. Having all of the following:
      a. Positioning accuracy with "all compensations available" equal to or less (better) than 4.5 µm according to ISO 230/2 (1997) or national equivalents along any linear axis; **and**
      b. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control";
   2. Five or more axes which can be coordinated simultaneously for "contouring control";
   3. A positioning accuracy for jig boring machines, with "all compensations available", equal to or less (better) than 3.0 µm according to ISO 230/2 (1997) or national equivalents along any linear axis; **or**
   4. Fly cutting machines, having all of the following characteristics:
      a. Spindle "run-out" and "camming" less (better) than 0.0004 mm TIR; **and**
      b. Angular deviation of slide movement (yaw, pitch and roll) less (better) than 2 seconds of arc, TIR, over 300 mm of travel.

c. Machine tools for grinding, having any of the following characteristics:
   1. Having all of the following:
      a. Positioning accuracy with "all compensations available" equal to or less (better) than 3.0 µm according to ISO 230/2 (1997) or national equivalents along any linear axis; **and**
      b. Three or more axes which can be coordinated simultaneously for "contouring control"; **or**
   2. Five or more axes which can be coordinated simultaneously for "contouring control";

   Notes:
   1-2.B.1.c. does not control grinding machines, as follows:
   1. Cylindrical external, internal, and external-internal grinding machines having all the following characteristics:
      a. Limited to cylindrical grinding; and
      b. Limited to a maximum workpiece capacity of 150 mm outside diameter or length.
   2. Machines designed specifically as jig grinders that do not have a z-axis or a w-axis, with a positioning accuracy with "all compensations available" less (better) than 3 µm according to ISO 230/2 (1997) or national equivalents.
   3. Surface grinders.

d. Electrical discharge machines (EDM) of the non-wire type which have two or more rotary axes which can be coordinated simultaneously for "contouring control";
e. Machine tools for removing metals, ceramics or "composites" having all of the following characteristics:
   1. Removing material by means of any of the following:
      a. Water or other liquid jets, including those employing abrasive additives;
      b. Electron beam; **or**
      c. "Laser" beam; **and**
   2. Having two or more rotary axes which:
      a. Can be coordinated simultaneously for "contouring control"; **and**
      b. Have a positioning accuracy of less (better) than 0.003°;
f. Deep-hole-drilling machines and turning machines modified for deep-hole-drilling, having a maximum depth-of-bore capability exceeding 5,000 mm and specially designed components therefor.

2. Numerically controlled optical finishing machine tools equipped to produce non-spherical optical surfaces, having all of the following characteristics:
   a. Finishing the form to less (better) than 1.0 µm;
   b. Finishing to a roughness less (better) than 100 nm rms;
   c. Three or more axes which can be coordinated simultaneously for "contouring control"; **and**
   d. Using any of the following processes:
      1. Magnetorheological finishing (MRF);
      2. Electrorheological finishing (ERF); **or**
      3. Energetic particle beam finishing.

   Technical Note:
   For the purposes of 1-2.B.2., 'MRF' is a material removal process using an abrasive magnetic fluid whose viscosity is controlled by a magnetic field. 'ERF' is a removal process using an abrasive fluid whose viscosity is controlled by an electric field. 'Energetic particle beam finishing' uses Reactive Atom Plasmas (RAP) or ion-beams to selectively remove material.

3. “Numerically controlled” or manual machine tools, and specially designed components, controls and accessories therefor, specially designed for the shaving, finishing, grinding or honing of hardened (R_c = 40 or more) spur, helical and double-helical gears with a pitch diameter exceeding 1,250 mm and a face width of 15% of pitch diameter or larger finished to a quality of AGMA 14 or better (equivalent to ISO 1328 class 3).
4. Hot “isostatic presses”, having all of the following, and specially designed components and accessories therefor:
   a. A controlled thermal environment within the closed cavity and a chamber cavity with an inside diameter of 406 mm or more; **and**
   b. Any of the following:
      1. A maximum working pressure exceeding 207 MPa;
      2. A controlled thermal environment exceeding 1,773 K (1,500°C); **or**
      3. A facility for hydrocarbon impregnation and removal of resultant gaseous degradation products.

Technical Note:
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.

N.B.:
For specially designed dies, moulds and tooling see Items 1-1.B.3., 1-9.B.9. and 2-18. of the Munitions List.

5. Equipment specially designed for the deposition, processing and in-process control of inorganic overlays, coatings and surface modifications, as follows, for non-electronic substrates, by processes shown in the Table and associated Notes following 1-2.E.3.f., and specially designed automated handling, positioning, manipulation and control components therefor:
   a. Chemical vapour deposition (CVD) production equipment having all of the following:
      1. Process modified for one of the following:
         a. Pulsating CVD;
         b. Controlled nucleation thermal deposition (CNTD); **or**
         c. Plasma enhanced or plasma assisted CVD; **and**
      2. Any of the following:
         a. Incorporating high vacuum (equal to or less than 0.01 Pa) rotating seals; **or**
         b. Incorporating *in situ* coating thickness control;
   b. Ion implantation production equipment having beam currents of 5 mA or more;
   c. Electron beam physical vapour deposition (EB-PVD) production equipment incorporating power systems rated for over 80 kW, having any of the following:
      1. A liquid pool level “laser” control system which regulates precisely the ingots feed rate; **or**
      2. A computer controlled rate monitor operating on the principle of photo-luminescence of the ionised atoms in the evaporant stream to control the deposition rate of a coating containing two or more elements;
   d. Plasma spraying production equipment having any of the following characteristics:
      1. Operating at reduced pressure controlled atmosphere (equal to or less than 10 kPa measured above and within 300 mm of the gun nozzle exit) in a vacuum chamber capable of evacuation down to 0.01 Pa prior to the spraying process; **or**
      2. Incorporating *in situ* coating thickness control;
   e. Sputter deposition production equipment capable of current densities of 0.1 mA/mm^2 or higher at a deposition rate of 15 µm/h or more;
   f. Cathodic arc deposition production equipment incorporating a grid of electromagnets for steering control of the arc spot on the cathode;
   g. Ion plating production equipment allowing for the *in situ* measurement of any of the following:
      1. Coating thickness on the substrate and rate control; **or**
      2. Optical characteristics.

Note:
1-2.B.5.a., 1-2.B.5.b., 1-2.B.5.e., 1-2.B.5.f. and 1-2.B.5.g. do not control chemical vapour deposition, cathodic arc, sputter deposition, ion plating or ion implantation equipment specially designed for cutting or machining tools.

6. Dimensional inspection or measuring systems, equipment and “electronic assemblies”, as follows:
   a. Computer controlled or “numerically controlled” co-ordinate measuring machines (CMM), having a three dimensional (volumetric) maximum permissible error of indication (MPEE) at any point within the operating range of the machine (i.e., within the length of axes) equal to or less (better) than 1.7 + L/1,000 µm (L is the measured length in mm), tested according to ISO 10360-2 (2001);
   b. Linear and angular displacement measuring instruments, as follows:
      1. Linear displacement measuring instruments having any of the following:

Technical Note:
For the purpose of 1-2.B.6.b.1., ‘linear displacement’ means the change of distance between the measuring probe and the measured object.

         a. Non-contact type measuring systems with a “resolution” equal to or less (better) than 0.2 µm within a measuring range up to 0.2 mm;
         b. Linear voltage differential transformer systems having all of the following characteristics:
            1. “Linearity” equal to or less (better) than 0.1% within a measuring range up to 5 mm; **and**
            2. Drift equal to or less (better) than 0.1% per day at a standard ambient test room temperature ±1 K; **or**
         c. Measuring systems having all of the following:
            1. Containing a “laser”; **and**
            2. Maintaining, for at least 12 hours, over a temperature range of ±1 K around a standard temperature and at a standard pressure, all of the following:
               a. A “resolution” over their full scale of 0.1 µm or less (better); **and**
               b. A “measurement uncertainty” equal to or less (better) than (0.2 + L/2,000) µm (L is the measured length in mm);
         d. “Electronic assemblies” specially designed to provide feedback capability in systems controlled by 1-2.B.6.b.1.c.

Note:
1-2.B.6.b.1. does not control measuring interferometer systems, with an automatic control system that is designed to use no feedback techniques, containing a "laser" to measure slide movement errors of machine-tools, dimensional inspection machines or similar equipment.

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

Note:
1-2.B.6.b.2. does not control optical instruments, such as autocollimators, using collimated light (e.g., laser light) to detect angular displacement of a mirror.

c. Equipment for measuring surface irregularities, by measuring optical scatter as a function of angle, with a sensitivity of 0.5 nm or less (better).

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

7. "Robots" having any of the following characteristics and specially designed controllers and "end-effectors" therefor:
   a. Capable in real time of full three-dimensional image processing or full three-dimensional scene analysis to generate or modify "programmes" or to generate or modify numerical programme data;

   Technical Note:
   The scene analysis limitation does not include approximation of the third dimension by viewing at a given angle, or limited grey scale interpretation for the perception of depth or texture for the approved tasks (2 1/2 D).

   b. Specially designed to comply with national safety standards applicable to explosive munitions environments;
   c. Specially designed or rated as radiation-hardened to withstand greater than 5 x 10^3 Gy (Si) without operational degradation**; or**
   d. Specially designed to operate at altitudes exceeding 30,000 m.
8. Assemblies or units, specially designed for machine tools, or dimensional inspection or measuring systems and equipment, as follows:
   a. Linear position feedback units (e.g., inductive type devices, graduated scales, infrared systems or "laser" systems) having an overall "accuracy" less (better) than (800 + (600 x L x 10^{-3})) nm (L equals the effective length in mm);

   N.B.:
   For "laser" systems see also Note to 1-2.B.6.b.1.

   b. Rotary position feedback units (e.g., inductive type devices, graduated scales, infrared systems or "laser" systems) having an "accuracy" less (better) than 0.00025°;

   N.B.:
   For "laser" systems see also Note to 1-2.B.6.b.1.

   c. "Compound rotary tables" and "tilting spindles", capable of upgrading, according to the manufacturer's specifications, machine tools to or above the levels specified in 1-2.B.
9. Spin-forming machines and flow-forming machines, which, according to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control and having all of the following:
   a. Two or more controlled axes of which at least two can be coordinated simultaneously for "contouring control"; **and**
   b. A roller force more than 60 kN.

   Technical Note:
   Machines combining the function of spin-forming and flow-forming are for the purpose of 1-2.B.9. regarded as flow-forming machines.

1-2.C. Materials

None

1-2.D. Software

1. "Software", other than that controlled by 1-2.D.2., specially designed or modified for the "development", "production" or "use" of equipment controlled by 1-2.A. or 1-2.B.
2. "Software" for electronic devices, even when residing in an electronic device or system, enabling such devices or systems to function as a "numerical control" unit, capable of co-ordinating simultaneously more than 4 axes for "contouring control".

   Note 1:
   1-2.D.2. does not control "software" specially designed or modified for the operation of machine tools not controlled by Category 2.

   Note 2:
   1-2.D.2. does not control "software" for items controlled by 1-2.B.2. See 1-2.D.1. for control of "software" for items controlled by 1-2.B.2.

1-2.E. Technology

1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 1-2.A., 1-2.B. or 1-2.D.
2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 1-2.A. or 1-2.B.
3. Other "technology", as follows:
   a. "Technology" for the "development" of interactive graphics as an integrated part in "numerical control" units for preparation or modification of part programmes;
   b. "Technology" for metal-working manufacturing processes, as follows:
      1. "Technology" for the design of tools, dies or fixtures specially designed for any of the following processes:
         a. "Superplastic forming";
         b. "Diffusion bonding"; **or**
         c. "Direct-acting hydraulic pressing";
      2. Technical data consisting of process methods or parameters as listed below used to control:
         a. "Superplastic forming" of aluminium alloys, titanium alloys or "superalloys":
            1. Surface preparation;
            2. Strain rate;
            3. Temperature;
            4. Pressure;
         b. "Diffusion bonding" of "superalloys" or titanium alloys:
            1. Surface preparation;
            2. Temperature;
            3. Pressure;

c. "Direct-acting hydraulic pressing" of aluminium alloys or titanium alloys:
    1. Pressure;
    2. Cycle time;
d. "Hot isostatic densification" of titanium alloys, aluminium alloys or "superalloys":
    1. Temperature;
    2. Pressure;
    3. Cycle time;

c. "Technology" for the "development" or "production" of hydraulic stretch-forming machines and dies therefor, for the manufacture of airframe structures;
d. "Technology" for the "development" of generators of machine tool instructions (e.g., part programmes) from design data residing inside "numerical control" units;
e. "Technology" for the "development" of integration "software" for incorporation of expert systems for advanced decision support of shop floor operations into "numerical control" units;
f. "Technology" for the application of inorganic overlay coatings or inorganic surface modification coatings (specified in column 3 of the following table) to non-electronic substrates (specified in column 2 of the following table), by processes specified in column 1 of the following table and defined in the Technical Note.

N.B.:

This Table should be read to control the technology of a particular 'Coating Process' only when the 'Resultant Coating' in column 3 is in a paragraph directly across from the relevant 'Substrate' under column 2. For example, Chemical Vapour Deposition (CVD) coating process technical data are controlled for the application of 'silicides' to 'Carbon-carbon, Ceramic and Metal "matrix" "composites" 'substrates, but are not controlled for the application of 'silicides' to 'Cemented tungsten carbide (16), Silicon carbide (18)' substrates. In the second case, the 'Resultant Coating' is not listed in the paragraph under column 3 directly across from the paragraph under column 2 listing 'Cemented tungsten carbide (16), Silicon carbide (18)'.

Table – Deposition Techniques

Coating Process (1)*	**Substrate**	**Resultant Coating**
A. Chemical Vapour Deposition (CVD)	"Superalloys"	Aluminides for internal passages
	Ceramics (19) and Low-expansion glasses (14)	Silicides Carbides Dielectric layers (15) Diamond Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Aluminides Alloyed aluminides (2) Boron nitride
	Cemented tungsten carbide (16) Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Diamond Diamond-like carbon (17)
	Sensor window materials (9)	Dielectric layers (15) Diamond Diamond-like carbon (17)
B. Thermal-Evaporation Physical Vapour Deposition (TE-PVD)		
B. 1. Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD)	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5) Modified zirconia (12) Silicides Aluminides Mixtures thereof (4)
	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15)
	Corrosion resistant steel (7)	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride

*** *Note:*** The numbers in parenthesis refer to the Notes following this table.

Table – Deposition Techniques

Coating Process (1)*	**Substrate**	**Resultant Coating**
B. 1. Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD) Con't:	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Borides Beryllium
	Sensor window materials (9)	Dielectric layers (15)
	Titanium alloys (13)	Borides Nitrides
B. 2. Ion assisted resistive heating Physical Vapour Deposition (PVD) (Ion Plating)	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15) Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
B. 3. Physical Vapour Deposition (PVD): "Laser" Vaporization	Ceramics (19) and Low-expansion glasses (14)	Silicides Dielectric layers (15) Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon
B. 4. Physical Vapour Deposition (PVD): Cathodic Arc Discharge	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5)
	Polymers (11) and Organic "matrix" "composites"	Borides Carbides Nitrides Diamond-like carbon (17)

*** *Note:*** The numbers in parenthesis refer to the Notes following this table.

Table – Deposition Techniques

Coating Process (1)*	**Substrate**	**Resultant Coating**
C. Pack cementation (see A above for out-of-pack cementation) (10)	Carbon-carbon, Ceramic and metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)
	Titanium alloys (13)	Silicides Aluminides
	Refractory metals and alloys (8)	Alloyed aluminides (2) Silicides Oxides
D. Plasma spraying	"Superalloys"	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si- Polyester Alloyed aluminides (2)
	Aluminum alloys (6)	MCrAlX (5) Modified zirconia (12) Silicides Mixtures thereof (4)
	Refractory metals and alloys (8)	Aluminides Silicides Carbides
	Corrosion resistant steel (7)	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4)
	Titanium alloys (13)	Carbides Aluminides Silicides Alloyed aluminides (2) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester
E. Slurry Deposition	Refractory metals and alloys (8)	Fused silicides Fused aluminides except for resistance heating elements
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)
F. Sputter Deposition	"Superalloys"	Alloyed silicides Alloyed aluminides (2) Noble metal modified aluminides (3) MCrAlX (5) Modified zirconia (12) Platinum Mixtures thereof (4)

***** ***Note:*** The numbers in parenthesis refer to the Notes following this table.

Table – Deposition Techniques

Coating Process (1)*	Substrate	Resultant Coating
F. Sputter Deposition (con't)	Ceramics and Low-expansion glasses (14)	Silicides Platinum Mixtures thereof (4) Dielectic layers (15) Diamond-like carbon (17)
	Titanium alloys (13)	Borides Nitrides Oxides Silicides Aluminides Alloyed aluminides (2) Carbides
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Borides Dielectric layers (15) Beryllium
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
	Refractory metals and alloys (8)	Aluminides Silicides Oxides Carbides
G. Ion Implantation	High temperature bearing steels	Additions of Chromium, Tantalum or Niobium (Columbium)
	Titanium alloys (13)	Borides Nitrides
	Beryllium and Beryllium alloys	Borides
	Cemented tungsten carbide (16)	Carbides Nitrides

* ***Note:*** The numbers in parenthesis refer to the Notes following this table.

Table - Deposition Techniques – Notes:

1. The term ‘coating process’ includes coating repair and refurbishing as well as original coating.
2. The term ‘alloyed aluminide coating’ includes single or multiple-step coatings in which an element or elements are deposited prior to or during application of the aluminide coating, even if these elements are deposited by another coating process. It does not, however, include the multiple use of single-step pack cementation processes to achieve alloyed aluminides.
3. The term ‘noble metal modified aluminide’ coating includes multiple-step coatings in which the noble metal or noble metals are laid down by some other coating process prior to application of the aluminide coating.
4. The term ‘mixtures thereof’ includes infiltrated material, graded compositions, co-deposits and multilayer deposits and are obtained by one or more of the coating processes specified in the Table.
5. ‘MCrAlX’ refers to a coating alloy where M equals cobalt, iron, nickel or combinations thereof and X equals hafnium, yttrium, silicon, tantalum in any amount or other intentional additions over 0.01 weight percent in various proportions and combinations, except:
   a. CoCrAlY coatings which contain less than 22 weight percent of chromium, less than 7 weight percent of aluminium and less than 2 weight percent of yttrium;
   b. CoCrAlY coatings which contain 22 to 24 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.5 to 0.7 weight percent of yttrium; **or**
   c. NiCrAlY coatings which contain 21 to 23 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.9 to 1.1 weight percent of yttrium.
6. The term ‘aluminium alloys’ refers to alloys having an ultimate tensile strength of 190 MPa or more measured at 293 K (20°C).
7. The term ‘corrosion resistant steel’ refers to AISI (American Iron and Steel Institute) 300 series or equivalent national standard steels.
8. ‘Refractory metals and alloys’ include the following metals and their alloys: niobium (columbium), molybdenum, tungsten and tantalum.
9. ‘Sensor window materials’, as follows: alumina, silicon, germanium, zinc sulphide, zinc selenide, gallium arsenide, diamond, gallium phosphide, sapphire and the following metal halides: sensor window materials of more than 40 mm diameter for zirconium fluoride and hafnium fluoride.
10. “Technology” for single-step pack cementation of solid airfoils is not controlled by Category 2.
11. Polymers’, as follows: polyimide, polyester, polysulphide, polycarbonates and polyurethanes.
12. ‘Modified zirconia’ refers to additions of other metal oxides (e.g., calcia, magnesia, yttria, hafnia, rare earth oxides) to zirconia in order to stabilise certain crystallographic phases and phase compositions. Thermal barrier coatings made of zirconia, modified with calcia or magnesia by mixing or fusion, are not controlled.
13. ‘Titanium alloys’ refers only to aerospace alloys having an ultimate tensile strength of 900 MPa or more measured at 293 K (20°C).
14. ‘Low-expansion glasses’ refers to glasses which have a coefficient of thermal expansion of $1 \times 10^{-7} K^{-1}$ or less measured at 293 K (20°C).
15. ‘Dielectric layers’ are coatings constructed of multi-layers of insulator materials in which the interference properties of a design composed of materials of various refractive indices are used to reflect, transmit or absorb various wavelength bands. Dielectric layers refers to more than four dielectric layers or dielectric/metal “composite” layers.
16. ‘Cemented tungsten carbide’ does not include cutting and forming tool materials consisting of tungsten carbide/(cobalt, nickel), titanium carbide/(cobalt, nickel), chromium carbide/nickel-chromium and chromium carbide/nickel.
17. “Technology” specially designed to deposit diamond-like carbon on any of the following is not controlled: magnetic disk drives and heads, equipment for the manufacture of disposables, valves for faucets, acoustic diaphragms for speakers, engine parts for automobiles, cutting tools, punching-pressing dies, office automation equipment, microphones, medical devices or moulds, for casting or moulding of plastics, manufactured from alloys containing less than 5% beryllium.
18. ‘Silicon carbide’ does not include cutting and forming tool materials.
19. Ceramic substrates, as used in this entry, does not include ceramic materials containing 5% by weight, or greater, clay or cement content, either as separate constituents or in combination.

Table - Deposition Techniques - Technical Notes:

Processes specified in Column 1 of the Table are defined as follows:

a. Chemical Vapour Deposition (CVD) is an overlay coating or surface modification coating process wherein a metal, alloy, “composite”, dielectric or ceramic is deposited upon a heated substrate. Gaseous reactants are decomposed or combined in the vicinity of a substrate resulting in the deposition of the desired elemental, alloy or compound material on the substrate. Energy for this decomposition or chemical reaction process may be provided by the heat of the substrate, a glow discharge plasma, or “laser” irradiation.
   N.B.1:
   CVD includes the following processes: directed gas flow out-of-pack deposition, pulsating CVD, controlled nucleation thermal deposition (CNTD), plasma enhanced or plasma assisted CVD processes.
   N.B.2:
   Pack denotes a substrate immersed in a powder mixture.
   N.B.3:
   The gaseous reactants used in the out-of-pack process are produced using the same basic reactions and parameters as the pack cementation process, except that the substrate to be coated is not in contact with the powder mixture.
b. Thermal Evaporation-Physical Vapour Deposition (TE-PVD) is an overlay coating process conducted in a vacuum with a pressure less than 0.1 Pa wherein a source of thermal energy is used to vaporize the coating material. This process results in the condensation, or deposition, of the evaporated species onto appropriately positioned substrates.
   The addition of gases to the vacuum chamber during the coating process to synthesize compound coatings is an ordinary modification of the process.
   The use of ion or electron beams, or plasma, to activate or assist the coating’s deposition is also a common modification in this technique. The use of monitors to provide in-process measurement of optical characteristics and thickness of coatings can be a feature of these processes.
   Specific TE-PVD processes are as follows:
   1. Electron Beam PVD uses an electron beam to heat and evaporate the material which forms the coating;
   2. Ion Assisted Resistive Heating PVD employs electrically resistive heating sources in combination with impinging ion beam(s) to produce a controlled and uniform flux of evaporated coating species;
   3. “Laser” Vaporization uses either pulsed or continuous wave “laser” beams to vaporize the material which forms the coating;
   4. Cathodic Arc Deposition employs a consumable cathode of the material which forms the coating and has an arc discharge established on the surface by a momentary contact of a ground trigger. Controlled motion of arcing erodes the cathode surface creating a highly ionized plasma. The anode can be either a cone attached to the periphery of the cathode, through an insulator, or the chamber. Substrate biasing is used for non line-of-sight deposition.
      N.B.:
      This definition does not include random cathodic arc deposition with non-biased substrates.
   5. Ion Plating is a special modification of a general TE-PVD process in which a plasma or an ion source is used to ionize the species to be deposited, and a negative bias is applied to the substrate in order to facilitate the extraction of the species from the plasma. The introduction of reactive species, evaporation of solids within the process chamber, and the use of monitors to provide in-process measurement of optical characteristics and thicknesses of coatings are ordinary modifications of the process.
c. Pack Cementation is a surface modification coating or overlay coating process wherein a substrate is immersed in a powder mixture (a pack), that consists of:
   1. The metallic powders that are to be deposited (usually aluminium, chromium, silicon or combinations thereof);
   2. An activator (normally a halide salt); **and**
   3. An inert powder, most frequently alumina.
   The substrate and powder mixture is contained within a retort which is heated to between 1,030 K (757°C) and 1,375 K (1,102°C) for sufficient time to deposit the coating.

d. Plasma Spraying is an overlay coating process wherein a gun (spray torch) which produces and controls a plasma accepts powder or wire coating materials, melts them and propels them towards a substrate, whereon an integrally bonded coating is formed. Plasma spraying constitutes either low pressure plasma spraying or high velocity plasma spraying.
   N.B.1:
   Low pressure means less than ambient atmospheric pressure.
   N.B.2:
   High velocity refers to nozzle-exit gas velocity exceeding 750 m/s calculated at 293 K (20°C) at 0.1 MPa.
e. Slurry Deposition is a surface modification coating or overlay coating process wherein a metallic or ceramic powder with an organic binder is suspended in a liquid and is applied to a substrate by either spraying, dipping or painting, subsequent air or oven drying, and heat treatment to obtain the desired coating.
f. Sputter Deposition is an overlay coating process based on a momentum transfer phenomenon, wherein positive ions are accelerated by an electric field towards the surface of a target (coating material). The kinetic energy of the impacting ions is sufficient to cause target surface atoms to be released and deposited on an appropriately positioned substrate.
   N.B.1:
   The Table refers only to triode, magnetron or reactive sputter deposition which is used to increase adhesion of the coating and rate of deposition and to radio frequency (RF) augmented sputter deposition used to permit vaporisation of non-metallic coating materials.
   N.B.2:
   Low-energy ion beams (less than 5 keV) can be used to activate the deposition.
g. Ion Implantation is a surface modification coating process in which the element to be alloyed is ionized, accelerated through a potential gradient and implanted into the surface region of the substrate. This includes processes in which ion implantation is performed simultaneously with electron beam physical vapour deposition or sputter deposition.

Table - Deposition Techniques – Statement of Understanding

It is understood that the following technical information, accompanying the table of deposition techniques, is for use as appropriate.

1. “Technology” for pretreatments of the substrates listed in the Table, as follows:
   a. Chemical stripping and cleaning bath cycle parameters, as follows:
      1. Bath composition
         a. For the removal of old or defective coatings, corrosion product or foreign deposits;
         b. For preparation of virgin substrates;
      2. Time in bath;
      3. Temperature of bath;
      4. Number and sequences of wash cycles;
   b. Visual and macroscopic criteria for acceptance of the cleaned part;
   c. Heat treatment cycle parameters, as follows:
      1. Atmosphere parameters, as follows:
         a. Composition of the atmosphere;
         b. Pressure of the atmosphere;
      2. Temperature for heat treatment;
      3. Time of heat treatment;
   d. Substrate surface preparation parameters, as follows:
      1. Grit blasting parameters, as follows:
         a. Grit composition;
         b. Grit size and shape;
         c. Grit velocity;
      2. Time and sequence of cleaning cycle after grit blast;
      3. Surface finish parameters;
      4. Application of binders to promote adhesion;
   e. Masking technique parameters, as follows:
      1. Material of mask;
      2. Location of mask;
2. “Technology” for in situ quality assurance techniques for evaluation of the coating processes listed in the Table, as follows:
   a. Atmosphere parameters, as follows:
      1. Composition of the atmosphere;
      2. Pressure of the atmosphere;
   b. Time parameters;
   c. Temperature parameters;
   d. Thickness parameters;
   e. Index of refraction parameters;
   f. Control of composition;
3. “Technology” for post deposition treatments of the coated substrates listed in the Table, as follows:
   a. Shot peening parameters, as follows:
      1. Shot composition;
      2. Shot size;
      3. Shot velocity;
   b. Post shot peening cleaning parameters;
   c. Heat treatment cycle parameters, as follows:
      1. Atmosphere parameters, as follows:
         a. Composition of the atmosphere;
         b. Pressure of the atmosphere;
      2. Time-temperature cycles;
   d. Post heat treatment visual and macroscopic criteria for acceptance of the coated substrates;
4. “Technology” for quality assurance techniques for the evaluation of the coated substrates listed in the Table, as follows:
   a. Statistical sampling criteria;
   b. Microscopic criteria for:
      1. Magnification;
      2. Coating thickness uniformity;
      3. Coating integrity;
      4. Coating composition;
      5. Coating and substrates bonding;
      6. Microstructural uniformity;
   c. Criteria for optical properties assessment (measured as a function of wavelength):
      1. Reflectance;
      2. Transmission;
      3. Absorption;
      4. Scatter;
5. “Technology” and parameters related to specific coating and surface modification processes listed in the Table, as follows:
   a. For Chemical Vapour Deposition (CVD):
      1. Coating source composition and formulation;
      2. Carrier gas composition;
      3. Substrate temperature;
      4. Time-temperature-pressure cycles;
      5. Gas control and part manipulation;
   b. For Thermal Evaporation - Physical Vapour Deposition (PVD):
      1. Ingot or coating material source composition;
      2. Substrate temperature;
      3. Reactive gas composition;
      4. Ingot feed rate or material vaporisation rate;
      5. Time-temperature-pressure cycles;
      6. Beam and part manipulation;
      7. “Laser” parameters, as follows:
         a. Wave length;
         b. Power density;
         c. Pulse length;
         d. Repetition ratio;
         e. Source;
   c. For Pack Cementation:
      1. Pack composition and formulation;
      2. Carrier gas composition;
      3. Time-temperature-pressure cycles;
   d. For Plasma Spraying:
      1. Powder composition, preparation and size distributions;
      2. Feed gas composition and parameters;
      3. Substrate temperature;
      4. Gun power parameters;
      5. Spray distance;
      6. Spray angle;
      7. Cover gas composition, pressure and flow rates;
      8. Gun control and part manipulation;
   e. For Sputter Deposition:
      1. Target composition and fabrication;
      2. Geometrical positioning of part and target;
      3. Reactive gas composition;
      4. Electrical bias;

5. Time-temperature-pressure cycles;
6. Triode power;
7. Part manipulation;

f. For Ion Implantation:
1. Beam control and part manipulation;
2. Ion source design details;
3. Control techniques for ion beam and deposition rate parameters;
4. Time-temperature-pressure cycles;

g. For Ion Plating:
1. Beam control and part manipulation;
2. Ion source design details;
3. Control techniques for ion beam and deposition rate parameters;
4. Time-temperature-pressure cycles;
5. Coating material feed rate and vaporisation rate;
6. Substrate temperature;
7. Substrate bias parameters.

Category 3: Electronics

1-3.A. Systems, Equipment and Components

Note 1:
The control status of equipment and components described in 1-3.A., other than those described in 1-3.A.1.a.3. to 1-3.A.1.a.10. or 1-3.A.1.a.12., which are specially designed for or which have the same functional characteristics as other equipment is determined by the control status of the other equipment.

Note 2:
The control status of integrated circuits described in 1-3.A.1.a.3. to 1-3.A.1.a.9. or 1-3.A.1.a.12. which are unalterably programmed or designed for a specific function for another equipment is determined by the control status of the other equipment.

N.B.:
When the manufacturer or applicant cannot determine the control status of the other equipment, the control status of the integrated circuits is determined in 1-3.A.1.a.3. to 1-3.A.1.a.9. and 1-3.A.1.a.12.
If the integrated circuit is a silicon-based “microcomputer microcircuit” or microcontroller microcircuit described in 1-3.A.1.a.3. having an operand (data) word length of 8 bit or less, the control status of the integrated circuit is determined in 1-3.A.1.a.3.

1. Electronic components, as follows:
   a. General purpose integrated circuits, as follows:
   Note 1:
   The control status of wafers (finished or unfinished), in which the function has been determined, is to be evaluated against the parameters of 1-3.A.1.a.
   Note 2:
   Integrated circuits include the following types:
   “Monolithic integrated circuits”;
   “Hybrid integrated circuits”;
   “Multichip integrated circuits”;
   “Film type integrated circuits”, including silicon-on-sapphire integrated circuits;
   “Optical integrated circuits”.
      1. Integrated circuits, designed or rated as radiation hardened to withstand any of the following:
         a. A total dose of 5×10^3 Gy (Si) or higher;
         b. A dose rate upset of 5×10^6 Gy (Si)/s or higher; **or**
         c. A fluence (integrated flux) of neutrons (1 MeV equivalent) of 5×10^{13} n/cm^2 or higher on silicon, or its equivalent for other materials;
         Note:
         1-3.A.1.a.1.c. does not apply to Metal Insulator Semi-conductors (MIS).
      2. “Microprocessor microcircuits”, “microcomputer microcircuits”, microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, digital-to-analogue converters, electro-optical or “optical integrated circuits” designed for “signal processing”, field programmable logic devices, neural network integrated circuits, custom integrated circuits for which either the function is unknown or the control status of the equipment in which the integrated circuit will be used is unknown, Fast Fourier Transform (FFT) processors, electrical erasable programmable read-only memories (EEPROMs), flash memories or static random-access memories (SRAMs), having any of the following:
         a. Rated for operation at an ambient temperature above 398 K (+125°C);
         b. Rated for operation at an ambient temperature below 218 K (-55°C); **or**
         c. Rated for operation over the entire ambient temperature range from 218 K (-55°C) to 398 K (+125°C);
         Note:
         1-3.A.1.a.2. does not apply to integrated circuits for civil automobile or railway train applications.
      3. “Microprocessor microcircuits”, “micro-computer microcircuits” and microcontroller microcircuits, manufactured from a compound semiconductor and operating at a clock frequency exceeding 40 MHz;
         Note:
         1-3.A.1.a.3. includes digital signal processors, digital array processors and digital coprocessors.
      4. Storage integrated circuits manufactured from a compound semiconductor;
      5. Analogue-to-digital and digital-to-analogue converter integrated circuits, as follows:
         a. Analogue-to-digital converters having any of the following:
            1. A resolution of 8 bit or more, but less than 10 bit, with an output rate greater than 500 million words per second;
            2. A resolution of 10 bit or more, but less than 12 bit, with an output rate greater than 200 million words per second;
            3. A resolution of 12 bit with an output rate greater than 105 million words per second;
            4. A resolution of more than 12 bit but equal to or less than 14 bit with an output rate greater than 10 million words per second; **or**
            5. A resolution of more than 14 bit with an output rate greater than 2.5 million words per second.
         b. Digital-to-analogue converters with a resolution of 12 bit or more, and a “settling time” of less than 10 ns;
         Technical Notes:
            1. A resolution of n bit corresponds to a quantisation of 2^n levels.
            2. The number of bits in the output word is equal to the resolution of the analogue-to-digital converter.

3. The output rate is the maximum output rate of the converter, regardless of architecture or oversampling. Vendors may also refer to the output rate as sampling rate, conversion rate or throughput rate. It is often specified in megahertz (MHz) or mega samples per second (MSPS).
4. For the purpose of measuring output rate, one output word per second is equivalent to one Hertz or one sample per second.

6. Electro-optical and "optical integrated circuits" designed for "signal processing" having all of the following:
   a. One or more than one internal "laser" diode;
   b. One or more than one internal light detecting element; **and**
   c. Optical waveguides;
7. Field programmable logic devices having any of the following:
   a. An equivalent usable gate count of more than 30,000 (2 input gates);
   b. A typical "basic gate propagation delay time" of less than 0.1 ns; **or**
   c. A toggle frequency exceeding 133 MHz;

Note:
1-3.A.1.a.7. includes:
- Simple Programmable Logic Devices (SPLDs)
- Complex Programmable Logic Devices (CPLDs)
- Field Programmable Gate Arrays (FPGAs)
- Field Programmable Logic Arrays (FPLAs)
- Field Programmable Interconnects (FPICs)

N.B.:
Field programmable logic devices are also known as field programmable gate or field programmable logic arrays.

8. Deleted;
9. Neural network integrated circuits;
10. Custom integrated circuits for which the function is unknown, or the control status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:
    a. More than 1,000 terminals;
    b. A typical "basic gate propagation delay time" of less than 0.1 ns; **or**
    c. An operating frequency exceeding 3 GHz;
11. Digital integrated circuits, other than those described in 1-3.A.1.a.3. to 1-3.A.1.a.10. and 1-3.A.1.a.12., based upon any compound semiconductor and having any of the following:
    a. An equivalent gate count of more than 3000 (2 input gates); **or**
    b. A toggle frequency exceeding 1.2 GHz;
12. Fast Fourier Transform (FFT) processors having a rated execution time for an N-point complex FFT of less than $(N \log_2 N)/20,480$ ms, where N is the number of points;

Technical Note:
When N is equal to 1,024 points, the formula in 1-3.A.1.a.12. gives an execution time of 500 µs.

b. Microwave or millimetre wave components, as follows:
   1. Electronic vacuum tubes and cathodes, as follows:

Note 1:
1-3.A.1.b.1. does not control tubes designed or rated for operation in any frequency band which meets all of the following characteristics:
a. Does not exceed 31.8 GHz; **and**
b. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

Note 2:
1-3.A.1.b.1. does not control non-"space-qualified" tubes which meet all of the following characteristics:
a. An average output power equal to or less than 50 W; and
b. Designed or rated for operation in any frequency band which meets all of the following characteristics:
   1. Exceeds 31.8 GHz but does not exceed 43.5 GHz; **and**
   2. Is "allocated by the ITU" for radio-communications services, but not for radio-determination;

a. Travelling wave tubes, pulsed or continuous wave, as follows:
   1. Operating at frequencies exceeding 31.8 GHz;
   2. Having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;
   3. Coupled cavity tubes, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW;
   4. Helix tubes, or derivatives thereof, with any of the following characteristics:
      a. An "instantaneous bandwidth" of more than one octave, and average power (expressed in kW) times frequency (expressed in GHz) of more than 0.5;
      b. An "instantaneous bandwidth" of one octave or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than 1; **or**
      c. Being "space qualified";
b. Crossed-field amplifier tubes with a gain of more than 17 dB;
c. Impregnated cathodes designed for electronic tubes producing a continuous emission current density at rated operating conditions exceeding 5 A/cm^2;

2. Microwave monolithic integrated circuits (MMIC) power amplifiers having any of the following:
   a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and with an average output power greater than 4W (36 dBm) with a "fractional bandwidth" greater than 15%;
   b. Rated for operation at frequencies exceeding 6 GHz up to and including 16 GHz and with an average output power greater than 1W (30 dBm) with a "fractional bandwidth" greater than 10%;
   c. Rated for operation at frequencies exceeding 16 GHz up to and including 31.8 GHz and with an average output power greater than 0.8W (29 dBm) with a "fractional bandwidth" greater than 10%;
   d. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz;
   e. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and with an average output power greater than 0.25W (24 dBm) with a "fractional bandwidth" greater than 10%; or
   f. Rated for operation at frequencies exceeding 43.5 GHz.

Note 1:
1-3.A.1.b.2. does not control broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 to 42.5 GHz.

Note 2:
The control status of the MMIC whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 1-3.A.1.b.2.a. through 1-3.A.1.b.2.f., is determined by the lowest average output power control threshold.
Note 3:
Notes 1 and 2 in the chapeau to Category 3 mean that 1-3.A.1.b.2. does not control MMICs if they are specially designed for other applications, e.g., telecommunications, radar, automobiles.

3. Discrete microwave transistors having any of the following:
   a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and having an average output power greater than 60W (47.8 dBm);
   b. Rated for operation at frequencies exceeding 6 GHz up to and including 31.8 GHz and having an average output power greater than 20W (43 dBm);
   c. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz and having an average output power greater than 0.5W (27 dBm);
   d. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and having an average output power greater than 1W (30 dBm); **or**
   e. Rated for operation at frequencies exceeding 43.5 GHz.

   Note:
   The control status of a transistor whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 1-3.A.1.b.3.a. through 1-3.A.1.b.3.e., is determined by the lowest average output power control threshold.

4. Microwave solid state amplifiers and microwave assemblies/modules containing microwave amplifiers having any of the following:
   a. Rated for operation at frequencies exceeding 3.2 GHz up to and including 6 GHz and with an average output power greater than 60W (47.8 dBm) with a "fractional bandwidth" greater than 15%;
   b. Rated for operation at frequencies exceeding 6 GHz up to and including 31.8 GHz and with an average output power greater than 15W (42 dBm) with a "fractional bandwidth" greater than 10%;
   c. Rated for operation at frequencies exceeding 31.8 GHz up to and including 37.5 GHz;
   d. Rated for operation at frequencies exceeding 37.5 GHz up to and including 43.5 GHz and with an average output power greater than 1W (30 dBm) with a "fractional bandwidth" greater than 10%;
   e. Rated for operation at frequencies exceeding 43.5 GHz; **or**
   f. Rated for operation at frequencies above 3.2 GHz and having all of the following:
      1. An average output power (in watts), P, greater than 150 divided by the maximum operating frequency (in GHz) squared [$P > 150\ W*GHz^2/f_{GHz}^2$];
      2. A fractional bandwidth of 5% or greater; **and**
      3. Any two sides perpendicular to one another with length d (in cm) equal to or less than 15 divided by the lowest operating frequency in GHz [$d \leq 15cm*GHz/\ f_{GHz}$].

      Technical Note:
      3.2 GHz should be used as the lowest operating frequency (f_{GHz}) in the formula in 1-3.A.1.b.4.f.3., for amplifiers that have a rated operation range extending downward to 3.2 GHz and below [$d \leq 15cm*GHz/3.2\ GHz$].

   N.B.:
   MMIC power amplifiers should be evaluated against the criteria in 1-3.A.1.b.2.
   Note 1:
   1-3.A.1.b.4. does not control broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 to 42.5 GHz.
   Note 2:
   The control status of an item whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 1-3.A.1.b.4.a. through 1-3.A.1.b.4.e., is determined by the lowest average output power control threshold.

5. Electronically or magnetically tunable band-pass or band-stop filters having more than 5 tunable resonators capable of tuning across a 1.5:1 frequency band (f_{max}/f_{min}) in less than 10 µs having any of the following:
   a. A band-pass bandwidth of more than 0.5% of centre frequency; **or**
   b. A band-stop bandwidth of less than 0.5% of centre frequency;
6. Deleted;
7. Mixers and converters designed to extend the frequency range of equipment described in 1-3.A.2.c., 1-3.A.2.e. or 1-3.A.2.f. beyond the limits stated therein;
8. Microwave power amplifiers containing tubes controlled by 1-3.A.1.b. and having all of the following:
   a. Operating frequencies above 3 GHz;
   b. An average output power density exceeding 80 W/kg; **and**
   c. A volume of less than 400 cm^3;

   Note:
   1-3.A.1.b.8. does not control equipment designed or rated for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.

9. Microwave power modules (MPM), consisting of, at least, a travelling wave tube, a microwave monolithic integrated circuit and an integrated electronic power conditioner, having all of the following characteristics:
   a. A turn-on time from off to fully operational in less than 10 seconds;
   b. A volume less than the maximum rated power in Watts multiplied by 10 cm^3/W; **and**
   c. An "instantaneous bandwidth" greater than 1 octave ($f_{max.} > 2f_{min.}$) and any of the following:
      1. For frequencies equal to or less than 18 GHz, an RF output power greater than 100 W; **or**
      2. Having a frequency greater than 18 GHz.

   Technical Notes:
   1. To calculate the control volume in 1-3.A.1.b.9.b., the following example is provided: for a maximum rated power of 20 W, the volume would be: 20 W x 10 cm^3/W = 200 cm^3.
   2. The turn-on time in 1-3.A.1.b.9.a. refers to the time from fully-off to fully operational; i.e., it includes the warm-up time of the MPM.

c. Acoustic wave devices, as follows, and specially designed components therefor:

1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices (i.e., "signal processing" devices employing elastic waves in materials), having any of the following:
   a. A carrier frequency exceeding 2.5 GHz;
   b. A carrier frequency exceeding 1 GHz, but not exceeding 2.5 GHz, and having any of the following:
      1. A frequency side-lobe rejection exceeding 55 dB;
      2. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
      3. A bandwidth greater than 250 MHz; **or**
      4. A dispersive delay of more than 10 µs; **or**
   c. A carrier frequency of 1 GHz or less, having any of the following:
      1. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
      2. A dispersive delay of more than 10 µs; **or**
      3. A frequency side-lobe rejection exceeding 55 dB and a bandwidth greater than 50 MHz;
2. Bulk (volume) acoustic wave devices (i.e., "signal processing" devices employing elastic waves) which permit the direct processing of signals at frequencies exceeding 1 GHz;
3. Acoustic-optic "signal processing" devices employing interaction between acoustic waves (bulk wave or surface wave) and light waves which permit the direct processing of signals or images, including spectral analysis, correlation or convolution;

d. Electronic devices and circuits containing components, manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents, with any of the following:
   1. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than 10^{-14} J; **or**
   2. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000;

e. High energy devices, as follows:
   1. Cells, as follows:
      a. Primary cells having an energy density exceeding 550 Wh/kg at 20°C;
      b. Secondary cells having an energy density exceeding 250 Wh/kg at 20°C;

Technical Notes:

1. For the purpose of 1-3.A.1.e.1., energy density (Wh/kg) is calculated from the nominal voltage multiplied by the nominal capacity in ampere-hours divided by the mass in kilograms. If the nominal capacity is not stated, energy density is calculated from the nominal voltage squared then multiplied by the discharge duration in hours divided by the discharge load in Ohms and the mass in kilograms.
2. For the purpose of 1-3.A.1.e.1., a 'cell' is defined as an electrochemical device, which has positive and negative electrodes, and electrolyte, and is a source of electrical energy. It is the basic building block of a battery.
3. For the purpose of 1-3.A.1.e.1.a., a 'primary cell' is a 'cell' that is not designed to be charged by any other source.
4. For the purpose of 1-3.A.1.e.1.b., a 'secondary cell' is a 'cell' that is designed to be charged by an external electrical source.

Note:
1-3.A.1.e. does not control batteries, including single cell batteries.

   2. High energy storage capacitors, as follows:
      a. Capacitors with a repetition rate of less than 10 Hz (single shot capacitors) having all of the following:
         1. A voltage rating equal to or more than 5 kV;
         2. An energy density equal to or more than 250 J/kg; **and**
         3. A total energy equal to or more than 25 kJ;
      b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) having all of the following:
         1. A voltage rating equal to or more than 5 kV;
         2. An energy density equal to or more than 50 J/kg;
         3. A total energy equal to or more than 100 J; **and**
         4. A charge/discharge cycle life equal to or more than 10,000;
   3. "Superconductive" electromagnets and solenoids specially designed to be fully charged or discharged in less than one second, having all of the following:

Note:
1-3.A.1.e.3. does not control "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance Imaging (MRI) medical equipment.

      a. Energy delivered during the discharge exceeding 10 kJ in the first second;
      b. Inner diameter of the current carrying windings of more than 250 mm; **and**
      c. Rated for a magnetic induction of more than 8 T or "overall current density" in the winding of more than 300 A/mm^2;
   4. Solar cells, cell-interconnect-coverglass (CIC) assemblies, solar panels, and solar arrays, which are "space qualified," having a minimum average efficiency exceeding 20% at an operating temperature of 301 K (28°C) under simulated AM0 illumination with an irradiance of 1,367 Watts per square meter (W/m^2).

Technical Note:
'AM0', or 'Air Mass Zero', refers to the spectral irradiance of sun light in the earth's outer atmosphere when the distance between the earth and sun is one astronomical unit (AU).

f. Rotary input type shaft absolute position encoders having any of the following:
   1. A resolution of better than 1 part in 265,000 (18 bit resolution) of full scale; **or**
   2. An accuracy better than ± 2.5 seconds of arc.

g. Solid-state pulsed power switching thyristor devices and thyristor modules using either electrically, optically, or electron radiation controlled switch methods, having any of the following:
   1. A maximum turn-on current rate of rise (di/dt) greater than 30,000 A/µs and off-state voltage greater than 1,100 V; **or**
   2. A maximum turn-on current rate of rise (di/dt) greater than 2,000 A/µs and all of the following:

a. An off-state peak voltage equal to or greater than 3,000 V; **and**
b. A peak (surge) current equal to or greater than 3,000 A.

Note 1:
1-3.A.1.g. includes:
– Silicon Controlled Rectifiers (SCRs)
– Electrical Triggering Thyristors (ETTs)
– Light Triggering Thyristors (LTTs)
– Integrated Gate Commutated Thyristors (IGCTs)
– Gate Turn-off Thyristors (GTOs)
– MOS Controlled Thyristors (MCTs)
– Solidtrons

Note 2:
1-3.A.1.g. does not control thyristor devices and thyristor modules incorporated into equipment designed for civil railway or “civil aircraft” applications.

Technical Note:
For the purposes of 1-3.A.1.g., a ‘thyristor module’ contains one or more thyristor devices.

2. General purpose electronic equipment, as follows:
   a. Recording equipment, as follows, and specially designed test tape therefor:
      1. Analogue instrumentation magnetic tape recorders, including those permitting the recording of digital signals (e.g., using a high density digital recording (HDDR) module), having any of the following:
         a. A bandwidth exceeding 4 MHz per electronic channel or track;
         b. A bandwidth exceeding 2 MHz per electronic channel or track and having more than 42 tracks; **or**
         c. A time displacement (base) error, measured in accordance with applicable IRIG or EIA documents, of less than ± 0.1 µs;

         Note:
         Analogue magnetic tape recorders specially designed for civilian video purposes are not considered to be instrumentation tape recorders.

      2. Digital video magnetic tape recorders having a maximum digital interface transfer rate exceeding 360 Mbit/s;

         Note:
         1-3.A.2.a.2. does not control digital video magnetic tape recorders specially designed for television recording using a signal format, which may include a compressed signal format, standardised or recommended by the ITU, the IEC, the SMPTE, the EBU, the ETSI or the IEEE for civil television applications.

      3. Digital instrumentation magnetic tape data recorders employing helical scan techniques or fixed head techniques, having any of the following:
         a. A maximum digital interface transfer rate exceeding 175 Mbit/s; **or**
         b. Being “space qualified”;

         Note:
         1-3.A.2.a.3. does not control analogue magnetic tape recorders equipped with HDDR conversion electronics and configured to record only digital data.

      4. Equipment, having a maximum digital interface transfer rate exceeding 175 Mbit/s, designed to convert digital video magnetic tape recorders for use as digital instrumentation data recorders;
      5. Waveform digitisers and transient recorders having all of the following:
         a. Digitising rates equal to or more than 200 million samples per second and a resolution of 10 bits or more; **and**
         b. A continuous throughput of 2 Gbit/s or more;

         Technical Note:
         For those instruments with a parallel bus architecture, the continuous throughput rate is the highest word rate multiplied by the number of bits in a word.
         Continuous throughput is the fastest data rate the instrument can output to mass storage without the loss of any information whilst sustaining the sampling rate and analogue-to-digital conversion.

      6. Digital instrumentation data recorders, using magnetic disk storage technique, having all of the following:
         a. Digitizing rate equal to or more than 100 million samples per second and a resolution of 8 bit or more; **and**
         b. A continuous throughput of 1 Gbit/s or more;
   b. “Frequency synthesiser” “electronic assemblies” having a “frequency switching time” from one selected frequency to another of less than 1 ms;

      Note:
      The control status of signal analysers, signal generators, network analysers, and microwave test receivers as stand-alone instruments is determined by 1-3.A.2.c., 1-3.A.2.d., 1-3.A.2.e., and 1-3.A.2.f., respectively.

   c. Radio frequency “signal analysers”, as follows:
      1. “Signal analysers” capable of analysing any frequencies exceeding 31.8 GHz but not exceeding 37.5 GHz and having a 3 dB resolution bandwidth (RBW) exceeding 10 MHz;
      2. “Signal analysers” capable of analyzing frequencies exceeding 43.5 GHz;
      3. “Dynamic signal analysers” having a “real-time bandwidth” exceeding 500 kHz;

         Note:
         1-3.A.2.c.3. does not control those “dynamic signal analysers” using only constant percentage bandwidth filters (also known as octave or fractional octave filters).

   d. Frequency synthesised signal generators producing output frequencies, the accuracy and short term and long term stability of which are controlled, derived from or disciplined by the internal master reference oscillator, and having any of the following:
      1. A maximum synthesised frequency exceeding 31.8 GHz but not exceeding 43.5 GHz and rated to generate a pulse duration of less than 100 ns;
      2. A maximum synthesised frequency exceeding 43.5 GHz;
      3. A “frequency switching time” from one selected frequency to another as specified by any of the following:
         a. Less than 10 ns;
         b. Less than 100 µs for any frequency change exceeding 1.6 GHz within the synthesised frequency range exceeding 3.2 GHz but not exceeding 10.6 GHz;
         c. Less than 250 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 10.6 GHz but not exceeding 31.8 GHz;
         d. Less than 500 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 31.8 GHz but not exceeding 43.5 GHz; **or**

e. Less than 1 ms within the synthesised frequency range exceeding 43.5 GHz; **or**

4. A single sideband (SSB) phase noise better than -(126 + 20 $\log_{10}F$ - 20 $\log_{10}f$) in dBc/Hz, where F is the off-set from the operating frequency in Hz and f is the operating frequency in MHz;

Note 1:
For the purpose of 1-3.A.2.d., the term frequency synthesised signal generators includes arbitrary waveform and function generators.

Note 2:
1-3.A.2.d. does not control equipment in which the output frequency is either produced by the addition or subtraction of two or more crystal oscillator frequencies, or by an addition or subtraction followed by a multiplication of the result.

Technical Notes:
1. Arbitrary waveform and function generators are normally specified by sample rate (e.g., GSample/s), which is converted to the RF domain by the Nyquist factor of two. Thus, a 1 GSample/s arbitrary waveform has a direct output capability of 500 MHz. Or, when oversampling is used, the maximum direct output capability is proportionately lower.
2. For the purposes of 1-3.A.2.d.1., 'pulse duration' is defined as the time interval between the leading edge of the pulse achieving 90% of the peak and the trailing edge of the pulse achieving 10% of the peak.

e. Network analysers with a maximum operating frequency exceeding 43.5 GHz;

f. Microwave test receivers having all of the following:
1. A maximum operating frequency exceeding 43.5 GHz; **and**
2. Being capable of measuring amplitude and phase simultaneously;

g. Atomic frequency standards having any of the following:
1. Long-term stability (aging) less (better) than 1×10^{-11}/month; **or**
2. Being "space qualified".

Note:
1-3.A.2.g.1. does not control non-"space qualified" rubidium standards.

3. Spray cooling thermal management systems employing closed loop fluid handling and reconditioning equipment in a sealed enclosure where a dielectric fluid is sprayed onto electronic components using specially designed spray nozzles that are designed to maintain electronic components within their operating temperature range, and specially designed components therefor.

1-3.B. Test, Inspection and Production Equipment

1. Equipment for the manufacturing of semiconductor devices or materials, as follows, and specially designed components and accessories therefor:

a. Equipment designed for epitaxial growth, as follows:
1. Equipment capable of producing a layer of any material other than silicon with a thickness uniform to less than ± 2.5% across a distance of 75 mm or more;
2. Metal organic chemical vapour deposition (MOCVD) reactors specially designed for compound semiconductor crystal growth by the chemical reaction between materials controlled by 1-3.C.3. or 1-3.C.4.;
3. Molecular beam epitaxial growth equipment using gas or solid sources;

b. Equipment designed for ion implantation, having any of the following:
1. A beam energy (accelerating voltage) exceeding 1 MeV;
2. Being specially designed and optimised to operate at a beam energy (accelerating voltage) of less than 2 keV;
3. Direct write capability; **or**
4. A beam energy of 65 keV or more and a beam current of 45 mA or more for high energy oxygen implant into a heated semiconductor material "substrate";

c. Anisotropic plasma dry etching equipment, as follows:
1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:
   a. Designed or optimised to produce critical dimensions of 180 nm or less with ±5% 3 sigma precision; **or**
   b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;
2. Equipment specially designed for equipment controlled by 1-3.B.1.e. and having any of the following:
   a. Designed or optimised to produce critical dimensions of 180 nm or less with ±5% 3 sigma precision; **or**
   b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

d. Plasma enhanced CVD equipment, as follows:
1. Equipment with cassette-to-cassette operation and load-locks, and designed according to the manufacturer's specifications or optimised for use in the production of semiconductor devices with critical dimensions of 180 nm or less;
2. Equipment specially designed for equipment controlled by 1-3.B.1.e. and designed according to the manufacturer's specifications or optimised for use in the production of semiconductor devices with critical dimensions of 180 nm or less;

e. Automatic loading multi-chamber central wafer handling systems, having all of the following:
1. Interfaces for wafer input and output, to which more than two pieces of semiconductor processing equipment are to be connected; **and**
2. Designed to form an integrated system in a vacuum environment for sequential multiple wafer processing;

Note:
1-3.B.1.e. does not control automatic robotic wafer handling systems not designed to operate in a vacuum environment.

f. Lithography equipment, as follows:
1. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods, having any of the following:
   a. A light source wavelength shorter than 245 nm; **or**
   b. Capable of producing a pattern with a minimum resolvable feature size of 180 nm or less;

Technical Note:
The minimum resolvable feature size is calculated by the following formula:

MRF = (an exposure light source wavelength in nm) x (K factor) / Numerical aperture

where the K factor = 0.45
MRF = minimum resolvable feature size.

2. Imprint lithography equipment capable of producing features of 180 nm or less.
   Note:
   1-3.B.1.f.2 includes:
   – Micro contact printing tools
   – Hot embossing tools
   – Nano-imprint lithography tools
   – Step and flash imprint lithography (S-FIL) tools

3. Equipment specially designed for mask making or semiconductor device processing using deflected focussed electron beam, ion beam or “laser” beam, having any of the following:
   a. A spot size smaller than 0.2 µm;
   b. Being capable of producing a pattern with a feature size of less than 1 µm; **or**
   c. An overlay accuracy of better than ± 0.20 µm (3 sigma);

g. Masks and reticles designed for integrated circuits controlled by 1-3.A.1.;
h. Multi-layer masks with a phase shift layer.
   Note:
   1-3.B.1.h. does not control multi-layer masks with a phase shift layer designed for the fabrication of memory devices not controlled by 1-3.A.1.

i. Imprint lithography templates designed for integrated circuits controlled by 1-3.A.1.

2. Test equipment, specially designed for testing finished or unfinished semiconductor devices, as follows, and specially designed components and accessories therefor:
   a. For testing S-parameters of transistor devices at frequencies exceeding 31.8 GHz;
   b. Deleted;
   c. For testing microwave integrated circuits controlled by 1-3.A.1.b.2.

1-3.C. Materials

1. Hetero-epitaxial materials consisting of a “substrate” having stacked epitaxially grown multiple layers of any of the following:
   a. Silicon;
   b. Germanium;
   c. Silicon Carbide; **or**
   d. III/V compounds of gallium or indium.
   Technical Note:
   III/V compounds are polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev’s periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).

2. Resist materials, as follows, and “substrates” coated with controlled resists:
   a. Positive resists designed for semiconductor lithography specially adjusted (optimised) for use at wavelengths below 245 nm;
   b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 µcoulomb/mm^2 or better;
   c. All resists designed for use with X-rays, with a sensitivity of 2.5 mJ/mm^2 or better;
   d. All resists optimised for surface imaging technologies, including silylated resists.
   Technical Note:
   Silylation techniques are defined as processes incorporating oxidation of the resist surface to enhance performance for both wet and dry developing.

3. Organo-inorganic compounds, as follows:
   a. Organo-metallic compounds of aluminium, gallium or indium having a purity (metal basis) better than 99.999%;
   b. Organo-arsenic, organo-antimony and organo-phosphorus compounds having a purity (inorganic element basis) better than 99.999%.
   Note:
   1-3.C.3. only controls compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.

4. Hydrides of phosphorus, arsenic or antimony, having a purity better than 99.999%, even diluted in inert gases or hydrogen.
   Note:
   1-3.C.4. does not control hydrides containing 20% molar or more of inert gases or hydrogen.

5. Silicon carbide (SiC) wafers having a resistivity of more than 10,000 ohm-cm.

1-3.D. Software

1. “Software” specially designed for the “development” or “production” of equipment controlled by 1-3.A.1.b. to 1-3.A.2.g. or 1-3.B.
2. “Software” specially designed for the “use” of any of the following:
   a. Equipment controlled by 1-3.B.1.a. to f.; **or**
   b. Equipment controlled by 1-3.B.2.
3. Physics-based simulation “software” specially designed for the “development” of lithographic, etching or deposition processes for translating masking patterns into specific topographical patterns in conductors, dielectrics or semiconductor materials.
   Technical Note:
   ‘Physics-based’ in 1-3.D.3. means using computations to determine a sequence of physical cause and effect events based on physical properties (e.g., temperature, pressure, diffusion constants and semiconductor materials properties).
   Note:
   Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as “technology”.

4. “Software” specially designed for the “development” of the equipment controlled by 1-3.A.3.

1-3.E. Technology

1. “Technology” according to the General Technology Note for the “development” or “production” of equipment or materials controlled by 1-3.A., 1-3.B. or 1-3.C.;

Note 1:
1-3.E.1. does not control "technology" for the "production" of equipment or components controlled by 1-3.A.3.
Note 2:
1-3.E.1. does not control "technology" for the "development" or "production" of integrated circuits controlled by 1-3.A.1.a.3. to 1-3.A.1.a.12., having all of the following:
a. Using "technology" of 0.5 µm or more; **and**
b. Not incorporating multi-layer structures.
Technical Note:
The term multi-layer structures in Note 2. above does not include devices incorporating a maximum of three metal layers and three polysilicon layers.

2. "Technology" according to the General Technology Note other than that controlled in 1-3.E.1. for the "development" or "production" of a "microprocessor microcircuit", "microcomputer microcircuit" or microcontroller microcircuit core, having an arithmetic logic unit with an access width of 32 bits or more and any of the following features or characteristics:
   a. A vector processor unit designed to perform more than two calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously;
      Technical Note:
      A vector processing unit is a processor element with built-in instructions that perform multiple calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously, having at least one vector arithmetic logic unit.
   b. Designed to perform more than two 64-bit or larger floating-point operation results per cycle; **or**
   c. Designed to perform more than four 16-bit fixed-point multiply-accumulate results per cycle (e.g., digital manipulation of analogue information that has been previously converted into digital form, also known as digital signal processing).
      Note:
      1-3.E.2.c. does not control technology for multimedia extensions.

Note 1:
1-3.E.2. does not control "technology" for the "development" or "production" of micro-processor cores, having all of the following:
a. Using "technology" at or above 0.130 µm; **and**
b. Incorporating multi-layer structures with five or fewer metal layers.
Note 2:
1-3.E.2. includes "technology" for digital signal processors and digital array processors.

3. Other "technology" for the "development" or "production" of:
   a. Vacuum microelectronic devices;
   b. Hetero-structure semiconductor devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices;
      Note:
      1-3.E.3.b does not control technology for high electron mobility transistors (HEMT) operating at frequencies lower than 31.8 GHz and hetero-junction bipolar transistors (HBT) operating at frequencies lower than 31.8 GHz.
   c. "Superconductive" electronic devices;
   d. Substrates of films of diamond for electronic components;
   e. Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide;
   f. Substrates of silicon carbide for electronic components;
   g. Electronic vacuum tubes operating at frequencies of 31.8 GHz or higher.

Category 4: Computers

Note 1:
Computers, related equipment and "software" performing telecommunications or "local area network" functions must also be evaluated against the performance characteristics of Category 5, Part 1 (Telecommunications).
Note 2:
Control units which directly interconnect the buses or channels of central processing units, "main storage" or disk controllers are not regarded as telecommunications equipment described in Category 5, Part 1 (Telecommunications).
N.B.:
For the control status of "software" specially designed for packet switching, see Category 1-5.D.1. (Telecommunications).
Note 3:
Computers, related equipment and "software" performing cryptographic, cryptanalytic, certifiable multi-level security or certifiable user isolation functions, or which limit electromagnetic compatibility (EMC), must also be evaluated against the performance characteristics in Category 5, Part 2 ("Information Security").

1-4.A. Systems, Equipment and Components

1. Electronic computers and related equipment, as follows, and "electronic assemblies" and specially designed components therefor:
   a. Specially designed to have any of the following characteristics:
      1. Rated for operation at an ambient temperature below 228 K (-45°C) or above 358 K (85°C);
         Note:
         1-4.A.1.a.1. does not apply to computers specially designed for civil automobile or railway train applications.
      2. Radiation hardened to exceed any of the following specifications:
         a. Total Dose 5×10^3 Gy (Si);
         b. Dose Rate Upset 5×10^6 Gy (Si)/s; **or**
         c. Single Event Upset 1×10^{-7} Error/bit/day;
   b. Having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security").
      Note:
      1-4.A.1.b. does not control electronic computers and related equipment when accompanying their user for the user's personal use.
2. Deleted.
3. "Digital computers", "electronic assemblies", and related equipment therefor, as follows, and specially designed components therefor:
   Note 1:
   1-4.A.3. includes the following:
   a. Vector processors;
   b. Array processors;
   c. Digital signal processors;
   d. Logic processors;
   e. Equipment designed for "image enhancement";
   f. Equipment designed for "signal processing".
   Note 2:
   The control status of the "digital computers" and related equipment described in 1-4.A.3. is determined by the control status of other equipment or systems provided:
   a. The "digital computers" or related equipment are essential for the operation of the other equipment or systems;
   b. The "digital computers" or related equipment are not a "principal element" of the other equipment or systems; **and**

N.B.1:
The control status of "signal processing" or "image enhancement" equipment specially designed for other equipment with functions limited to those required for the other equipment is determined by the control status of the other equipment even if it exceeds the "principal element" criterion.
N.B.2:
For the control status of "digital computers" or related equipment for telecommunications equipment, see Category 5, Part 1 (Telecommunications).

c. The "technology" for the "digital computers" and related equipment is determined by 1-4.E.

a. Designed or modified for "fault tolerance";

Note:
For the purposes of 1-4.A.3.a., "digital computers" and related equipment are not considered to be designed or modified for "fault tolerance" if they utilise any of the following:
1. Error detection or correction algorithms in "main storage";
2. The interconnection of two "digital computers" so that, if the active central processing unit fails, an idling but mirroring central processing unit can continue the system's functioning;
3. The interconnection of two central processing units by data channels or by using shared storage to permit one central processing unit to perform other work until the second central processing unit fails, at which time the first central processing unit takes over in order to continue the system's functioning; **or**
4. The synchronisation of two central processing units by "software" so that one central processing unit recognises when the other central processing unit fails and recovers tasks from the failing unit.

b. "Digital computers" having an "Adjusted Peak Performance" ("APP") exceeding 0.75 Weighted TeraFLOPS (WT);
c. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of processors so that the "APP" of the aggregation exceeds the limit in 1-4.A.3.b.;

Note 1:
1-4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit in 1-4.A.3.b. when shipped as unintegrated "electronic assemblies". It does not apply to "electronic assemblies" inherently limited by nature of their design for use as related equipment controlled by 1-4.A.3.e.
Note 2:
1-4.A.3.c. does not control "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit of 1-4.A.3.b.

d. Deleted;
e. Equipment performing analogue-to-digital conversions exceeding the limits in 1-3.A.1.a.5.;
f. Deleted;
g. Equipment specially designed to provide external interconnection of "digital computers" or associated equipment which allows communications at data rates exceeding 1.25 Gbyte/s.

Note:
1-4.A.3.g. does not control internal interconnection equipment (e.g., backplanes, buses), passive interconnection equipment, "network access controllers" or "communications channel controllers".

4. Computers, as follows, and specially designed related equipment, "electronic assemblies" and components therefor:
   a. "Systolic array computers";
   b. "Neural computers";
   c. "Optical computers".

1-4.B. Test, Inspection and Production Equipment

None.

1-4.C. Materials

None.

1-4.D. Software

Note:
The control status of "software" for the "development", "production", or "use" of equipment described in other Categories is dealt with in the appropriate Category. The control status of "software" for equipment described in this Category is dealt with herein.

1. a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" controlled by 1-4.A. or 1-4.D.
   b. "Software", other than that controlled by 1-4.D.1.a., specially designed or modified for the "development" or "production" of:
      1. "Digital computers" having an "Adjusted Peak Performance" ("APP") exceeding 0.04 Weighted TeraFLOPS (WT); **or**
      2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of processors so that the "APP" of the aggregation exceeds the limit in 1-4.D.1.b.1.
2. "Software" specially designed or modified to support "technology" controlled by 1-4.E.
3. Specific "software", as follows:
   a. Operating system "software", "software" development tools and compilers specially designed for "multi-data-stream processing" equipment, in "source code";
   b. Deleted;
   c. "Software" having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security");

      Note:
      1-4.D.3.c. does not control "software" when accompanying its user for the user's personal use.

   d. Deleted.

1-4.E. Technology

1. a. "Technology" according to the General Technology Note, for the "development", "production" or "use" of equipment or "software" controlled by 1-4.A. or 1-4.D.
   b. "Technology", other than that controlled by 1-4.E.1.a., specially designed or modified for the "development" or "production" of:
      1. "Digital computers" having an "Adjusted Peak Performance" ("APP") exceeding 0.04 Weighted TeraFLOPS (WT); **or**

2. “Electronic assemblies” specially designed or modified for enhancing performance by aggregation of processors so that the “APP” of the aggregation exceeds the limit in 1-4.E.1.b.1.

Technical Note on “Ajusted Peak Performance” (“APP”):
“APP” is an adjusted peak rate at which “digital computers” perform 64-bit or larger floating point additions and multiplications.

Abbreviations used in this Technical Note
n number of processors in the “digital computer”
i processor number (i,...n)
ti processor cycle time ($t_i = 1/F_i$)
Fi processor frequency
Ri peak floating point calculating rate
Wi architecture adjustment factor

“APP” is expressed in Weighted TeraFLOPS (WT), in units of 10^{12} adjusted floating point operations per second.

Outline of “APP” calculation method:
1. For each processor i, determine the peak number of 64-bit or larger floating point operations, FPOi, performed per cycle for each processor in the “digital computer”.
   Note:
   In determining FPO, include only 64-bit or larger floating point additions and/or multiplications. All floating point operations must be expressed in operations per processor cycle; operations requiring multiple cycles may be expressed in fractional results per cycle. For processors not capable of performing calculations on floating point operands of 64-bits or more, the effective calculating rate R is zero.
2. Calculate the floating point rate R for each processor $Ri = FPOi/t_i$
3. Calculate “APP” as “APP” = $W_1 \times R_1 + W_2 \times R_2 + ... + W_n \times R_n$.
4. For “vector processors”, $W_i = 0.9$. For non-”vector processors”, $W_i = 0.3$.

Note 1:
For processors that perform compound operations in a cycle, such as addition and multiplication, each operation is counted.
Note 2:
For a pipelined processor the effective calculating rate R is the faster of the pipelined rate, once the pipeline is full, or the non-pipelined rate.
Note 3:
The calculating rate R of each contributing processor is to be calculated at its maximum value theoretically possible before the “APP” of the combination is derived. Simultaneous operations are assumed to exist when the computer manufacturer claims concurrent, parallel, or simultaneous operation or execution in a manual or brochure for the computer.
Note 4:
Do not include processors that are limited to input/output and peripheral functions (e.g., disk drive, communication and video display) when calculating “APP”.
Note 5:
“APP” values are not to be calculated for processor combinations (inter)connected by “Local Area Networks”, Wide Area Networks, I/O shared connections/devices, I/O controllers and any communication interconnection implemented by “software”.
Note 6:
“APP” values must be calculated for 1) processor combinations containing processors specially designed to enhance performance by aggregation, operating simultaneously and sharing memory; or 2) multiple memory/processor combinations operating simultaneously utilizing specially designed hardware.
Note 7:
A “vector processor” is defined as a processor with built-in instructions that perform multiple calculations on floating-point vectors (one-dimensional arrays of 64-bit or larger numbers) simultaneously, having at least 2 vector functional units and at least 8 vector registers of at least 64 elements each.

Category 5 – Part 1: Telecommunications

Note 1:
The control status of components, “lasers”, test and “production” equipment and “software” therefor which are specially designed for telecommunications equipment or systems is determined in Category 5, Part 1.
Note 2:
“Digital computers”, related equipment or “software”, when essential for the operation and support of telecommunications equipment described in this Category, are regarded as specially designed components, provided they are the standard models customarily supplied by the manufacturer. This includes operation, administration, maintenance, engineering or billing computer systems.

1-5.A.1. Systems, Equipment and Components

a. Any type of telecommunications equipment having any of the following characteristics, functions or features:
   1. Specially designed to withstand transitory electronic effects or electromagnetic pulse effects, both arising from a nuclear explosion;
   2. Specially hardened to withstand gamma, neutron or ion radiation; **or**
   3. Specially designed to operate outside the temperature range from 218 K (-55°C) to 397 K (124°C).
      Note:
      1-5.A.1.a.3. applies only to electronic equipment.

   Note:
   1-5.A.1.a.2. and 1-5.A.1.a.3. do not control equipment designed or modified for use on board satellites.

b. Telecommunication systems and equipment, and specially designed components and accessories therefor, having any of the following characteristics, functions or features:
   1. Being underwater communications systems having any of the following characteristics:
      a. An acoustic carrier frequency outside the range from 20 kHz to 60 kHz;
      b. Using an electromagnetic carrier frequency below 30 kHz; **or**
      c. Using electronic beam steering techniques;
   2. Being radio equipment operating in the 1.5 MHz to 87.5 MHz band and having all of the following characteristics:
      a. Automatically predicting and selecting frequencies and “total digital transfer rates” per channel to optimise the transmission; **and**
      b. Incorporating a linear power amplifier configuration having a capability to support multiple signals simultaneously at an output power of 1 kW or more in the frequency range of 1.5 MHz or more but less than 30 MHz, or 250 W or more in the frequency range of 30 MHz or more but not exceeding 87.5 MHz, over an “instantaneous bandwidth” of one octave or more and with an output harmonic and distortion content of better than -80 dB;
   3. Being radio equipment employing “spread spectrum” techniques, including “frequency hopping” techniques, not controlled in 1-5.A.1.b.4., having any of the following characteristics:

a. User programmable spreading codes; **or**
b. A total transmitted bandwidth which is 100 or more times the bandwidth of any one information channel and in excess of 50 kHz.

Note:
1-5.A.1.b.3.b. does not control radio equipment specially designed for use with civil cellular radio-communications systems.

Note:
1-5.A.1.b.3. does not control equipment designed to operate at an output power of 1.0 Watt or less.

4. Being radio equipment employing ultra-wideband modulation techniques having user programmable channelizing codes, scrambling codes or network identification codes, having any of the following characteristics:
a. A bandwidth exceeding 500 MHz; **or**
b. A “fractional bandwidth” of 20% or more.
5. Being digitally controlled radio receivers having all of the following:
a. More than 1,000 channels;
b. A “frequency switching time” of less than 1 ms;
c. Automatic searching or scanning of a part of the electromagnetic spectrum; **and**
d. Identification of the received signals or the type of transmitter; **or**

Note:
1-5.A.1.b.5. does not control radio equipment specially designed for use with civil cellular radio-communications systems.

6. Employing functions of digital “signal processing” to provide voice coding output at rates of less than 2,400 bit/s.

Technical Notes:
1. For variable rate voice coding, 1-5.A.1.b.6. applies to the voice coding output of continuous speech.
2. For the purpose of 1-5.A.1.b.6., ‘voice coding’ is defined as the technique to take samples of human voice and then convert these samples into a digital signal, taking into account specific characteristics of human speech.

c. Optical fibre communication cables, optical fibres and accessories, as follows:
1. Optical fibres of more than 500 m in length, specified by the manufacturer as being capable of withstanding a proof test tensile stress of 2×10^9 N/m^2 or more;

Technical Note:
Proof Test: on-line or off-line production screen testing that dynamically applies a prescribed tensile stress over a 0.5 to 3 m length of fibre at a running rate of 2 to 5 m/s while passing between capstans approximately 150 mm in diameter. The ambient temperature is a nominal 293 K and relative humidity 40%. Equivalent national standards may be used for executing the proof test.

2. Optical fibre cables and accessories designed for underwater use.

Note:
1-5.A.1.c.2. does not control standard civil telecommunication cables and accessories.

N.B.1:
For underwater umbilical cables, and connectors therefor, see 1-8.A.2.a.3.

N.B.2:
For fibre-optic hull penetrators or connectors, see 1-8.A.2.c.

d. “Electronically steerable phased array antennae” operating above 31.8 GHz.

Note:
1-5.A.1.d. does not control “electronically steerable phased array antennae” for landing systems with instruments meeting ICAO standards covering microwave landing systems (MLS).

e. Radio direction finding equipment operating at frequencies above 30 MHz and having all of the following characteristics, and specially designed components therefor:
1. “Instantaneous bandwidth” of 10 MHz or more; **and**
2. Capable of finding a line of bearing (LOB) to non-cooperating radio transmitters with a signal duration of less than 1ms.

f. Jamming equipment specially designed or modified to intentionally and selectively interfere with, deny, inhibit, degrade or seduce cellular mobile telecommunication services, having any of the following characteristics, and specially designed components therefor:
1. Simulating the functions of Radio Access Network (RAN) equipment; **or**
2. Detecting and exploiting specific characteristics of the mobile telecommunications protocol employed (eg., GSM).

N.B.:
For GNSS jamming equipment see the Munitions List.

g. Passive Coherent Location systems or equipment specially designed for detecting and tracking moving objects by measuring reflections of ambient radio frequency emissions, supplied by non-radar transmitters.

Technical Note:
Non-radar transmitters may include commercial radio, television or cellular telecommunications base stations.

Note:
1-5.A.1.g. does not control:
1. Radio-astronomical equipment;
2. Systems or equipment that require any radio transmission from the target.

1-5.B.1. Test, Inspection and Production Equipment

a. Equipment and specially designed components or accessories therefor, specially designed for the “development”, “production” or “use” of equipment, functions or features controlled by Category 5 - Part 1.

Note:
1-5.B.1.a. does not control optical fibre characterization equipment.

b. Equipment and specially designed components or accessories therefor, specially designed for the “development” of any of the following telecommunication transmission or switching equipment:
1. Equipment employing digital techniques designed to operate at a “total digital transfer rate” exceeding 15 Gbit/s;

Technical Note:
For switching equipment the “total digital transfer rate” is measured at the highest speed port or line.

2. Equipment employing a “laser” and having any of the following:
a. A transmission wavelength exceeding 1750 nm;
b. Performing “optical amplification”;
c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques); **or**

d. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

Note:
1-5.B.1.b.2.d. does not control equipment specially designed for the "development" of commercial TV systems.

3. Equipment employing "optical switching";
4. Radio equipment employing quadrature-amplitude-modulation (QAM) techniques above level 256; **or**
5. Equipment employing "common channel signalling" operating in non-associated mode of operation.

1-5.C.1. Materials

None.

1-5.D.1. Software

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment, functions or features controlled by Category 5 - Part 1.
b. "Software" specially designed or modified to support "technology" controlled by 1-5.E.1.
c. Specific "software" specially designed or modified to provide characteristics, functions or features of equipment controlled by 1-5.A.1. or 1-5.B.1.
d. "Software" specially designed or modified for the "development" of any of the following telecommunication transmission or switching equipment:
   1. Equipment employing digital techniques designed to operate at a "total digital transfer rate" exceeding 15 Gbit/s;

      Technical Note:
      For switching equipment the "total digital transfer rate" is measured at the highest speed port or line.

   2. Equipment employing a "laser" and having any of the following:
      a. A transmission wavelength exceeding 1750 nm; **or**
      b. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

         Note:
         1-5.D.1.d.2.b. does not control "software" specially designed or modified for the "development" of commercial TV systems.

   3. Equipment employing "optical switching"; or
   4. Radio equipment employing quadrature-amplitude-modulation (QAM) techniques above level 256.

1-5.E.1. Technology

a. "Technology" according to the General Technology Note for the "development", "production" or "use" (excluding operation) of equipment, functions or features, or "software" controlled by Category 5 - Part 1.
b. Specific "technologies", as follows:
   1. "Required" "technology" for the "development" or "production" of telecommunications equipment specially designed to be used on board satellites;
   2. "Technology" for the "development" or "use" of "laser" communication techniques with the capability of automatically acquiring and tracking signals and maintaining communications through exoatmosphere or sub-surface (water) media;
   3. "Technology" for the "development" of digital cellular radio base station receiving equipment whose reception capabilities that allow multi-band, multi-channel, multi-mode, multi-coding algorithm or multi-protocol operation can be modified by changes in "software";
   4. "Technology" for the "development" of "spread spectrum" techniques, including "frequency hopping" techniques.
c. "Technology" according to the General Technology Note for the "development" or "production" of any of the following telecommunication transmission or switching equipment, functions or features:
   1. Equipment employing digital techniques designed to operate at a "total digital transfer rate" exceeding 15 Gbit/s;

      Technical Note:
      For switching equipment the "total digital transfer rate" is measured at the highest speed port or line.

   2. Equipment employing a "laser" and having any of the following:
      a. A transmission wavelength exceeding 1750 nm;
      b. Performing "optical amplification" using praseodymium-doped fluoride fibre amplifiers (PDFFA);
      c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques);
      d. Employing wavelength division multiplexing techniques exceeding 8 optical carriers in a single optical window; **or**
      e. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

         Note:
         1-5.E.1.c.2.e. does not control "technology" for the "development" or "production" of commercial TV systems.

   3. Equipment employing "optical switching";
   4. Radio equipment having any of the following:
      a. Quadrature-amplitude-modulation (QAM) techniques above level 256; **or**
      b. Operating at input or output frequencies exceeding 31.8 GHz; **or**

         Note:
         1-5.E.1.c.4.b. does not control "technology" for the "development" or "production" of equipment designed or modified for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.

      c. Operating in the 1.5 MHz to 87.5 MHz band and incorporating adaptive techniques providing more than 15 dB suppression of an interfering signal.
   5. Equipment employing "common channel signalling" operating in non-associated mode of operation.

Category 5 – Part 2: “Information Security”

Note 1:
The control status of “information security” equipment, “software”, systems, application specific “electronic assemblies”, modules, integrated circuits, components or functions is determined in Category 5, Part 2 even if they are components or “electronic assemblies” of other equipment.
Note 2:
Category 5 - Part 2 does not control products when accompanying their user for the user’s personal use.
Note 3:
Cryptography Note
1-5.A.2. and 1-5.D.2. do not control items that meet all of the following:
a. Generally available to the public by being sold, without restriction, from stock at retail selling points by means of any of the following:
  1. Over-the-counter transactions;
  2. Mail order transactions;
  3. Electronic transactions; **or**
  4. Telephone call transactions;
b. The cryptographic functionality cannot easily be changed by the user;
c. Designed for installation by the user without further substantial support by the supplier; **and**
d. Deleted;
e. When necessary, details of the items are accessible and will be provided, upon request, to the appropriate authority in the exporter’s country in order to ascertain compliance with conditions described in paragraphs a. to c. above.
Technical Note:
In Category 5 - Part 2, parity bits are not included in the key length.

1-5.A.2. Systems, Equipment and Components

a. Systems, equipment, application specific “electronic assemblies”, modules and integrated circuits for “information security”, as follows, and other specially designed components therefor:
N.B.:
For the control of global navigation satellite systems receiving equipment containing or employing decryption (i.e. GPS or GLONASS), see 1-7.A.5.

  1. Designed or modified to use “cryptography” employing digital techniques performing any cryptographic function other than authentication or digital signature having any of the following:
  Technical Notes:
  1. Authentication and digital signature functions include their associated key management function.
  2. Authentication includes all aspects of access control where there is no encryption of files or text except as directly related to the protection of passwords, Personal Identification Numbers (PINs) or similar data to prevent unauthorised access.
  3. “Cryptography” does not include “fixed” data compression or coding techniques.
  Note:
  1-5.A.2.a.1. includes equipment designed or modified to use “cryptography” employing analogue principles when implemented with digital techniques.

    a. A “symmetric algorithm” employing a key length in excess of 56 bits; **or**
    b. An “asymmetric algorithm” where the security of the algorithm is based on any of the following:
      1. Factorisation of integers in excess of 512 bits (e.g., RSA);
      2. Computation of discrete logarithms in a multiplicative group of a finite field of size greater than 512 bits (e.g., Diffie-Hellman over Z/pZ); **or**
      3. Discrete logarithms in a group other than mentioned in 1-5.A.2.a.1.b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve);
  2. Designed or modified to perform cryptanalytic functions;
  3. Deleted;
  4. Specially designed or modified to reduce the compromising emanations of information-bearing signals beyond what is necessary for health, safety or electromagnetic interference standards;
  5. Designed or modified to use cryptographic techniques to generate the spreading code for “spread spectrum” systems, not controlled in 1-5.A.2.a.6., including the hopping code for “frequency hopping” systems;
  6. Designed or modified to use cryptographic techniques to generate channelizing codes, scrambling codes or network identification codes, for systems using ultra-wideband modulation techniques, having any of the following characteristics:
    a. A bandwidth exceeding 500MHz; **or**
    b. A “fractional bandwidth” of 20% or more.
  7. Deleted.
  8. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion.
  9. Designed or modified to use “quantum cryptography”.
  Technical Note:
  “Quantum cryptography” is also known as quantum key distribution (QKD).

Note:
1-5.A.2. does not control:
a. “Personalised smart cards”:
  1. Where the cryptographic capability is restricted for use in equipment or systems excluded from control under entries b. to f. of this Note; **or**
  2. For general public-use applications where the cryptographic capability is not user-accessible and it is specially designed and limited to allow protection of personal data stored within.
  N.B.:
  If a “personalised smart card” has multiple functions, the control status of each function is assessed individually.
b. Receiving equipment for radio broadcast, pay television or similar restricted audience broadcast of the consumer type, without digital encryption except that exclusively used for sending the billing or programme-related information back to the broadcast providers.
c. Equipment where the cryptographic capability is not user-accessible and which is specially designed and limited to allow any of the following:
  1. Execution of copy-protected software;
  2. Access to any of the following:
    a. Copy-protected contents stored on read-only media; **or**
    b. Information stored in encrypted form on media (e.g. in connection with the protection of intellectual property rights) when the media is offered for sale in identical sets to the public;
  3. Copying control of copyright protected audio/video data; **or**
  4. Encryption and/or decryption for protection of libraries, design attributes, or associated data for the design of semiconductor devices or integrated circuits;
d. Cryptographic equipment specially designed and limited for banking use or money transactions.
  Technical Note:
  ‘Money transactions’ in 1-5.A.2. Note d. includes the collection and settlement of fares or credit functions.

e. Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular radiocommunications systems) that are not capable of end-to-end encryption;
f. Cordless telephone equipment not capable of end-to-end encryption where the maximum effective range of unboosted cordless operation (i.e., a single, unrelayed hop between terminal and home basestation) is less than 400 metres according to the manufacturer’s specifications.

1-5.B.2. Test, Inspection and Production Equipment

a. Equipment specially designed for:
   1. The “development” of equipment or functions controlled by Category 5 - Part 2, including measuring or test equipment;
   2. The “production” of equipment or functions controlled by Category 5 - Part 2, including measuring, test, repair or production equipment.
b. Measuring equipment specially designed to evaluate and validate the “information security” functions controlled by 1-5.A.2. or 1-5.D.2.

1-5.C.2. Materials

None.

1-5.D.2. Software

a. “Software” specially designed or modified for the “development”, “production” or “use” of equipment or “software” controlled by Category 5 - Part 2;
b. “Software” specially designed or modified to support “technology” controlled by 1-5.E.2.;
c. Specific “software”, as follows:
   1. “Software” having the characteristics, or performing or simulating the functions of the equipment controlled by 1-5.A.2. or 1-5.B.2.;
   2. “Software” to certify “software” controlled by 1-5.D.2.c.1.

Note:
1-5.D.2. does not control:
a. “Software” required for the “use” of equipment excluded from control under the Note to 1-5.A.2.;
b. “Software” providing any of the functions of equipment excluded from control under the Note to 1-5.A.2.

1-5.E.2. Technology

a. “Technology” according to the General Technology Note for the “development”, “production” or “use” of equipment or “software” controlled by Category 5 - Part 2.

Category 6: Sensors and “Lasers”

1-6.A. Systems, Equipment and Components

1. Acoustics
   a. Marine acoustic systems, equipment and specially designed components therefor, as follows:
      1. Active (transmitting or transmitting-and-receiving) systems, equipment and specially designed components therefor, as follows:

Note:
1-6.A.1.a.1. does not control:
a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding ± 20°, and limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;
b. Acoustic beacons, as follows:
   1. Acoustic emergency beacons;
   2. Pingers specially designed for relocating or returning to an underwater position.

a. Wide-swath bathymetric survey systems designed for sea bed topographic mapping, having all of the following:
   1. Being designed to take measurements at an angle exceeding 20° from the vertical;
   2. Being designed to measure depths exceeding 600 m below the water surface; **and**
   3. Being designed to provide any of the following:
      a. Incorporation of multiple beams any of which is less than 1.9°; **or**
      b. Data accuracies of better than 0.3% of water depth across the swath averaged over the individual measurements within the swath.
b. Object detection or location systems having any of the following:
   1. A transmitting frequency below 10 kHz;
   2. Sound pressure level exceeding 224 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band from 10 kHz to 24 kHz inclusive;
   3. Sound pressure level exceeding 235 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band between 24 kHz and 30 kHz;
   4. Forming beams of less than 1° on any axis and having an operating frequency of less than 100 kHz;
   5. Designed to operate with an unambiguous display range exceeding 5,120 m; **or**
   6. Designed to withstand pressure during normal operation at depths exceeding 1,000 m and having transducers with any of the following:
      a. Dynamic compensation for pressure; **or**
      b. Incorporating other than lead zirconate titanate as the transduction element;
c. Acoustic projectors, including transducers, incorporating piezoelectric, magnetostrictive, electrostrictive, electro-dynamic or hydraulic elements operating individually or in a designed combination, having any of the following:

   Note 1:
   The control status of acoustic projectors, including transducers, specially designed for other equipment is determined by the control status of the other equipment.

   Note 2:
   1-6.A.1.a.1.c. does not control electronic sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosive) sources.

   1. An instantaneous radiated acoustic power density exceeding 0.01 $mW/mm^2/Hz$ for devices operating at frequencies below 10 kHz;

2. A continuously radiated acoustic power density exceeding 0.001 mW/mm^2/Hz for devices operating at frequencies below 10 kHz; **or**

Technical Note:
Acoustic power density is obtained by dividing the output acoustic power by the product of the area of the radiating surface and the frequency of operation.

3. Side-lobe suppression exceeding 22 dB;

d. Acoustic systems, equipment and specially designed components for determining the position of surface vessels or underwater vehicles designed to operate at a range exceeding 1,000 m with a positioning accuracy of less than 10 m rms (root mean square) when measured at a range of 1,000 m;

Note:
1-6.A.1.a.1.d. includes:

a. Equipment using coherent "signal processing" between two or more beacons and the hydrophone unit carried by the surface vessel or underwater vehicle;
b. Equipment capable of automatically correcting speed-of-sound propagation errors for calculation of a point.

2. Passive (receiving, whether or not related in normal application to separate active equipment) systems, equipment and specially designed components therefor, as follows:

a. Hydrophones having any of the following characteristics:

Note:
The control status of hydrophones specially designed for other equipment is determined by the control status of the other equipment.

1. Incorporating continuous flexible sensing elements;
2. Incorporating flexible assemblies of discrete sensing elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;
3. Having any of the following sensing elements:
   a. Optical fibres;
   b. Piezoelectric polymer films other than polyvinylidene-fluoride (PVDF) and its co-polymers {P(VDF-TrFE) and P(VDF-TFE)}; **or**
   c. Flexible piezoelectric composites;
4. A hydrophone sensitivity better than -180 dB at any depth with no acceleration compensation;
5. When designed to operate at depths exceeding 35 m with acceleration compensation; **or**
6. Designed for operation at depths exceeding 1,000 m;

Technical Notes:

1. 'Piezoelectric polymer film' sensing elements consist of polarized polymer film that is stretched over and attached to a supporting frame or spool (mandrel).
2. 'Flexible piezoelectric composite' sensing elements consist of piezoelectric ceramic particles or fibres combined with an electrically insulating, acoustically transparent rubber, polymer or epoxy compound, where the compound is an integral part of the sensing elements.
3. Hydrophone sensitivity is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydrophone sensor, without a pre-amplifier, is placed in a plane wave acoustic field with an rms pressure of 1 µPa. For example, a hydrophone of -160 dB (reference 1 V per µPa) would yield an output voltage of 10^{-8} V in such a field, while one of -180 dB sensitivity would yield only 10^{-9} V output. Thus, -160 dB is better than -180 dB.

b. Towed acoustic hydrophone arrays having any of the following:

1. Hydrophone group spacing of less than 12.5 m or able to be modified to have hydrophone group spacing of less than 12.5 m;
2. Designed or 'able to be modified' to operate at depths exceeding 35 m;

Technical Note:
'Able to be modified' in 1-6.A.1.a.2.b. means having provisions to allow a change of the wiring or interconnections to alter hydrophone group spacing or operating depth limits. These provisions are: spare wiring exceeding 10% of the number of wires, hydrophone group spacing adjustment blocks or internal depth limiting devices that are adjustable or that control more than one hydrophone group.

3. Heading sensors controlled by 1-6.A.1.a.2.d.;
4. Longitudinally reinforced array hoses;
5. An assembled array of less than 40 mm in diameter;
6. Multiplexed hydrophone group signals designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; **or**
7. Hydrophone characteristics specified in 1-6.A.1.a.2.a.;

c. Processing equipment, specially designed for towed acoustic hydrophone arrays, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

d. Heading sensors having all of the following:

1. An accuracy of better than ± 0.5°; **and**
2. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m;

e. Bottom or bay cable systems having any of the following:

1. Incorporating hydrophones specified in 1-6.A.1.a.2.a.; **or**
2. Incorporating multiplexed hydrophone group signal modules having all of the following characteristics:
   a. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; **and**
   b. Capable of being operationally interchanged with towed acoustic hydrophone array modules;

f. Processing equipment, specially designed for bottom or bay cable systems, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes;

b. Correlation-velocity sonar log equipment designed to measure the horizontal speed of the equipment carrier relative to the sea bed at distances between the carrier and the sea bed exceeding 500 m.

2. Optical Sensors
   a. Optical detectors, as follows:

      Note:
      1-6.A.2.a. does not control germanium or silicon photodevices.

      N.B.:
      Silicon and other material based microbolometer non "space-qualified" "focal plane arrays" are only specified in 1-6.A.2.a.3.f.

      1. "Space-qualified" solid-state detectors, as follows:
         a. "Space-qualified" solid-state detectors, having all of the following:
            1. A peak response in the wavelength range exceeding 10 nm but not exceeding 300 nm; **and**
            2. A response of less than 0.1% relative to the peak response at a wavelength exceeding 400 nm;
         b. "Space-qualified" solid-state detectors, having all of the following:
            1. A peak response in the wavelength range exceeding 900 nm but not exceeding 1,200 nm; **and**
            2. A response "time constant" of 95 ns or less;
         c. "Space-qualified" solid-state detectors having a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;
      2. Image intensifier tubes and specially designed components therefor, as follows:
         a. Image intensifier tubes having all of the following:
            1. A peak response in the wavelength range exceeding 400 nm but not exceeding 1,050 nm;
            2. A microchannel plate for electron image amplification with a hole pitch (centre-to-centre spacing) of 12 µm or less; **and**
            3. Any of the following photocathodes:
               a. S-20, S-25 or multialkali photocathodes with a luminous sensitivity exceeding 350 µA/lm;
               b. GaAs or GaInAs photocathodes; **or**
               c. Other III-V compound semiconductor photocathodes;

                  Note:
                  1-6.A.2.a.2.a.3.c. does not apply to compound semiconductor photocathodes with a maximum radiant sensitivity of 10 mA/W or less.

         b. Specially designed components, as follows:
            1. Microchannel plates having a hole pitch (centre-to-centre spacing) of 12 µm or less;
            2. GaAs or GaInAs photocathodes;
            3. Other III-V compound semiconductor photocathodes;

               Note:
               1-6.A.2.a.2.b.3. does not control compound semiconductor photocathodes with a maximum radiant sensitivity of 10 mA/W or less.

      3. Non-"space-qualified" "focal plane arrays", as follows:

         N.B.:
         Silicon and other material based microbolometer non "space-qualified" "focal plane arrays" are only specified in 1-6.A.2.a.3.f.

         Technical Note:
         1. Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays".
         2. For the purposes of 1-6.A.2.a.3. 'cross scan direction' is defined as the axis parallel to the linear array of detector elements and the 'scan direction' is defined as the axis perpendicular to the linear array of detector elements.

         Note 1:
         1-6.A.2.a.3. includes photoconductive arrays and photovoltaic arrays.

         Note 2:
         1-6.A.2.a.3. does not control:
         a. Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;
         b. Pyroelectric detectors using any of the following:
            1. Triglycine sulphate and variants;
            2. Lead-lanthanum-zirconium titanate and variants;
            3. Lithium tantalate;
            4. Polyvinylidene fluoride and variants; **or**
            5. Strontium barium niobate and variants.

         a. Non-"space-qualified" "focal plane arrays", having all of the following:
            1. Individual elements with a peak response within the wavelength range exceeding 900 nm but not exceeding 1,050 nm; and
            2. A response "time constant" of less than 0.5 ns;
         b. Non-"space-qualified" "focal plane arrays", having all of the following:
            1. Individual elements with a peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,200 nm; and
            2. A response "time constant" of 95 ns or less;
         c. Non-"space-qualified" non-linear (2-dimensional) "focal plane arrays", having individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

            N.B.:
            Silicon and other material based microbolometer non "space-qualified" "focal plane arrays" are only specified in 1-6.A.2.a.3.f.

         d. Non-"space-qualified" linear (1-dimensional) "focal plane arrays", having all of the following :
            1. Individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 3,000 nm; **and**
            2. Any of the following :
               a. A ratio of scan direction dimension of the detector element to the cross-scan direction dimension of the detector element of less than 3.8; **or**
               b. Signal processing in the element (SPRITE);
         e. Non-"space-qualified" linear (1-dimensional) "focal plane arrays", having individual elements with a peak response in the wavelength range exceeding 3,000 nm but not exceeding 30,000 nm.
         f. Non-"space-qualified" non-linear (2-dimensional) infrared "focal plane arrays" based on micro-bolometer material having individual elements with an unfiltered response in the wavelength range equal to or exceeding 8,000 nm but not exceeding 14,000 nm.

Technical Note:
For the purposes of 1-6.A.2.a.3.f. 'micro-bolometer' is defined as a thermal imaging detector that, as a result of a temperature change in the detector caused by the absorption of infrared radiation, is used to generate any usable signal.

b. "Monospectral imaging sensors" and "multispectral imaging sensors" designed for remote sensing applications, having any of the following:
   1. An Instantaneous-Field-Of-View (IFOV) of less than 200 µrad (microradians); **or**
   2. Being specified for operation in the wavelength range exceeding 400 nm but not exceeding 30,000 nm and having all the following:
      a. Providing output imaging data in digital format; and
      b. Being any of the following:
         1. "Space-qualified"; **or**
         2. Designed for airborne operation, using other than silicon detectors, and having an IFOV of less than 2.5 mrad (milliradians).

c. Direct view imaging equipment operating in the visible or infrared spectrum, incorporating any of the following:
   1. Image intensifier tubes having the characteristics listed in 1-6.A.2.a.2.a.; **or**
   2. "Focal plane arrays" having the characteristics listed in 1-6.A.2.a.3.

Technical Note:
'Direct view' refers to imaging equipment, operating in the visible or infrared spectrum, that presents a visual image to a human observer without converting the image into an electronic signal for television display, and that cannot record or store the image photographically, electronically or by any other means.

Note:
1-6.A.2.c. does not control the following equipment incorporating other than GaAs or GaInAs photocathodes:
a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
b. Medical equipment;
c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
d. Flame detectors for industrial furnaces;
e. Equipment specially designed for laboratory use.

d. Special support components for optical sensors, as follows:
   1. "Space-qualified" cryocoolers;
   2. Non-"space-qualified" cryocoolers, having a cooling source temperature below 218 K (-55°C), as follows:
      a. Closed cycle type with a specified Mean-Time-To-Failure (MTTF), or Mean-Time-Between-Failures (MTBF), exceeding 2,500 hours;
      b. Joule-Thomson (JT) self-regulating minicoolers having bore (outside) diameters of less than 8 mm;
   3. Optical sensing fibres specially fabricated either compositionally or structurally, or modified by coating, to be acoustically, thermally, inertially, electromagnetically or nuclear radiation sensitive.

e. "Space qualified" "focal plane arrays" having more than 2,048 elements per array and having a peak response in the wavelength range exceeding 300 nm but not exceeding 900 nm.

3. Cameras

N.B.:
For cameras specially designed or modified for underwater use, see 1-8.A.2.d. and 1-8.A.2.e.

a. Instrumentation cameras and specially designed components therefor, as follows:

Note:
Instrumentation cameras, controlled by 1-6.A.3.a.3. to 1-6.A.3.a.5., with modular structures should be evaluated by their maximum capability, using plug-ins available according to the camera manufacturer's specifications.

   1. High-speed cinema recording cameras using any film format from 8 mm to 16 mm inclusive, in which the film is continuously advanced throughout the recording period, and that are capable of recording at framing rates exceeding 13,150 frames/s;

   Note:
   1-6.A.3.a.1. does not control cinema recording cameras designed for civil purposes.

   2. Mechanical high speed cameras, in which the film does not move, capable of recording at rates exceeding 1,000,000 frames/s for the full framing height of 35 mm film, or at proportionately higher rates for lesser frame heights, or at proportionately lower rates for greater frame heights;
   3. Mechanical or electronic streak cameras having writing speeds exceeding 10 mm/µs;
   4. Electronic framing cameras having a speed exceeding 1,000,000 frames/s;
   5. Electronic cameras, having all of the following:
      a. An electronic shutter speed (gating capability) of less than 1 µs per full frame; **and**
      b. A read out time allowing a framing rate of more than 125 full frames per second.
   6. Plug-ins, having all of the following characteristics:
      a. Specially designed for instrumentation cameras which have modular structures and which are controlled by 1-6.A.3.a.; **and**
      b. Enabling these cameras to meet the characteristics specified in 1-6.A.3.a.3., 1-6.A.3.a.4. or 1-6.A.3.a.5., according to the manufacturer's specifications.

b. Imaging cameras, as follows:

Note:
1-6.A.3.b. does not control television or video cameras specially designed for television broadcasting.

   1. Video cameras incorporating solid state sensors, having a peak response in the wavelength range exceeding 10 nm, but not exceeding 30,000 nm and having all of the following:
      a. Having any of the following:
         1. More than 4 x 10^6 "active pixels" per solid state array for monochrome (black and white) cameras;
         2. More than 4 x 10^6 "active pixels" per solid state array for colour cameras incorporating three solid state arrays; **or**

3. More than 12 x 10^6 "active pixels" for solid state array colour cameras incorporating one solid state array; **and**

b. Having any of the following:
1. Optical mirrors controlled by 1-6.A.4.a.;
2. Optical control equipment controlled by 1-6.A.4.d.; **or**
3. The capability for annotating internally generated camera tracking data.

Technical Notes:
1. For the purpose of this entry, digital video cameras should be evaluated by the maximum number of "active pixels" used for capturing moving images.
2. For the purpose of this entry, camera tracking data is the information necessary to define camera line of sight orientation with respect to the earth. This includes: 1) the horizontal angle the camera line of sight makes with respect to the earth's magnetic field direction and; 2) the vertical angle between the camera line of sight and the earth's horizon.

2. Scanning cameras and scanning camera systems, having all of the following:
a. A peak response in the wavelength range exceeding 10 nm, but not exceeding 30,000 nm;
b. Linear detector arrays with more than 8,192 elements per array; **and**
c. Mechanical scanning in one direction;
3. Imaging cameras incorporating image intensifier tubes having the characteristics listed in 1-6.A.2.a.2.a.;
4. Imaging cameras incorporating "focal plane arrays" having any of the following:
a. Incorporating "focal plane arrays" controlled by 1-6.A.2.a.3.a. to 1-6.A.2.a.3.e.; or
b. Incorporating "focal plane arrays" controlled by 1-6.A.2.a.3.f.

Note 1:
'Imaging cameras' described in 1-6.A.3.b.4. include "focal plane arrays" combined with sufficient signal processing electronics, beyond the read out integrated circuit, to enable as a minimum the output of an analogue or digital signal once power is supplied.

Note 2:
1-6.A.3.b.4.a. does not control imaging cameras incorporating linear "focal plane arrays" with twelve elements or fewer, not employing time-delay-and-integration within the element, designed for any of the following:
a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
b. Industrial equipment used for inspection or monitoring of heat flows in buildings, equipment or industrial processes;
c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
d. Equipment specially designed for laboratory use; **or**
e. Medical equipment.

Note 3:
1-6.A.3.b.4.b. does not control imaging cameras having any of the following characteristics:
a. A maximum frame rate equal to or less than 9 Hz ;
b. Having all of the following:
1. Having a minimum horizontal or vertical Instantaneous-Field-of-View (IFOV) of at least 10 mrad/pixel (milliradians/pixel);
2. Incorporating a fixed focal-length lens that is not designed to be removed;
3. Not incorporating a direct view display; **and**

Technical Note:
'Direct view' refers to an imaging camera operating in the infrared spectrum that presents a visual image to a human observer using a near-to-eye micro display incorporating any light-security mechanism.

4. Having any of the following:
a. No facility to obtain a viewable image of the detected field-of-view; **or**
b. The camera is designed for a single kind of application and designed not to be user modified; **or**

Technical Note:
Instantaneous Field of View (IFOV) specified in Note 3.b. is the lesser figure of the Horizontal FOV or the Vertical FOV.
Horizontal IFOV = horizontal Field of View (FOV)/number of horizontal detector elements
Vertical IFOV= vertical Field of View (FOV)/number of vertical detector elements.

c. Where the camera is specially designed for installation into a civilian passenger land vehicle of less than three tonnes (gross vehicle weight) and having all of the following:
1. Is only operable when installed in any of the following:
a. The civilian passenger land vehicle for which it was intended; **or**
b. A specially designed, authorized maintenance test facility; **and**
2. Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended.

Note:
When necessary, details of the item will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with the conditions described in Note 3.b.4. and Note 3.c. above.

4. Optics
a. Optical mirrors (reflectors), as follows:
1. "Deformable mirrors" having either continuous or multi-element surfaces, and specially designed components therefor, capable of dynamically repositioning portions of the surface of the mirror at rates exceeding 100 Hz;
2. Lightweight monolithic mirrors having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 10 kg;
3. Lightweight "composite" or foam mirror structures having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 2 kg;
4. Beam steering mirrors more than 100 mm in diameter or length of major axis, which maintain a flatness of lambda/^{2} or better (lambda is equal to 633 nm) having a control bandwidth exceeding 100 Hz.

N.B.:
For optical mirrors specially designed for lithography equipment, see Item 1-3.B.1.

b. Optical components made from zinc selenide (ZnSe) or zinc sulphide (ZnS) with transmission in the wavelength range exceeding 3,000 nm but not exceeding 25,000 nm and having any of the following:
1. Exceeding 100 cm^3 in volume; **or**
2. Exceeding 80 mm in diameter or length of major axis and 20 mm in thickness (depth).

c. "Space-qualified" components for optical systems, as follows:

1. Lightweighted to less than 20% “equivalent density” compared with a solid blank of the same aperture and thickness;
2. Raw substrates, processed substrates having surface coatings (single-layer or multi-layer, metallic or dielectric, conducting, semiconducting or insulating) or having protective films;
3. Segments or assemblies of mirrors designed to be assembled in space into an optical system with a collecting aperture equivalent to or larger than a single optic 1 m in diameter;
4. Manufactured from “composite” materials having a coefficient of linear thermal expansion equal to or less than 5 x 10^{-6} in any coordinate direction.

d. Optical control equipment, as follows:
1. Specially designed to maintain the surface figure or orientation of the “space-qualified” components controlled by 1-6.A.4.c.1. or 1-6.A.4.c.3.;
2. Having steering, tracking, stabilisation or resonator alignment bandwidths equal to or more than 100 Hz and an accuracy of 10 µrad (microradians) or less;
3. Gimbals having all of the following:
   a. A maximum slew exceeding 5°;
   b. A bandwidth of 100 Hz or more;
   c. Angular pointing errors of 200 µrad (microradians) or less; and
   d. Having any of the following:
      1. Exceeding 0.15 m but not exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 2 rad (radians)/s^2; **or**
      2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 rad (radians)/s^2;
4. Specially designed to maintain the alignment of phased array or phased segment mirror systems consisting of mirrors with a segment diameter or major axis length of 1 m or more.

e. Aspheric optical elements having all of the following characteristics:
1. The largest dimension of the optical-aperture is greater than 400 mm;
2. The surface roughness is less than 1 nm (rms) for sampling lengths equal to or greater than 1 mm; **and**
3. The coefficient of linear thermal expansion’s absolute magnitude is less than 3x10^{-6}/K at 25 °C;

Technical Notes:
1. An ‘aspheric optical element’ is any element used in an optical system whose imaging surface or surfaces are designed to depart from the shape of an ideal sphere.
2. Manufacturers are not required to measure the surface roughness listed in 1-6.A.4.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the control parameter.

Note:
1-6.A.4.e. does not control aspheric optical elements having any of the following:
a. A largest optical-aperture dimension less than 1 m and a focal length to aperture ratio equal to or greater than 4.5:1;
b. A largest optical-aperture dimension equal to or greater than 1 m and a focal length to aperture ratio equal to or greater than 7:1;
c. Being designed as Fresnel, flyeye, stripe, prism or diffractive optical elements;
d. Being fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than 2.5x10^{-6}/K at 25 °C; **or**
e. Being an x-ray optical element having inner mirror capabilities (e.g. tube-type mirrors).

N.B.:
For aspheric optical elements specially designed for lithography equipment, see Item 1-3.B.1.

5. Lasers

“Lasers”, components and optical equipment, as follows:

Note 1:
Pulsed “lasers” include those that run in a continuous wave (CW) mode with pulses superimposed.

Note 2:
Excimer, semiconductor, chemical, CO, CO_2, and non-repetitive pulsed Nd:glass “lasers” are only specified in 1-6.A.5.d.

Note 3:
1-6.A.5. includes fibre “lasers”.

Note 4:
The control status of “lasers” incorporating frequency conversion (i.e. wavelength change) by means other than one “laser” pumping another “laser” is determined by applying the control parameters for both the output of the source “laser” and the frequency-converted optical output.

Note 5:
1-6.A.5. does not control the following “lasers”:
a. Ruby with output energy below 20 J;
b. Nitrogen;
c. Krypton.

Technical Note
‘Wall-plug efficiency’ is defined as the ratio of “laser” output power (or “average output power”) to total electrical input power required to operate the “laser”, including the power supply/conditioning and thermal conditioning/heat exchanger.

a. Non-“tunable” continuous wave “(CW) lasers”, having any of the following:
1. An output wavelength less than 150 nm with an output power exceeding 1 W;
2. An output wavelength of 150 nm or more but not exceeding 520 nm and having an output power exceeding 30 W;

Note:
1-6.A.5.a.2. does not control Argon “lasers” having an output power equal to or less than 50 W.

3. An output wavelength exceeding 520 nm but not exceeding 540 nm and having any of the following:
   a. A single transverse mode output having an output power exceeding 50 W; **or**
   b. A multiple transverse mode output having an output power exceeding 150 W;
4. An output wavelength exceeding 540 nm but not exceeding 800 nm and having an output power exceeding 30 W;
5. An output wavelength exceeding 800 nm but not exceeding 975 nm and having any of the following:
   a. A single transverse mode output having an output power exceeding 50 W; **or**
   b. A multiple transverse mode output having an output power exceeding 80 W;
6. An output wavelength exceeding 975 nm but not exceeding 1,150 nm and having any of the following:

a. A single transverse mode output having any of the following:
   1. A wall-plug efficiency exceeding 12% and an output power exceeding 100 W; **or**
   2. An output power exceeding 150 W; **or**
b. A multiple transverse mode output having any of the following:
   1. A wall-plug efficiency exceeding 18% and an output power exceeding 500 W; **or**
   2. An output power exceeding 2 kW;

Note:
1-6.A.5.a.6.b. does not control multiple transverse mode, industrial "lasers" with output power exceeding 2 kW and not exceeding 6 kW with a total mass greater than 1,200 kg. For the purpose of this note, total mass includes all components required to operate the "laser", e.g., "laser", power supply, heat exchanger, but excludes external optics for beam conditioning and/or delivery.

7. An output wavelength exceeding 1,150 nm but not exceeding 1,555 nm and having any of the following:
   a. A single transverse mode having an output power exceeding 50 W; **or**
   b. A multiple transverse mode having an output power exceeding 80 W; **or**
8. An output wavelength exceeding 1,555 nm and having an output power exceeding 1 W.

b. Non-"tunable" "pulsed lasers", having any of the following:
   1. An output wavelength less than 150 nm and having any of the following:
      a. An output energy exceeding 50 mJ per pulse and a "peak power" exceeding 1 W; **or**
      b. An "average output power" exceeding 1 W;
   2. An output wavelength of 150 nm or more but not exceeding 520 nm and having any of the following:
      a. An output energy exceeding 1.5 J per pulse and a "peak power" exceeding 30W; **or**
      b. An "average output power" exceeding 30 W;

      Note:
      1-6.A.5.b.2.b. does not control Argon "lasers" having an "average output power" equal to or less than 50 W.

   3. An output wavelength exceeding 520 nm but not exceeding 540 nm and having any of the following:
      a. A single transverse mode output having any of the following:
         1. An output energy exceeding 1.5 J per pulse and a "peak power" exceeding 50 W; **or**
         2. An "average output power" exceeding 50 W; **or**
      b. A multiple transverse mode output having any of the following:
         1. An output energy exceeding 1.5 J per pulse and a "peak power" exceeding 150 W; **or**
         2. An "average output power" exceeding 150 W;
   4. An output wavelength exceeding 540 nm but not exceeding 800 nm and having any of the following:
      a. An output energy exceeding 1.5 J per pulse and a "peak power" exceeding 30 W; **or**
      b. An "average output power" exceeding 30 W;
   5. An output wavelength exceeding 800 nm but not exceeding 975 nm and having any of the following:
      a. A "pulse duration" not exceeding 1 µs and having any of the following:
         1. An output energy exceeding 0.5 J per pulse and a "peak power" exceeding 50 W;
         2. A single transverse mode output having an "average output power" exceeding 20 W; **or**
         3. A multiple transverse mode output having an "average output power" exceeding 50 W; **or**
      b. A "pulse duration" exceeding 1 µs and having any of the following:
         1. An output energy exceeding 2 J per pulse and a "peak power" exceeding 50 W;
         2. A single transverse mode output having an "average output power" exceeding 50 W; **or**
         3. A multiple transverse mode output having an "average output power" exceeding 80 W;
   6. An output wavelength exceeding 975 nm but not exceeding 1,150 nm and having any of the following:
      a. A "pulse duration" of less than 1 ns and having any of the following:
         1. An output "peak power" exceeding 5 GW per pulse;
         2. An "average output power" exceeding 10 W; **or**
         3. An output energy exceeding 0.1 J per pulse;
      b. A "pulse duration" exceeding 1 ns but not exceeding 1 µs, and having any of the following:
         1. A single transverse mode output having any of the following:
            a. A "peak power" exceeding 100 MW;
            b. An "average output power" exceeding 20 W limited by design to a maximum pulse repetition frequency less than or equal to 1 kHz;
            c. A wall-plug efficiency exceeding 12% and an "average output power" exceeding 100 W and capable of operating at a pulse repetition frequency greater than 1 kHz;
            d. An "average output power" exceeding 150 W and capable of operating at a pulse repetition frequency greater than 1 kHz; **or**
            e. An output energy exceeding 2 J per pulse; **or**
         2. A multiple transverse mode output having any of the following:
            a. A "peak power" exceeding 400 MW;
            b. A wall-plug efficiency exceeding 18% and an "average output power" exceeding 500 W;
            c. An "average output power" exceeding 2 kW; **or**
            d. An output energy exceeding 4 J per pulse; **or**
      c. A "pulse duration" exceeding 1 µs and having any of the following:
         1. A single transverse mode output having any of the following:
            a. A "peak power" exceeding 500 kW;
            b. A wall-plug efficiency exceeding 12% and an "average output power" exceeding 100 W; **or**
            c. An "average output power" exceeding 150 W; **or**
         2. A multiple transverse mode output having any of the following:
            a. A "peak power" exceeding 1 MW;

b. A wall-plug efficiency exceeding 18% and an "average output power" exceeding 500 W; **or**
c. An "average output power" exceeding 2 kW;

7. An output wavelength exceeding 1,150 nm but not exceeding 1,555 nm and having any of the following:
   a. A "pulse duration" not exceeding 1 µs and having any of the following:
      1. An output energy exceeding 0.5 J per pulse and a "peak power" exceeding 50 W;
      2. A single transverse mode output having an "average output power" exceeding 20 W; **or**
      3. A multiple transverse mode output having an "average output power" exceeding 50 W; **or**
   b. A "pulse duration" exceeding 1 µs and having any of the following:
      1. An output energy exceeding 2 J per pulse and a "peak power" exceeding 50 W;
      2. A single transverse mode output having an "average output power" exceeding 50 W; **or**
      3. A multiple transverse mode output having an "average output power" exceeding 80 W; **or**
8. An output wavelength exceeding 1,555 nm and having any of the following:
   a. An output energy exceeding 100 mJ per pulse and a "peak power" exceeding 1 W; **or**
   b. An "average output power" exceeding 1 W;

c. "Tunable" "lasers", having any of the following:

Note:
1-6.A.5.c. includes titanium-sapphire (Ti: Al_2O_3), thulium-YAG (Tm: YAG), thulium-YSGG (Tm: YSGG), alexandrite (Cr: $BeAl_2O_4$), colour centre "lasers", dye "lasers", and liquid "lasers".

1. An output wavelength less than 600 nm and having any of the following:
   a. An output energy exceeding 50 mJ per pulse and a "peak power" exceeding 1 W; **or**
   b. An average or CW output power exceeding 1 W;
2. An output wavelength of 600 nm or more but not exceeding 1,400 nm and having any of the following:
   a. An output energy exceeding 1 J per pulse and a "peak power" exceeding 20 W; **or**
   b. An average or CW output power exceeding 20 W; **or**
3. An output wavelength exceeding 1,400 nm and having any of the following:
   a. An output energy exceeding 50 mJ per pulse and a "peak power" exceeding 1 W; **or**
   b. An average or CW output power exceeding 1 W;

d. Other "lasers", not controlled in 1-6.A.5.a., 1-6.A.5.b. or 1-6.A.5.c. as follows:

1. Semiconductor "lasers", as follows:

Note 1:
1-6.A.5.d.1. includes semiconductor "lasers" having optical output connectors (e.g. fibre optic pigtails).

Note 2:
The control status of semiconductor "lasers" specially designed for other equipment is determined by the control status of the other equipment.

   a. Individual single-transverse mode semiconductor "lasers", having any of the following:
      1. A wavelength equal to or less than 1,510 nm and having an average or CW output power exceeding 1.5 W; **or**
      2. A wavelength greater than 1,510 nm, and having an average or CW output power exceeding 500 mW;
   b. Individual, multiple-transverse mode semiconductor "lasers", having any of the following:
      1. A wavelength of less than 1,400 nm and having an average or CW output power exceeding 10W;
      2. A wavelength equal to or greater than 1,400 nm and less than 1,900 nm, and having an average or CW output power exceeding 2.5 W; **or**
      3. A wavelength equal to or greater than 1,900 nm and having an average or CW output power exceeding 1 W.
   c. Individual semiconductor "laser" arrays, having any of the following:
      1. A wavelength of less than 1,400 nm and having an average or CW output power exceeding 80 W;
      2. A wavelength equal to or greater than 1,400 nm and less than 1,900 nm and having an average or CW output power exceeding 25 W; **or**
      3. A wavelength equal to or greater than 1,900 nm and having an average or CW output power exceeding 10 W.
   d. Array stacks of semiconductor "lasers" containing at least one array that is controlled under 1-6.A.5.d.1.c.

Technical Notes:
1. Semiconductor "lasers" are commonly called "laser" diodes.
2. An 'array' consists of multiple semiconductor "laser" emitters fabricated as a single chip so that the centres of the emitted light beams are on parallel paths.
3. An 'array stack' is fabricated by stacking, or otherwise assembling, 'arrays' so that the centres of the emitted light beams are on parallel paths.

2. Carbon monoxide (CO) "lasers" having any of the following:
   a. An output energy exceeding 2 J per pulse and a "peak power" exceeding 5 kW; **or**
   b. An average or CW output power exceeding 5 kW;
3. Carbon dioxide (CO2) "lasers" having any of the following:
   a. A CW output power exceeding 15 kW;
   b. A pulsed output having a "pulse duration" exceeding 10 µs and having any of the following:
      1. An "average output power" exceeding 10 kW; **or**
      2. A "peak power" exceeding 100 kW; **or**
   c. A pulsed output having a "pulse duration" equal to or less than 10 µs and having any of the following:
      1. A pulse energy exceeding 5 J per pulse; **or**
      2. An "average output power" exceeding 2.5 kW;
4. Excimer "lasers", having any of the following:
   a. An output wavelength not exceeding 150 nm and having any of the following:
      1. An output energy exceeding 50 mJ per pulse; **or**
      2. An "average output power" exceeding 1 W;
   b. An output wavelength exceeding 150 nm but not exceeding 190 nm and having any of the following:
      1. An output energy exceeding 1.5 J per pulse; **or**
      2. An "average output power" exceeding 120 W;
   c. An output wavelength exceeding 190 nm but not exceeding 360 nm and having any of the following:

1. An output energy exceeding 10 J per pulse; **or**
2. An "average output power" exceeding 500 W; **or**

d. An output wavelength exceeding 360 nm and having any of the following:
1. An output energy exceeding 1.5 J per pulse; **or**
2. An "average output power" exceeding 30 W;

N.B.:
For excimer "lasers" specially designed for lithography equipment, see 1-3.B.1.

5. "Chemical lasers", as follows:
a. Hydrogen Fluoride (HF) "lasers";
b. Deuterium Fluoride (DF) "lasers";
c. "Transfer lasers", as follows:
1. Oxygen Iodine (O_2-I) "lasers";
2. Deuterium Fluoride-Carbon dioxide (DF-CO_2) "lasers"

6. Non-repetitive pulsed Nd: glass "lasers" having any of the following:
a. A "pulse duration" not exceeding 1 µs and an output energy exceeding 50 J per pulse; or
b. A "pulse duration" exceeding 1 µs and an output energy exceeding 100 J per pulse;

Note:
Non-repetitive pulsed refers to "lasers" that produce either a single output pulse or that have a time interval between pulses exceeding one minute.

e. Components, as follows:
1. Mirrors cooled either by active cooling or by heat pipe cooling;

Technical Note:
'Active cooling' is a cooling technique for optical components using flowing fluids within the subsurface (nominally less than 1 mm below the optical surface) of the optical component to remove heat from the optic.

2. Optical mirrors or transmissive or partially transmissive optical or electro-optical components specially designed for use with controlled "lasers";

f. Optical equipment, as follows:

N.B.:
For shared aperture optical elements, capable of operating in "Super-High Power Laser" ("SHPL") applications, see Item 2-19. Note 2.d. on the Munitions List.

1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront having any of the following:
a. Frame rates equal to or more than 100 Hz and phase discrimination of at least 5% of the beam's wavelength; **or**
b. Frame rates equal to or more than 1,000 Hz and phase discrimination of at least 20% of the beam's wavelength;
2. "Laser" diagnostic equipment capable of measuring "SHPL" system angular beam steering errors of equal to or less than 10 µrad;
3. Optical equipment and components specially designed for a phased-array "SHPL" system for coherent beam combination to an accuracy of lambda/10 at the designed wavelength, or 0.1 µm, whichever is the smaller;
4. Projection telescopes specially designed for use with "SHPL" systems.

6. Magnetic and Electric Field Sensors
"Magnetometers", "magnetic gradiometers", "intrinsic magnetic gradiometers", underwater electric field sensors, and "compensation systems", and specially designed components therefor, as follows:

Note:
1-6.A.6. does not control instruments specially designed for fishery applications or biomagnetic measurements for medical diagnostics.

a. "Magnetometers" and subsystems, as follows:
1. Using "superconductive" (SQUID) "technology" and having any of the following characteristics:
a. SQUID systems designed for stationary operation, without specially designed subsystems designed to reduce in-motion noise, and having a "noise level" (sensitivity) equal to or lower (better) than 50 fT (rms) per square root Hz at a frequency of 1 Hz; **or**
b. SQUID systems having an in-motion-magnetometer "noise level" (sensitivity) lower (better) than 20 pT (rms) per square root Hz at a frequency of 1 Hz and specially designed to reduce in-motion noise;
2. Using optically pumped or nuclear precession (proton/Overhauser) "technology" having a "noise level" (sensitivity) lower (better) than 20 pT (rms) per square root Hz;
3. Using fluxgate "technology" having a "noise level" (sensitivity) equal to or lower (better) than 10 pT (rms) per square root Hz at a frequency of 1 Hz;
4. Induction coil "magnetometers" having a "noise level" (sensitivity) lower (better) than any of the following:
a. 0.05 nT (rms)/square root Hz at frequencies of less than 1 Hz;
b. 1×10^{-3} nT (rms)/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; **or**
c. 1×10^{-4} nT (rms)/square root Hz at frequencies exceeding 10 Hz;
5. Fibre optic "magnetometers" having a "noise level" (sensitivity) lower (better) than 1 nT (rms) per square root Hz;

b. Underwater Electric Field Sensors having a "noise level" (sensitivity) lower (better) than 8 nanovolt per meter per square root Hz when measured at 1 Hz.

c. Magnetic gradiometers, as follows:
1. "Magnetic gradiometers" using multiple "magnetometers" controlled by 1-6.A.6.a.;
2. Fibre optic "intrinsic magnetic gradiometers" having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.3 nT/m (rms) per square root Hz;
3. "Intrinsic magnetic gradiometers", using "technology" other than fibre-optic "technology", having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.015 nT/m (rms) per square root Hz;

d. "Compensation systems" for magnetic or underwater electric field sensors resulting in a performance equal to or better than the control parameters of 1-6.A.6.a., 1-6.A.6.b., or 1-6.A.6.c.

7. Gravimeters

Gravity meters (gravimeters) and gravity gradiometers, as follows:

a. Gravity meters designed or modified for ground use having a static accuracy of less (better) than 10 µgal;

Note:

1-6.A.7.a. does not control ground gravity meters of the quartz element (Worden) type.

b. Gravity meters designed for mobile platforms, having all of the following:
   1. A static accuracy of less (better) than 0.7 mgal; **and**
   2. An in-service (operational) accuracy of less (better) than 0.7 mgal having a time-to-steady-state registration of less than 2 minutes under any combination of attendant corrective compensations and motional influences;

c. Gravity gradiometers.

8. Radar

Radar systems, equipment and assemblies having any of the following characteristics, and specially designed components therefor:

Note:

1-6.A.8. does not control:

a. Secondary surveillance radar (SSR);
b. Civil Automotive Radar;
c. Displays or monitors used for air traffic control (ATC) having no more than 12 resolvable elements per mm;
d. Meteorological (weather) radar.

a. Operating at frequencies from 40 GHz to 230 GHz and having any of the following:
   1. An average output power exceeding 100 mW; **or**
   2. Locating accuracy of 1 m or less (better) in range and 0.2 degree or less (better) in azimuth.

b. Having a tunable bandwidth exceeding ± 6.25% of the centre operating frequency;

Technical Note:

The centre operating frequency equals one half of the sum of the highest plus the lowest specified operating frequencies.

c. Capable of operating simultaneously on more than two carrier frequencies;

d. Capable of operating in synthetic aperture (SAR), inverse synthetic aperture (ISAR) radar mode, or sidelooking airborne (SLAR) radar mode;

e. Incorporating “electronically steerable phased array antennae”;

f. Capable of heightfinding non-cooperative targets;

Note:

1-6.A.8.f. does not control precision approach radar (PAR) equipment conforming to ICAO standards.

g. Specially designed for airborne (balloon or airframe mounted) operation and having Doppler “signal processing” for the detection of moving targets;

h. Employing processing of radar signals using any of the following:
   1. “Radar spread spectrum” techniques; **or**
   2. “Radar frequency agility” techniques;

i. Providing ground-based operation with a maximum “instrumented range” exceeding 185 km;

Note:

1-6.A.8.i. does not control:

a. Fishing ground surveillance radar;
b. Ground radar equipment specially designed for enroute air traffic control, provided that all the following conditions are met:
   1. It has a maximum “instrumented range” of 500 km or less;
   2. It is configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres;
   3. It contains no provisions for remote control of the radar scan rate from the enroute ATC centre; **and**
   4. It is to be permanently installed.
c. Weather balloon tracking radars.

j. Being “laser” radar or Light Detection and Ranging (LIDAR) equipment, having any of the following:
   1. “Space-qualified”; **or**
   2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 µrad (microradians);

Note:

1-6.A.8.j. does not control LIDAR equipment specially designed for surveying or for meteorological observation.

k. Having “signal processing” sub-systems using “pulse compression”, with any of the following:
   1. A “pulse compression” ratio exceeding 150; **or**
   2. A pulse width of less than 200 ns; **or**

l. Having data processing sub-systems with any of the following:
   1. “Automatic target tracking” providing, at any antenna rotation, the predicted target position beyond the time of the next antenna beam passage;

      Note:

      1-6.A.8.l.1. does not control conflict alert capability in ATC systems, or marine or harbour radar.

   2. Calculation of target velocity from primary radar having non-periodic (variable) scanning rates;
   3. Processing for automatic pattern recognition (feature extraction) and comparison with target characteristic data bases (waveforms or imagery) to identify or classify targets; **or**
   4. Superposition and correlation, or fusion, of target data from two or more “geographically dispersed” and “interconnected radar sensors” to enhance and discriminate targets.

      Note:

      1-6.A.8.l.4. does not control systems, equipment and assemblies used for marine traffic control.

1-6.B. Test, Inspection and Production Equipment

1. Acoustics – None.
2. Optical Sensors - None.
3. Cameras - None.
4. Optics

   Optical equipment, as follows:

   a. Equipment for measuring absolute reflectance to an accuracy of ± 0.1% of the reflectance value;
   b. Equipment other than optical surface scattering measurement equipment, having an unobscured aperture of more than 10 cm, specially designed for the non-contact optical measurement of a non-planar optical surface figure (profile) to an “accuracy” of 2 nm or less (better) against the required profile.

Note:
1-6.B.4. does not control microscopes.

5. Lasers - None.
6. Magnetic and Electric Field Sensors - None.
7. Gravimeters
   Equipment to produce, align and calibrate land-based gravity meters with a static accuracy of better than 0.1 mgal.
8. Radar
   Pulse radar cross-section measurement systems having transmit pulse widths of 100 ns or less and specially designed components therefor.

1-6.C. Materials

1. Acoustics - None.
2. Optical Sensors
   Optical sensor materials, as follows:
   a. Elemental tellurium (Te) of purity levels of 99.9995% or more;
   b. Single crystals (including epitaxial wafers) of any of the following:
      1. Cadmium zinc telluride (CdZnTe) with zinc content of less than 6% by mole fraction;
      2. Cadmium telluride (CdTe) of any purity level; **or**
      3. Mercury cadmium telluride (HgCdTe) of any purity level.

      Technical Note:
      Mole fraction is defined as the ratio of moles of ZnTe to the sum of the moles of CdTe and ZnTe present in the crystal.
3. Cameras - None.
4. Optics
   Optical materials, as follows:
   a. Zinc selenide (ZnSe) and zinc sulphide (ZnS) “substrate blanks” produced by the chemical vapour deposition process, having any of the following:
      1. A volume greater than 100 cm^3; **or**
      2. A diameter greater than 80 mm having a thickness of 20 mm or more;
   b. Boules of the following electro-optic materials:
      1. Potassium titanyl arsenate (KTA);
      2. Silver gallium selenide ($AgGaSe_2$);
      3. Thallium arsenic selenide (Tl_3AsSe_3, also known as TAS);
   c. Non-linear optical materials, having all of the following:
      1. Third order susceptibility (chi 3) of 10^{-6} m^2/V^2 or more; **and**
      2. A response time of less than 1 ms;
   d. “Substrate blanks” of silicon carbide or beryllium beryllium (Be/Be) deposited materials exceeding 300 mm in diameter or major axis length;
   e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride (ZrF_4) and hafnium fluoride (HfF_4), having all of the following:
      1. A hydroxyl ion (OH-) concentration of less than 5 ppm;
      2. Integrated metallic purity levels of less than 1 ppm; and
      3. High homogeneity (index of refraction variance) less than 5 x 10^{-6};
   f. Synthetically produced diamond material with an absorption of less than 10^{-5} cm^{-1} for wavelengths exceeding 200 nm but not exceeding 14,000 nm.
5. Lasers
   Synthetic crystalline “laser” host material in unfinished form, as follows:
   a. Titanium doped sapphire;
   b. Alexandrite.
6. Magnetic and Electric Field Sensors - None.
7. Gravimeters - None.
8. Radar - None.

1-6.D. Software

1. “Software” specially designed for the “development” or “production” of equipment controlled by 1-6.A.4., 1-6.A.5., 1-6.A.8. or 1-6.B.8.
2. “Software” specially designed for the “use” of equipment controlled by 1-6.A.2.b., 1-6.A.8. or 1-6.B.8.
3. Other “software”, as follows:
   a. Acoustics
      “Software”, as follows:
      1. “Software” specially designed for acoustic beam forming for the “real time processing” of acoustic data for passive reception using towed hydrophone arrays;
      2. “Source code” for the “real time processing” of acoustic data for passive reception using towed hydrophone arrays;
      3. “Software” specially designed for acoustic beam forming for the “real time processing” of acoustic data for passive reception using bottom or bay cable systems;
      4. “Source code” for the “real time processing” of acoustic data for passive reception using bottom or bay cable systems;
   b. Optical Sensors - None.
   c. Cameras - None.
   d. Optics - None.
   e. Lasers - None.
   f. Magnetic and Electric Field Sensors
      “Software”, as follows:
      1. “Software” specially designed for magnetic and electric field “compensation systems” for magnetic sensors designed to operate on mobile platforms;
      2. “Software” specially designed for magnetic and electric field anomaly detection on mobile platforms;
   g. Gravimeters
      “Software” specially designed to correct motional influences of gravity meters or gravity gradiometers;
   h. Radar
      “Software”, as follows:
      1. Air Traffic Control “software” application “programmes” hosted on general purpose computers located at Air Traffic Control centres and capable of any of the following:
         a. Processing and displaying more than 150 simultaneous “system tracks”; **or**
         b. Accepting radar target data from more than four primary radars;
      2. “Software” for the design or “production” of radomes which:

a. Are specially designed to protect the "electronically steerable phased array antennae" controlled by 1-6.A.8.e.; **and**
b. Result in an antenna pattern having an 'average side lobe level' more than 40 dB below the peak of the main beam level.

Technical Note:
'Average side lobe level' in 1-6.D.3.h.2.b. is measured over the entire array excluding the angular extent of the main beam and the first two side lobes on either side of the main beam.

1-6.E. Technology

1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" controlled by 1-6.A., 1-6.B., 1-6.C. or 1-6.D.
2. "Technology" according to the General Technology Note for the "production" of equipment or materials controlled by 1-6.A., 1-6.B. or 1-6.C.
3. Other "technology", as follows:
   a. Acoustics - None.
   b. Optical Sensors - None.
   c. Cameras - None.
   d. Optics
      "Technology", as follows:
      1. Optical surface coating and treatment "technology" "required" to achieve uniformity of 99.5% or better for optical coatings 500 mm or more in diameter or major axis length and with a total loss (absorption and scatter) of less than 5 x 10^{-3};

         N.B.:
         See also 1-2.E.3.f.

      2. Optical fabrication "technology" using single point diamond turning techniques to produce surface finish accuracies of better than 10 nm rms on non-planar surfaces exceeding 0.5 m^2;
   e. Lasers
      "Technology" "required" for the "development", "production" or "use" of specially designed diagnostic instruments or targets in test facilities for "SHPL" testing or testing or evaluation of materials irradiated by "SHPL" beams;
   f. Magnetic and Electric Field Sensors - Deleted.
   g. Gravimeters - None.
   h. Radar - None.

Category 7: Navigation and Avionics

1-7.A. Systems, Equipment and Components

N.B.:
For automatic pilots for underwater vehicles, see Category 8.
For radar, see Category 6.

1. Accelerometers, as follows, and specially designed components therefor:
   a. Linear accelerometers having any of the following:
      1. Specified to function at linear acceleration levels less than or equal to 15 g, and having any of the following:
         a. A "bias" "stability" of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year; **or**
         b. A "scale factor" "stability" of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year;
      2. Specified to function at linear acceleration levels exceeding 15 g, and having all of the following:
         a. A "bias" "repeatability" of less (better) than 5,000 micro g over a period of one year; **and**
         b. A "scale factor" "repeatability" of less (better) than 2,500 ppm over a period of one year; **or**
      3. Designed for use in inertial navigation or guidance systems and specified to function at linear acceleration levels exceeding 100 g.

      N.B.:
      For angular or rotational accelerometers, see 1-7.A.1.b.

   b. Angular or rotational accelerometers specified to function at linear acceleration levels exceeding 100 g.
2. Gyros or angular rate sensors, having any of the following characteristics, and specially designed components therefor:

   N.B.:
   For angular or rotational accelerometers, see 1-7.A.1.b.

   a. A "drift rate" "stability", when measured in a 1 g environment over a period of one month, and with respect to a fixed calibration value of less (better) than 0.5 degree per hour when specified to function at linear acceleration levels up to and including 100 g;
   b. An "angle random walk" of less (better) than or equal to 0.0035 degree per square root hour; **or**

      Note:
      1-7.A.2.b. does not control spinning mass gyros (spinning mass gyros are gyros which use a continually rotating mass to sense angular motion).

   c. A rate range greater than or equal to 500 degrees per second and having any of the following:
      1. A "drift rate" "stability", when measured in a 1 g environment over a period of three minutes, and with respect to a fixed calibration value of less (better) than 40 degrees per hour; **or**
      2. An "angle random walk" of less (better) than or equal to 0.2 degree per square root hour; or
   d. Specified to function at linear acceleration levels exceeding 100 g.
3. Inertial Systems and specially designed components, as follows:
   a. Inertial Navigation Systems (INS) (gimballed or strapdown) and inertial equipment designed for "aircraft", land vehicles, vessels (surface or underwater) or "spacecraft", for attitude, guidance or control, having any of the following characteristics, and specially designed components therefor:
      1. Navigation error (free inertial) subsequent to normal alignment of 0.8 nautical mile per hour (nm/hr) Circular Error Probable (CEP) or less (better); **or**
      2. Specified to function at linear acceleration levels exceeding 10 g.

b. Hybrid Inertial Navigation Systems embedded with Global Navigation Satellite System(s) (GNSS) or with "Data-Based Referenced Navigation" ("DBRN") System(s) for attitude, guidance or control, subsequent to normal alignment, having an INS navigation position accuracy, after loss of GNSS or "DBRN" for a period of up to 4 minutes, of less (better) than 10 meters CEP.
c. Inertial Equipment for Azimuth, Heading, or North Pointing having any of the following characteristics, and specially designed components therefor:
   1. Designed to have an Azimuth, Heading, or North Pointing accuracy equal to, or less (better) than 6 arc minutes RMS at 45 degrees latitude; **or**
   2. Designed to have a non-operating shock level of 900 g or greater at a duration of 1-msec, or greater.
d. Inertial measurement equipment including Inertial Measurement Units (IMU) and Inertial Reference Systems (IRS), incorporating accelerometers or gyros controlled by 1-7.A.1. or 1-7.A.2., and specially designed components therefor.

Note 1:
The parameters of 1-7.A.3.a. and 1-7.A.3.b. are applicable with any of the following environmental conditions:
1. Input random vibration with an overall magnitude of 7.7 g rms in the first half hour and a total test duration of one and one half hour per axis in each of the three perpendicular axes, when the random vibration meets the following:
   a. A constant power spectral density (PSD) value of 0.04 g^2/Hz over a frequency interval of 15 to 1,000 Hz; **and**
   b. The PSD attenuates with frequency from 0.04 g^2/Hz to 0.01 g^2/Hz over a frequency interval from 1,000 to 2,000 Hz;
2. A roll and yaw rate of equal to or more than +2.62 rad (radians)/s (150 deg/s); **or**
3. According to national standards equivalent to 1. or 2. above.

Note 2:
1-7.A.3. does not control inertial navigation systems which are certified for use on "civil aircraft" by civil authorities of a participating state.

Note 3:
1-7.A.3.c.1. does not control theodolite systems incorporating inertial equipment specially designed for civil surveying purposes.

Technical Notes:
1. 1-7.A.3.b. refers to systems in which an INS and other independent navigation aids are built into a single unit (embedded) in order to achieve improved performance.
2. 'Circular Error Probable' ('CEP') - In a circular normal distribution, the radius of the circle containing 50 percent of the individual measurements being made, or the radius of the circle within which there is a 50 percent probability of being located.

4. Gyro-astro compasses, and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, with an azimuth accuracy of equal to or less (better) than 5 seconds of arc.
5. Global navigation satellite systems (i.e., GPS or GLONASS) receiving equipment having any of the following characteristics, and specially designed components therefor:
   a. Employing decryption; **or**
   b. A null-steerable antenna.
6. Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz inclusive, having any of the following characteristics:
   a. "Power management"; **or**
   b. Using phase shift key modulation.
7. Deleted.
8. Underwater sonar navigation systems, using Doppler velocity or correlation velocity logs integrated with a heading source, having a positioning accuracy of equal to or less (better) than 3% of distance travelled Circular Error Probable (CEP), and specially designed components therefor.

Note:
1-7.A.8. does not control systems specially designed for installation on surface vessels or systems requiring acoustic beacons or buoys to provide positioning data.

N.B.:
See Category 1-6.A.1.a. for acoustic systems, and 1-6.A.1.b. for correlation-velocity sonar log equipment. See Category 1-8.A.2. for other marine systems.

1-7.B. Test, Inspection and Production Equipment

1. Test, calibration or alignment equipment specially designed for equipment controlled by 1-7.A.

Note:
1-7.B.1. does not control test, calibration or alignment equipment for Maintenance Level I or Maintenance Level II.

Technical Notes:
1. Maintenance Level I
   The failure of an inertial navigation unit is detected on the aircraft by indications from the control and display unit (CDU) or by the status message from the corresponding sub-system. By following the manufacturer's manual, the cause of the failure may be localised at the level of the malfunctioning line replaceable unit (LRU). The operator then removes the LRU and replaces it with a spare.
2. Maintenance Level II
   The defective LRU is sent to the maintenance workshop (the manufacturer's or that of the operator responsible for level II maintenance). At the maintenance workshop, the malfunctioning LRU is tested by various appropriate means to verify and localise the defective shop replaceable assembly (SRA) module responsible for the failure. This SRA is removed and replaced by an operative spare. The defective SRA (or possibly the complete LRU) is then shipped to the manufacturer. Maintenance Level II does not include the removal of controlled accelerometers or gyro sensors from the SRA.

2. Equipment, as follows, specially designed to characterize mirrors for ring "laser" gyros:
   a. Scatterometers having a measurement accuracy of 10 ppm or less (better);
   b. Profilometers having a measurement accuracy of 0.5 nm (5 angstrom) or less (better).
3. Equipment specially designed for the "production" of equipment controlled by 1-7.A.

Note:
1-7.B.3. includes:
a. Gyro tuning test stations;
b. Gyro dynamic balance stations;
c. Gyro run-in/motor test stations;
d. Gyro evacuation and fill stations;
e. Centrifuge fixtures for gyro bearings;
f. Accelerometer axis align stations;
g. Fibre optic gyro coil winding machines.

1-7. C. Materials

None.

1-7.D. Software

1. "Software" specially designed or modified for the "development" or "production" of equipment controlled by 1-7.A. or 1-7.B.
2. "Source code" for the "use" of any inertial navigation equipment, including inertial equipment not controlled by 1-7.A.3. or 1-7.A.4., or Attitude and Heading Reference Systems (AHRS).

   Note:
   1-7.D.2. does not control "source code" for the "use" of gimballed AHRS.

   Technical Note:
   AHRS generally differ from inertial navigation systems (INS) in that an AHRS provides attitude and heading information and normally does not provide the acceleration, velocity and position information associated with an INS.

3. Other "software", as follows:
   a. "Software" specially designed or modified to improve the operational performance or reduce the navigational error of systems to the levels specified in 1-7.A.3., 1-7.A.4. or 1-7.A.8.
   b. "Source code" for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified in 1-7.A.3. or 1-7.A.8. by continuously combining heading data with any of the following:
      1. Doppler radar or sonar velocity data;
      2. Global navigation satellite systems (i.e., GPS or GLONASS) reference data; **or**
      3. Data from "Data-Based Referenced Navigation" ("DBRN") systems;
   c. "Source code" for integrated avionics or mission systems which combine sensor data and employ "expert systems";
   d. "Source code" for the "development" of any of the following:
      1. Digital flight management systems for "total control of flight";
      2. Integrated propulsion and flight control systems;
      3. Fly-by-wire or fly-by-light control systems;
      4. Fault-tolerant or self-reconfiguring "active flight control systems";
      5. Airborne automatic direction finding equipment;
      6. Air data systems based on surface static data; or
      7. Raster-type head-up displays or three dimensional displays;
   e. Computer-aided-design (CAD) "software" specially designed for the "development" of "active flight control systems", helicopter multi-axis fly-by-wire or fly-by-light controllers or helicopter "circulation controlled anti-torque or circulation-controlled direction control systems" whose "technology" is controlled in 1-7.E.4.b., 1-7.E.4.c.1. or 1-7.E.4.c.2.

1-7.E. Technology

1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 1-7.A., 1-7.B. or 1-7.D.
2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 1-7.A. or 1-7.B.
3. "Technology" according to the General Technology Note for the repair, refurbishing or overhaul of equipment controlled by 1-7.A.1. to 1-7.A.4.

   Note:
   1-7.E.3. does not control maintenance "technology" directly associated with calibration, removal or replacement of damaged or unserviceable LRUs and SRAs of a "civil aircraft" as described in Maintenance Level I or Maintenance Level II.

   N.B.:
   See Technical Notes to 1-7.B.1.

4. Other "technology", as follows:
   a. "Technology" for the "development" or "production" of:
      1. Airborne automatic direction finding equipment operating at frequencies exceeding 5 MHz;
      2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;
      3. Raster-type head-up displays or three dimensional displays for "aircraft";
      4. Inertial navigation systems or gyro-astro compasses containing accelerometers or gyros controlled by 1-7.A.1. or 1-7.A.2.;
      5. Electric actuators (i.e., electromechanical, electrohydrostatic and integrated actuator package) specially designed for "primary flight control";
      6. "Flight control optical sensor array" specially designed for implementing "active flight control systems";
      7. "DBRN" systems designed to navigate underwater using sonar or gravity databases that provide a positioning accuracy equal to or less (better) than 0.4 nautical miles.
   b. "Development" "technology", as follows, for "active flight control systems" (including fly-by-wire or fly-by-light):
      1. Configuration design for interconnecting multiple microelectronic processing elements (on-board computers) to achieve "real time processing" for control law implementation;
      2. Control law compensation for sensor location or dynamic airframe loads, i.e., compensation for sensor vibration environment or for variation of sensor location from the centre of gravity;
      3. Electronic management of data redundancy or systems redundancy for fault detection, fault tolerance, fault isolation or reconfiguration;

         Note:
         1-7.E.4.b.3. does not control "technology" for the design of physical redundancy.

      4. Flight controls which permit inflight reconfiguration of force and moment controls for real time autonomous air vehicle control;
      5. Integration of digital flight control, navigation and propulsion control data into a digital flight management system for "total control of flight";

         Note:
         1-7.E.4.b.5. does not control:
         1. "Development" "technology" for integration of digital flight control, navigation and propulsion control data into a digital flight management system for "flight path optimisation";
         2. "Development" "technology" for "aircraft" flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches.

6. Full authority digital flight control or multisensor mission management systems employing "expert systems";

   N.B.:
   For "technology" for Full Authority Digital Engine Control ("FADEC"), see 1-9.E.3.a.9.

c. "Technology" for the "development" of helicopter systems, as follows:
   1. Multi-axis fly-by-wire or fly-by-light controllers which combine the functions of at least two of the following into one controlling element:
      a. Collective controls;
      b. Cyclic controls;
      c. Yaw controls;
   2. "Circulation-controlled anti-torque or circulation-controlled directional control systems";
   3. Rotor blades incorporating "variable geometry airfoils" for use in systems using individual blade control.

Category 8: Marine

1-8.A. Systems, Equipment and Components

1. Submersible vehicles and surface vessels, as follows:

   N.B.:
   For the control status of equipment for submersible vehicles, see:
   Category 5. – Part 2 "Information Security" for encrypted communication equipment;
   Category 6. for sensors;
   Categories 7. and 8. for navigation equipment;
   Category 1-8.A. for underwater equipment.

   a. Manned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m;
   b. Manned, untethered submersible vehicles, having any of the following:
      1. Designed to operate autonomously and having a lifting capacity of all the following:
         a. 10% or more of their weight in air; **and**
         b. 15 kN or more;
      2. Designed to operate at depths exceeding 1,000 m; **or**
      3. Having all of the following:
         a. Designed to carry a crew of 4 or more;
         b. Designed to operate autonomously for 10 hours or more;
         c. Having a range of 25 nautical miles or more; **and**
         d. Having a length of 21 m or less;

      Technical Notes:
      1. For the purposes of 1-8.A.1.b., operate autonomously means fully submerged, without snorkel, all systems working and cruising at minimum speed at which the submersible can safely control its depth dynamically by using its depth planes only, with no need for a support vessel or support base on the surface, sea-bed or shore, and containing a propulsion system for submerged or surface use.
      2. For the purposes of 1-8.A.1.b., range means half the maximum distance a submersible vehicle can cover.

   c. Unmanned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m, having any of the following:
      1. Designed for self-propelled manoeuvre using propulsion motors or thrusters controlled by 1-8.A.2.a.2.; **or**
      2. Having a fibre optic data link;
   d. Unmanned, untethered submersible vehicles, having any of the following:
      1. Designed for deciding a course relative to any geographical reference without real-time human assistance;
      2. Having an acoustic data or command link; **or**
      3. Having a fibre optic data or command link exceeding 1,000 m;
   e. Ocean salvage systems with a lifting capacity exceeding 5 MN for salvaging objects from depths exceeding 250 m and having any of the following:
      1. Dynamic positioning systems capable of position keeping within 20 m of a given point provided by the navigation system; **or**
      2. Seafloor navigation and navigation integration systems for depths exceeding 1,000 m with positioning accuracies to within 10 m of a predetermined point;
   f. Surface-effect vehicles (fully skirted variety) having all of the following characteristics:
      1. A maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1.25 m (Sea State 3) or more;
      2. A cushion pressure exceeding 3,830 Pa; **and**
      3. A light-ship-to-full-load displacement ratio of less than 0.70;
   g. Surface-effect vehicles (rigid sidewalls) with a maximum design speed, fully loaded, exceeding 40 knots in a significant wave height of 3.25 m (Sea State 5) or more;
   h. Hydrofoil vessels with active systems for automatically controlling foil systems, with a maximum design speed, fully loaded, of 40 knots or more in a significant wave height of 3.25 m (Sea State 5) or more;
   i. Small waterplane area vessels having any of the following:
      1. A full load displacement exceeding 500 tonnes with a maximum design speed, fully loaded, exceeding 35 knots in a significant wave height of 3.25 m (Sea State 5) or more; **or**
      2. A full load displacement exceeding 1,500 tonnes with a maximum design speed, fully loaded, exceeding 25 knots in a significant wave height of 4 m (Sea State 6) or more.

      Technical Note:
      A small waterplane area vessel is defined by the following formula: waterplane area at an operational design draft less than 2x (displaced volume at the operational design draft)$^{2/3}$.

2. Systems, equipment and components, as follows:

   N.B.:
   For underwater communications systems, see Category 5, Part 1 - Telecommunications.

   a. Systems, equipment and components, specially designed or modified for submersible vehicles, designed to operate at depths exceeding 1,000 m, as follows:
      1. Pressure housings or pressure hulls with a maximum inside chamber diameter exceeding 1.5 m;
      2. Direct current propulsion motors or thrusters;
      3. Umbilical cables, and connectors therefor, using optical fibre and having synthetic strength members;

4. Components manufactured from material specified in 1-8.C.1.

   Technical Note:
   The object of this control should not be defeated by the export of syntactic foam controlled by 1-8.C.1. when an intermediate stage of manufacture has been performed and it is not yet in its final component form.

b. Systems specially designed or modified for the automated control of the motion of submersible vehicles controlled by 1-8.A.1. using navigation data and having closed loop servo-controls:
   1. Enabling a vehicle to move within 10 m of a predetermined point in the water column;
   2. Maintaining the position of the vehicle within 10 m of a predetermined point in the water column; **or**
   3. Maintaining the position of the vehicle within 10 m while following a cable on or under the seabed;
c. Fibre optic hull penetrators or connectors;
d. Underwater vision systems, as follows:
   1. Television systems and television cameras, as follows:
      a. Television systems (comprising camera, monitoring and signal transmission equipment) having a limiting resolution when measured in air of more than 800 lines and specially designed or modified for remote operation with a submersible vehicle;
      b. Underwater television cameras having a limiting resolution when measured in air of more than 1,100 lines;
      c. Low light level television cameras specially designed or modified for underwater use containing all of the following:
         1. Image intensifier tubes controlled by 1-6.A.2.a.2.a.; **and**
         2. More than 150,000 "active pixels" per solid state area array;

      Technical Note:
      Limiting resolution in television is a measure of horizontal resolution usually expressed in terms of the maximum number of lines per picture height discriminated on a test chart, using IEEE Standard 208/1960 or any equivalent standard.

   2. Systems, specially designed or modified for remote operation with an underwater vehicle, employing techniques to minimise the effects of back scatter, including range-gated illuminators or "laser" systems;
e. Photographic still cameras specially designed or modified for underwater use below 150 m having a film format of 35 mm or larger, and having any of the following:
   1. Annotation of the film with data provided by a source external to the camera;
   2. Automatic back focal distance correction; **or**
   3. Automatic compensation control specially designed to permit an underwater camera housing to be usable at depths exceeding 1,000 m;
f. Electronic imaging systems, specially designed or modified for underwater use, capable of storing digitally more than 50 exposed images;

   Note:
   1-8.A.2.f. does not control digital cameras specially designed for consumer purposes, other than those employing electronic image multiplication techniques.

g. Light systems, as follows, specially designed or modified for underwater use:
   1. Stroboscopic light systems capable of a light output energy of more than 300 J per flash and a flash rate of more than 5 flashes per second;
   2. Argon arc light systems specially designed for use below 1,000 m;
h. "Robots" specially designed for underwater use, controlled by using a dedicated computer, having any of the following:
   1. Systems that control the "robot" using information from sensors which measure force or torque applied to an external object, distance to an external object, or tactile sense between the "robot" and an external object; **or**
   2. The ability to exert a force of 250 N or more or a torque of 250 Nm or more and using titanium based alloys or "fibrous or filamentary" "composite" materials in their structural members;
i. Remotely controlled articulated manipulators specially designed or modified for use with submersible vehicles, having any of the following:
   1. Systems which control the manipulator using the information from sensors which measure the torque or force applied to an external object, or tactile sense between the manipulator and an external object; **or**
   2. Controlled by proportional master-slave techniques or by using a dedicated computer, and having 5 degrees of freedom of movement or more;

   Note:
   Only functions having proportional control using positional feedback or by using a dedicated computer are counted when determining the number of degrees of freedom of movement.

j. Air independent power systems, specially designed for underwater use, as follows:
   1. Brayton or Rankine cycle engine air independent power systems having any of the following:
      a. Chemical scrubber or absorber systems specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;
      b. Systems specially designed to use a monoatomic gas;
      c. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; **or**
      d. Systems specially designed:
         1. To pressurise the products of reaction or for fuel reformation;
         2. To store the products of the reaction; **and**
         3. To discharge the products of the reaction against a pressure of 100 kPa or more;
   2. Diesel cycle engine air independent systems, having all of the following:
      a. Chemical scrubber or absorber systems specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;
      b. Systems specially designed to use a monoatomic gas;
      c. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; **and**

        d. Specially designed exhaust systems that do not exhaust continuously the products of combustion;
    3. Fuel cell air independent power systems with an output exceeding 2 kW having any of the following:
        a. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; **or**
        b. Systems specially designed:
            1. To pressurise the products of reaction or for fuel reformation;
            2. To store the products of the reaction; **and**
            3. To discharge the products of the reaction against a pressure of 100 kPa or more;
    4. Stirling cycle engine air independent power systems, having all of the following:
        a. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; **and**
        b. Specially designed exhaust systems which discharge the products of combustion against a pressure of 100 kPa or more;

k. Skirts, seals and fingers, having any of the following:
    1. Designed for cushion pressures of 3,830 Pa or more, operating in a significant wave height of 1.25 m (Sea State 3) or more and specially designed for surface effect vehicles (fully skirted variety) controlled by 1-8.A.1.f.; **or**
    2. Designed for cushion pressures of 6,224 Pa or more, operating in a significant wave height of 3.25 m (Sea State 5) or more and specially designed for surface effect vehicles (rigid sidewalls) controlled by 1-8.A.1.g.;

l. Lift fans rated at more than 400 kW specially designed for surface effect vehicles controlled by 1-8.A.1.f. or 1-8.A.1.g.;

m. Fully submerged subcavitating or supercavitating hydrofoils specially designed for vessels controlled by 1-8.A.1.h.;

n. Active systems specially designed or modified to control automatically the sea-induced motion of vehicles or vessels controlled by 1-8.A.1.f., 1-8.A.1.g., 1-8.A.1.h. or 1-8.A.1.i.;

o. Propellers, power transmission systems, power generation systems and noise reduction systems, as follows:
    1. Water-screw propeller or power transmission systems, as follows, specially designed for surface effect vehicles (fully skirted or rigid sidewall variety), hydrofoils or small waterplane area vessels controlled by 1-8.A.1.f., 1-8.A.1.g., 1-8.A.1.h. or 1-8.A.1.i.:
        a. Supercavitating, super-ventilated, partially-submerged or surface piercing propellers rated at more than 7.5 MW;
        b. Contrarotating propeller systems rated at more than 15 MW;
        c. Systems employing pre-swirl or post-swirl techniques for smoothing the flow into a propeller;
        d. Light-weight, high capacity (K factor exceeding 300) reduction gearing;
        e. Power transmission shaft systems, incorporating “composite” material components, capable of transmitting more than 1 MW;
    2. Water-screw propeller, power generation systems or transmission systems designed for use on vessels, as follows:
        a. Controllable-pitch propellers and hub assemblies rated at more than 30 MW;
        b. Internally liquid-cooled electric propulsion engines with a power output exceeding 2.5 MW;
        c. “Superconductive” propulsion engines, or permanent magnet electric propulsion engines, with a power output exceeding 0.1 MW;
        d. Power transmission shaft systems, incorporating “composite” material components, capable of transmitting more than 2 MW;
        e. Ventilated or base-ventilated propeller systems rated at more than 2.5 MW;
    3. Noise reduction systems designed for use on vessels of 1,000 tonnes displacement or more, as follows:
        a. Systems that attenuate underwater noise at frequencies below 500 Hz and consist of compound acoustic mounts for the acoustic isolation of diesel engines, diesel generator sets, gas turbines, gas turbine generator sets, propulsion motors or propulsion reduction gears, specially designed for sound or vibration isolation, having an intermediate mass exceeding 30% of the equipment to be mounted;
        b. Active noise reduction or cancellation systems, or magnetic bearings, specially designed for power transmission systems, and incorporating electronic control systems capable of actively reducing equipment vibration by the generation of anti-noise or anti-vibration signals directly to the source;

p. Pumpjet propulsion systems having a power output exceeding 2.5 MW using divergent nozzle and flow conditioning vane techniques to improve propulsive efficiency or reduce propulsion-generated underwater-radiated noise;

q. Self-contained, closed or semi-closed circuit (rebreathing) diving and underwater swimming apparatus.

Note:

1-8.A.2.q. does not control an individual apparatus for personal use when accompanying its user.

1-8.B. Test, Inspection and Production Equipment

1. Water tunnels, having a background noise of less than 100 dB (reference 1 μPa, 1 Hz) in the frequency range from 0 to 500 Hz, designed for measuring acoustic fields generated by a hydro-flow around propulsion system models.

1-8.C. Materials

1. Syntactic foam designed for underwater use, having all of the following:
    a. Designed for marine depths exceeding 1,000 m; **and**
    b. A density less than 561 kg/m^3.

Technical Note:

Syntactic foam consists of hollow spheres of plastic or glass embedded in a resin matrix.

N.B.:
See also 1-8.A.2.a.4.

1-8.D. Software

1. “Software” specially designed or modified for the “development”, “production” or “use” of equipment or materials controlled by 1-8.A., 1-8.B. or 1-8.C.
2. Specific “software” specially designed or modified for the “development”, “production”, repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction.

1-8.E. Technology

1. “Technology” according to the General Technology Note for the “development” or “production” of equipment or materials controlled by 1-8.A., 1-8.B. or 1-8.C.
2. Other “technology”, as follows:
   a. “Technology” for the “development”, “production”, repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction;
   b. “Technology” for the overhaul or refurbishing of equipment controlled by 1-8.A.1., 1-8.A.2.b., 1-8.A.2.j., 1-8.A.2.o. or 1-8.A.2.p.

Category 9: Aerospace and Propulsion

1-9.A. Systems, Equipment and Components

N.B.:
For propulsion systems designed or rated against neutron or transient ionizing radiation, see Group 2, the Munitions List.

1. Aero gas turbine engines having any of the following:
   a. Incorporating any of the technologies controlled by 1-9.E.3.a.; **or**

      Note:
      1-9.A.1.a. does not control aero gas turbine engines which meet all of the following:
      1. Certified by the civil aviation authority in a Participating State; **and**
      2. Intended to power non-military manned aircraft for which one of the following has been issued by a Participating State for the aircraft with this specific engine type:
         a. A civil Type Certificate; **or**
         b. An equivalent document recognised by the International Civil Aviation Organisation (ICAO).

   b. Designed to power an aircraft designed to cruise at Mach 1 or higher for more than 30 minutes.
2. Marine gas turbine engines with an ISO standard continuous power rating of 24,245 kW or more and a specific fuel consumption not exceeding 0.219 kg/kWh in the power range from 35 to 100%, and specially designed assemblies and components therefor.

   Note:
   The term ‘marine gas turbine engines’ includes those industrial, or aero-derivative, gas turbine engines adapted for a ship’s electric power generation or propulsion.
3. Specially designed assemblies and components, incorporating any of the “technologies” controlled by 1-9.E.3.a., for the following gas turbine engine propulsion systems:
   a. Controlled by 1-9.A.1.;
   b. Whose design or production origins are either non-participating states or unknown to the manufacturer.
4. Space launch vehicles and “spacecraft”.

   Note:
   1-9.A.4. does not control payloads.

   N.B.:
   For the control status of products contained in “spacecraft” payloads, see the appropriate Categories.

5. Liquid rocket propulsion systems containing any of the systems or components controlled by 1-9.A.6.
6. Systems and components specially designed for liquid rocket propulsion systems, as follows:
   a. Cryogenic refrigerators, flightweight dewars, cryogenic heat pipes or cryogenic systems specially designed for use in space vehicles and capable of restricting cryogenic fluid losses to less than 30% per year;
   b. Cryogenic containers or closed-cycle refrigeration systems capable of providing temperatures of 100 K (-173°C) or less for “aircraft” capable of sustained flight at speeds exceeding Mach 3, launch vehicles or “spacecraft”;
   c. Slush hydrogen storage or transfer systems;
   d. High pressure (exceeding 17.5 MPa) turbo pumps, pump components or their associated gas generator or expander cycle turbine drive systems;
   e. High-pressure (exceeding 10.6 MPa) thrust chambers and nozzles therefor;
   f. Propellant storage systems using the principle of capillary containment or positive expulsion (i.e., with flexible bladders);
   g. Liquid propellant injectors, with individual orifices of 0.381 mm or smaller in diameter (an area of 1.14×10^{-3} cm^2 or smaller for non-circular orifices) specially designed for liquid rocket engines;
   h. One-piece carbon-carbon thrust chambers or one-piece carbon-carbon exit cones with densities exceeding 1.4 g/cm^3 and tensile strengths exceeding 48 MPa.
7. Solid rocket propulsion systems with any of the following:
   a. Total impulse capacity exceeding 1.1 MNs;
   b. Specific impulse of 2.4 kNs/kg or more when the nozzle flow is expanded to ambient sea level conditions for an adjusted chamber pressure of 7 MPa;
   c. Stage mass fractions exceeding 88% and propellant solid loadings exceeding 86%;
   d. Any of the components controlled by 1-9.A.8.; **or**
   e. Insulation and propellant bonding systems using direct-bonded motor designs to provide a strong mechanical bond or a barrier to chemical migration between the solid propellant and case insulation material.

      Technical Note:
      For the purposes of 1-9.A.7.e., a strong mechanical bond means bond strength equal to or more than propellant strength.

8. Components, as follows, specially designed for solid rocket propulsion systems:

a. Insulation and propellant bonding systems using liners to provide a strong mechanical bond or a barrier to chemical migration between the solid propellant and case insulation material;

Technical Note:
For the purposes of 1-9.A.8.a., a strong mechanical bond means bond strength equal to or more than propellant strength.

b. Filament-wound "composite" motor cases exceeding 0.61 m in diameter or having structural efficiency ratios (PV/W) exceeding 25 km.

Technical Note:
The structural efficiency ratio (PV/W) is the burst pressure (P) multiplied by the vessel volume (V) divided by the total pressure vessel weight (W).

c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0.075 mm/s;
d. Movable nozzle or secondary fluid injection thrust vector control systems capable of any of the following:
   1. Omni-axial movement exceeding ± 5°;
   2. Angular vector rotations of 20°/s or more; **or**
   3. Angular vector accelerations of 40°/s^2 or more.

9. Hybrid rocket propulsion systems with:
   a. Total impulse capacity exceeding 1.1 MNs; **or**
   b. Thrust levels exceeding 220 kN in vacuum exit conditions.
10. Specially designed components, systems and structures for launch vehicles, launch vehicle propulsion systems or "spacecraft", as follows:
   a. Components and structures each exceeding 10 kg, specially designed for launch vehicles manufactured using metal "matrix", "composite", organic "composite", ceramic "matrix" or intermetallic reinforced materials controlled by 1-1.C.7. or 1-1.C.10.;

   Note:
   The weight cut-off is not relevant for nose cones.

   b. Components and structures specially designed for launch vehicle propulsion systems controlled by 1-9.A.5. to 1-9.A.9. manufactured using metal matrix, composite, organic composite, ceramic matrix or intermetallic reinforced materials controlled by 1-1.C.7. or 1-1.C.10.;
   c. Structural components and isolation systems specially designed to control actively the dynamic response or distortion of "spacecraft" structures;
   d. Pulsed liquid rocket engines with thrust-to-weight ratios equal to or more than 1 kN/kg and a response time (the time required to achieve 90% of total rated thrust from start-up) of less than 30 ms.
11. Ramjet, scramjet or combined cycle engines and specially designed components therefor.
12. "Unmanned Aerial Vehicles" ("UAVs"), associated systems, equipment and components as follows:
   a. "UAVs" having any of the following:
      1. An autonomous flight control and navigation capability (e.g. an autopilot with an Inertial Navigation System); or
      2. Capability of controlled flight out of the direct visual range involving a human operator (e.g., televisual remote control).
   b. Associated systems, equipment and components as follows:
      1. Equipment specially designed for remotely controlling the "UAVs" controlled by 1-9.A.12.a.;
      2. Guidance or control systems, other than those controlled in Category 7, specially designed for integration into "UAVs" controlled by 1-9.A.12.a.;
      3. Equipment and components specially designed to convert a manned "aircraft" to a "UAV" controlled by 1-9.A.12.a.

Note:
1-9.A.12. does not control model aircraft.

1-9.B. Test, Inspection and Production Equipment

1. Specially designed equipment, tooling and fixtures, as follows, for manufacturing gas turbine blades, vanes or tip shroud castings:
   a. Directional solidification or single crystal casting equipment;
   b. Ceramic cores or shells.
2. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for the "development" of gas turbine engines, assemblies or components incorporating "technologies" controlled by 1-9.E.3.a.
3. Equipment specially designed for the "production" or test of gas turbine brush seals designed to operate at tip speeds exceeding 335 m/s, and temperatures in excess of 773 K (500°C), and specially designed components or accessories therefor.
4. Tools, dies or fixtures for the solid state joining of "superalloy", titanium or intermetallic airfoil-to-disk combinations described in 1-9.E.3.a.3. or 1-9.E.3.a.6. for gas turbines.
5. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for use with any of the following wind tunnels or devices:
   a. Wind tunnels designed for speeds of Mach 1.2 or more, except those specially designed for educational purposes and having a test section size (measured laterally) of less than 250 mm;

   Technical Note:
   Test section size: the diameter of the circle, or the side of the square, or the longest side of the rectangle, at the largest test section location.

   b. Devices for simulating flow-environments at speeds exceeding Mach 5, including hot-shot tunnels, plasma arc tunnels, shock tubes, shock tunnels, gas tunnels and light gas guns; **or**
   c. Wind tunnels or devices, other than two-dimensional sections, capable of simulating Reynolds number flows exceeding 25 x 10^6.
6. Acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 μPa) with a rated output of 4 kW or more at a test cell temperature exceeding 1,273 K (1,000°C), and specially designed quartz heaters therefor.
7. Equipment specially designed for inspecting the integrity of rocket motors using non-destructive test (NDT) techniques other than planar X-ray or basic physical or chemical analysis.
8. Transducers specially designed for the direct measurement of the wall skin friction of the test flow with a stagnation temperature exceeding 833 K (560°C).

9. Tooling specially designed for producing turbine engine powder metallurgy rotor components capable of operating at stress levels of 60% of ultimate tensile strength (UTS) or more and metal temperatures of 873 K (600°C) or more.
10. Equipment specially designed for the production of "UAVs" and associated systems, equipment and components controlled by 1-9.A.12.

1-9.C. Materials

None.

1-9.D. Software

1. "Software" specially designed or modified for the "development" of equipment or "technology" controlled by 1-9.A., 1-9.B. or 1-9.E.3.
2. "Software" specially designed or modified for the "production" of equipment controlled by 1-9.A. or 1-9.B.
3. "Software" specially designed or modified for the "use" of full authority digital electronic engine controls (FADEC) for propulsion systems controlled by 1-9.A. or equipment controlled by 1-9.B., as follows:
   a. "Software" in digital electronic controls for propulsion systems, aerospace test facilities or air breathing aero-engine test facilities;
   b. Fault-tolerant "software" used in "FADEC" systems for propulsion systems and associated test facilities.
4. Other "software", as follows:
   a. 2D or 3D viscous "software" validated with wind tunnel or flight test data required for detailed engine flow modelling;
   b. "Software" for testing aero gas turbine engines, assemblies or components, specially designed to collect, reduce and analyse data in real time, and capable of feedback control, including the dynamic adjustment of test articles or test conditions, as the test is in progress;
   c. "Software" specially designed to control directional solidification or single crystal casting;
   d. "Software" in "source code", "object code" or machine code required for the "use" of active compensating systems for rotor blade tip clearance control.

      Note:
      1-9.D.4.d. does not control "software" embedded in uncontrolled equipment or required for maintenance activities associated with the calibration or repair or updates to the active compensating clearance control system.

   e. "Software" specially designed or modified for the "use" of "UAVs" and associated systems, equipment and components controlled by 1-9.A.12.
   f. "Software" specially designed to design the internal cooling passages of aero gas turbine engine blades, vanes and tip shrouds;
   g. "Software" having all of the following characteristics:
      1. Being specially designed to predict aero thermal, aeromechanical and combustion conditions in aero gas turbine engines; **and**
      2. Having theoretical modelling predictions of the aero thermal, aeromechanical and combustion conditions which have been validated with actual aero gas turbine engine (experimental or production) performance data.

1-9.E. Technology

1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 1-9.A.1.b., 1-9.A.4. to 1-9.A.12., 1-9.B. or 1-9.D.
2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 1-9.A.1.b., 1-9.A.4. to 1-9.A.11. or 1-9.B.

   N.B.:
   For "technology" for the repair of controlled structures, laminates or materials, see 1-1.E.2.f.

   Note:
   "Development" or "production" "technology" controlled by 1-9.E. for gas turbine engines remains controlled when used as "use" "technology" for repair, rebuild and overhaul. Excluded from control are: technical data, drawings or documentation for maintenance activities directly associated with calibration, removal or replacement of damaged or unserviceable line replaceable units, including replacement of whole engines or engine modules.

3. Other "technology", as follows:
   a. "Technology" "required" for the "development" or "production" of any of the following gas turbine engine components or systems:
      1. Gas turbine blades, vanes or tip shrouds made from directionally solidified (DS) or single crystal (SC) alloys having (in the 001 Miller Index Direction) a stress-rupture life exceeding 400 hours at 1,273 K (1,000°C) at a stress of 200 MPa, based on the average property values;
      2. Multiple domed combustors operating at average burner outlet temperatures exceeding 1,813 K (1,540°C) or combustors incorporating thermally decoupled combustion liners, non-metallic liners or non-metallic shells;
      3. Components manufactured from any of the following:
         a. Organic "composite" materials designed to operate above 588 K (315°C);
         b. Metal "matrix" "composite", ceramic "matrix", intermetallic or intermetallic reinforced materials controlled by 1-1.C.7.; **or**
         c. "Composite" material controlled by 1-1.C.10. and manufactured with resins controlled by 1-1.C.8.
      4. Uncooled turbine blades, vanes, tip-shrouds or other components designed to operate at gas path temperatures of 1,323 K (1,050°C) or more;
      5. Cooled turbine blades, vanes or tip-shrouds, other than those described in 1-9.E.3.a.1., exposed to gas path temperatures of 1,643 K (1,370°C) or more;
      6. Airfoil-to-disk blade combinations using solid state joining;
      7. Gas turbine engine components using "diffusion bonding" "technology" controlled by 1-2.E.3.b.;
      8. Damage tolerant gas turbine engine rotating components using powder metallurgy materials controlled by 1-1.C.2.b.;

9. "FADEC" for gas turbine and combined cycle engines and their related diagnostic components, sensors and specially designed components;
10. Adjustable flow path geometry and associated control systems for:
    a. Gas generator turbines;
    b. Fan or power turbines;
    c. Propelling nozzles; **or**

Note 1:
Adjustable flow path geometry and associated control systems in 1-9.E.3.a.10. do not include inlet guide vanes, variable pitch fans, variable stators or bleed valves for compressors.

Note 2:
1-9.E.3.a.10. does not control "development" or "production" "technology" for adjustable flow path geometry for reverse thrust.

11. Hollow fan blades;

b. "Technology" "required" for the "development" or "production" of any of the following:
    1. Wind tunnel aero-models equipped with non-intrusive sensors capable of transmitting data from the sensors to the data acquisition system; **or**
    2. "Composite" propeller blades or propfans capable of absorbing more than 2,000 kW at flight speeds exceeding Mach 0.55;

c. "Technology" "required" for the "development" or "production" of gas turbine engine components using "laser", water jet, ECM or EDM hole drilling processes to produce holes having any of the following sets of characteristics:
    1. All of the following:
        a. Depths more than four times their diameter;
        b. Diameters less than 0.76 mm; **and**
        c. Incidence angles equal to or less than 25°; **or**
    2. All of the following:
        a. Depths more than five times their diameter;
        b. Diameters less than 0.4 mm; **and**
        c. Incidence angles of more than 25°;

Technical Note:
For the purposes of 1-9.E.3.c., incidence angle is measured from a plane tangential to the airfoil surface at the point where the hole axis enters the airfoil surface.

d. "Technology" "required" for the "development" or "production" of helicopter power transfer systems or tilt rotor or tilt wing "aircraft" power transfer systems;

e. "Technology" for the "development" or "production" of reciprocating diesel engine ground vehicle propulsion systems having all of the following:
    1. A box volume of 1.2 m^3 or less;
    2. An overall power output of more than 750 kW based on 80/1269/EEC, ISO 2534 or national equivalents; **and**
    3. A power density of more than 700 kW/m^3 of box volume;

Technical Note:
Box volume: the product of three perpendicular dimensions is measured in the following way:

Length: The length of the crankshaft from front flange to flywheel face;

Width: The widest of the following:

a. The outside dimension from valve cover to valve cover;
b. The dimensions of the outside edges of the cylinder heads; **or**
c. The diameter of the flywheel housing;

Height: The largest of the following:

a. The dimension of the crankshaft centre-line to the top plane of the valve cover (or cylinder head) plus twice the stroke; **or**
b. The diameter of the flywheel housing.

f. "Technology" "required" for the "production" of specially designed components, as follows, for high output diesel engines:
    1. "Technology" "required" for the "production" of engine systems having all of the following components employing ceramics materials controlled by 1-1.C.7.:
        a. Cylinder liners;
        b. Pistons;
        c. Cylinder heads; **and**
        d. One or more other components (including exhaust ports, turbochargers, valve guides, valve assemblies or insulated fuel injectors);
    2. "Technology" "required" for the "production" of turbocharger systems, with single-stage compressors having all of the following:
        a. Operating at pressure ratios of 4:1 or higher;
        b. A mass flow in the range from 30 to 130 kg per minute; **and**
        c. Variable flow area capability within the compressor or turbine sections;
    3. "Technology" "required" for the "production" of fuel injection systems with a specially designed multifuel (e.g., diesel or jet fuel) capability covering a viscosity range from diesel fuel (2.5 cSt at 310.8 K (37.8°C)) down to gasoline fuel (0.5 cSt at 310.8 K (37.8°C)), having both of the following:
        a. Injection amount in excess of 230 mm^3 per injection per cylinder; **and**
        b. Specially designed electronic control features for switching governor characteristics automatically depending on fuel property to provide the same torque characteristics by using the appropriate sensors;

g. "Technology" "required" for the "development" or "production" of high output diesel engines for solid, gas phase or liquid film (or combinations thereof) cylinder wall lubrication, permitting operation to temperatures exceeding 723 K (450°C), measured on the cylinder wall at the top limit of travel of the top ring of the piston.

Technical Note:
High output diesel engines: diesel engines with a specified brake mean effective pressure of 1.8 MPa or more at a speed of 2,300 r.p.m., provided the rated speed is 2,300 r.p.m. or more.

Group 2 - Munitions List

Note 1:
Terms in “quotations” are defined terms. Refer to ‘Definitions of Terms used in these Lists’ annexed to this List. References to the “Dual-Use List” and “Munitions List” within Groups 1 and 2 refer to the “Group 1 – Dual-Use List” and the “Group 2 – Munitions List” respectively.
Note 2:
Chemicals are listed by name and CAS number. Chemicals of the same structural formula (including hydrates) are controlled regardless of name or CAS number. CAS numbers are shown to assist in identifying whether a particular chemical or mixture is controlled, irrespective of nomenclature. CAS numbers cannot be used as unique identifiers because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.

2-1. Smooth-bore weapons with a calibre of less than 20 mm, other arms and automatic weapons with a calibre of 12.7 mm (calibre 0.50 inches) or less and accessories, as follows, and specially designed components therefor:

(All destinations)

a. Rifles, carbines, revolvers, pistols, machine pistols and machine guns;
b. Smooth-bore weapons;
c. Weapons using caseless ammunition;
d. Silencers, special gun-mountings, clips, weapons sights and flash suppressors for arms controlled by sub-items 2-1.a., 2-1.b. or 2-1.c.
e. Other firearms as defined by the *Criminal Code*, as follows:
1. Any firearm capable of discharging a dart or other object carrying an electrical current or substance, including the firearm of the design commonly known as the Taser Public Defender and any variant or modified version of it as set out in Part I of the Schedule to the *Regulations Prescribing Certain Firearms and other Weapons, Components and Parts of Weapons, Accessories, Cartridge Magazines, Ammunition and Projectiles as Prohibited or Restricted*;
2. Firearms, not specified by 2-1.a., 2-1.b., 2-1.c. or 2-1.e.1., designed to discharge a projectile at a muzzle velocity exceeding 152.4 m/s or at a muzzle energy exceeding 5.7 Joules.

Note:
2-1. does not control the following:
1. Firearms specially designed for dummy ammunition and which are incapable of firing, or being modified to fire, any controlled ammunition;
2. Weapons deemed not to be firearms under the *Criminal Code* §84.3, as follows:
   a. Antique firearms;
   b. Those that are designed exclusively for firing stud cartridges, explosive-driven rivets or other industrial projectiles;
   c. Those that are designed exclusively for the slaughtering of domestic animals or the tranquilizing of animals.
3. Reproductions of flintlock, wheelock and matchlock muskets, rifles and carbines.
4. Optical weapon sights without electronic image processing, with a magnification of 4 times or less, provided they are not specially designed or modified for military use.

2-2. Smooth-bore weapons with a calibre of 20 mm or more, other weapons or armament with a calibre greater than 12.7 mm (calibre 0.50 inches), projectors and accessories, as follows, and specially designed components therefor:

a. Guns, howitzers, cannon, mortars, anti-tank weapons, projectile launchers, military flame throwers, rifles, recoilless rifles, smooth-bore weapons and signature reduction devices therefor;
(All destinations)
Note 1:
2-2.a. includes injectors, metering devices, storage tanks and other specially designed components for use with liquid propelling charges for any of the equipment controlled by 2-2.a.
Note 2:
2-2.a. does not control the following:
1. Antique firearms as defined by the Criminal Code;
2. Reproductions of flintlock, whealock and matchlock muskets, rifles and carbines.

b. Military smoke, gas and pyrotechnic projectors or generators.
(All destinations)
Note:
2-2.b. does not control signal pistols.

c. Weapons sights.

2-3. Ammunition and fuze setting devices, as follows, and specially designed components therefor:

(All destinations)

a. Ammunition for the weapons controlled by 2-1., 2-2. or 2-12.;
b. Fuze setting devices specially designed for ammunition controlled by 2-3.a.

Note 1:
Specially designed components include:
a. Metal or plastic fabrications such as primer anvils, bullet cups, cartridge links, rotating bands and munitions metal parts;
b. Safing and arming devices, fuses, sensors and initiation devices ;
c. Power supplies with high one-time operational output;
d. Combustible cases for charges;
e. Submunitions including bomblets, minelets and terminally guided projectiles.

Note 2:
2-3.a. does not control ammunition crimped without a projectile (blank star) and dummy ammunition with a pierced powder chamber.
Note 3:
2-3.a. does not control cartridges specially designed for any of the following purposes:
a. Signalling;
b. Bird scaring; **or**
c. Lighting of gas flares at oil wells.

2-4. Bombs, torpedoes, rockets, missiles, other explosive devices and charges and related equipment and accessories, as follows, specially designed for military use, and specially designed components therefor:

N.B.:
For guidance and navigation equipment, see 2-11., Note 7.

a. Bombs, torpedoes, grenades, smoke canisters, rockets, mines, missiles, depth charges, demolition-charges, demolition-devices and demolition-kits, “pyrotechnic” devices, cartridges and simulators (i.e. equipment simulating the characteristics of any of these items);
(All destinations)
Note:
2-4.a. includes:
1. Smoke grenades, fire bombs, incendiary bombs and explosive devices;
2. Missile rocket nozzles and re-entry vehicle nosetips.

b. Equipment specially designed for the handling, control, activation, powering with one-time operational output, launching, laying, sweeping, discharging, decoying, jamming, detonation or detection of items controlled by 2-4.a.
Note:
2-4.b. includes:
1. Mobile gas liquefying equipment capable of producing 1,000 kg or more per day of gas in liquid form;
2. Buoyant electric conducting cable suitable for sweeping magnetic mines.

Technical Note:
Hand-held devices, limited by design solely to the detection of metal objects and incapable of distinguishing between mines and other metal objects, are not considered to be specially designed for the detection of items controlled by 2-4.a.

2-5. Fire control, and related alerting and warning equipment, and related systems, test and alignment and countermeasure equipment, as follows, specially designed for military use, and specially designed components and accessories therefor:

a. Weapon sights, bombing computers, gun laying equipment and weapon control systems;
b. Target acquisition, designation, range-finding, surveillance or tracking systems; detection, data fusion, recognition or identification equipment; and sensor integration equipment;
c. Countermeasure equipment for items controlled by 2-5.a. or 2-5.b.;
d. Field test or alignment equipment, specially designed for items controlled by 2-5.a. or 2-5.b.

2-6. Ground vehicles and components, as follows:

N.B.:
For guidance and navigation equipment, see 2-11., Note 7.

a. Ground vehicles and components therefor, specially designed or modified for military use;
Technical Note:
For the purposes of 2-6.a. the term ground vehicles includes trailers.

b. All wheel-drive vehicles capable of off-road use which have been manufactured or fitted with materials to provide ballistic protection to level III (NIJ 0108.01, September 1985, or comparable national standard) or better.
N.B.:
See also 2-13.a.
Note 1:
2-6.a. includes:
a. Tanks and other military armed vehicles and military vehicles fitted with mountings for arms or equipment for mine laying or the launching of munitions controlled under 2-4.;
b. Armoured vehicles;
c. Amphibious and deep water fording vehicles;
d. Recovery vehicles and vehicles for towing or transporting ammunition or weapon systems and associated load handling equipment.

Note 2:
Modification of a ground vehicle for military use controlled by 2-6.a. entails a structural, electrical or mechanical change involving one or more specially designed military components. Such components include:
a. Pneumatic tyre casings of a kind specially designed to be bullet-proof or to run when deflated;
b. Tyre inflation pressure control systems, operated from inside a moving vehicle;
c. Armoured protection of vital parts, (e.g., fuel tanks or vehicle cabs);
d. Special reinforcements or mountings for weapons;
e. Black-out lighting.

Note 3:
2-6. does not control civil automobiles, or trucks designed or modified for transporting money or valuables, having armoured or ballistic protection.

2-7. Chemical or biological toxic agents, “riot control agents”, radioactive materials, related equipment, components, and materials, as follows:

a. Biological agents and radioactive materials “adapted for use in war” to produce casualties in humans or animals, degrade equipment or damage crops or the environment;
b. Chemical warfare (CW) agents including:
   1. CW nerve agents:
      a. O-Alkyl (equal to or less than C_{10}, including cycloalkyl) alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) - phosphonofluoridates, such as:
      Sarin (GB):O-Isopropyl methylphosphonofluoridate (CAS 107-44-8); **and**
      Soman (GD):O-Pinacolyl methylphosphonofluoridate (CAS 96-64-0);
      b. O-Alkyl (equal to or less than C_{10}, including cycloalkyl) N,N-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphoramidocyanidates, such as:
      Tabun (GA):O-Ethyl N,N-dimethylphosphoramidocyanidate (CAS 77-81-6);
      c. O-Alkyl (H or equal to or less than C_{10}, including cycloalkyl) S-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl)-aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonothiolates and corresponding alkylated and protonated salts, such as:
      VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate (CAS 50782-69-9);
   2. CW vesicant agents:
      a. Sulphur mustards, such as:
         1. 2-Chloroethylchloromethylsulphide (CAS 2625-76-5);
         2. Bis(2-chloroethyl) sulphide (CAS 505-60-2);
         3. Bis(2-chloroethylthio) methane (CAS 63869-13-6);
         4. 1,2-bis (2-chloroethylthio) ethane (CAS 3563-36-8);
         5. 1,3-bis (2-chloroethylthio) -n-propane (CAS 63905-10-2);
         6. 1,4-bis (2-chloroethylthio) -n-butane (CAS 142868-93-7) ;
         7. 1,5-bis (2-chloroethylthio) -n-pentane (CAS 142868-94-8);

8. Bis (2-chloroethylthiomethyl) ether (CAS 63918-90-1);
9. Bis (2-chloroethylthioethyl) ether (CAS 63918-89-8);

b. Lewisites, such as:
1. 2-chlorovinyldichloroarsine (CAS 541-25-3);
2. Tris (2-chlorovinyl) arsine (CAS 40334-70-1);
3. Bis (2-chlorovinyl) chloroarsine (CAS 40334-69-8);

c. Nitrogen mustards, such as:
1. HN1: bis (2-chloroethyl) ethylamine (CAS 538-07-8);
2. HN2: bis (2-chloroethyl) methylamine (CAS 51-75-2);
3. HN3: tris (2-chloroethyl) amine (CAS 555-77-1);

3. CW incapacitating agents, such as:
a. 3-Quinuclidinyl benzilate (BZ) (CAS 6581-06-2);

4. CW defoliants, such as:
a. Butyl 2-chloro-4-fluorophenoxyacetate (LNF);
b. 2,4,5-trichlorophenoxyacetic acid mixed with 2,4-dichlorophenoxyacetic acid (Agent Orange).

c. CW binary precursors and key precursors, as follows:
1. Alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) Phosphonyl Difluorides, such as: DF: Methyl Phosphonyldifluoride (CAS 676-99-3);
2. O-Alkyl (H or equal to or less than C_{10}, including cycloalkyl) O-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl) aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonites and corresponding alkylated and protonated salts, such as:
QL: O-Ethyl-2-di-isopropylaminoethyl methylphosphonite (CAS 57856-11-8);
3. Chlorosarin: O-Isopropyl methylphosphonochloridate (CAS 1445-76-7);
4. Chlorosoman: O-Pinacolyl methylphosphonochloridate (CAS 7040-57-5);

d. "Riot control agents", active constituent chemicals and combinations thereof, including:
1. -Bromobenzeneacetonitrile, (Bromobenzyl cyanide) (CA) (CAS 5798-79-8);
2. [(2-chlorophenyl) methylene] propanedinitrile, (o-Chlorobenzylidenemalononitrile) (CS) (CAS 2698-41-1);
3. 2-Chloro-1-phenylethanone, Phenylacyl chloride (-chloroacetophenone) (CN) (CAS 532-27-4);
4. Dibenz-(b,f)-1,4-oxazephine, (CR) (CAS 257-07-8);
5. 10-Chloro-5,10-dihydrophenarsazine, (Phenarsazine chloride), (Adamsite), (DM) (CAS 578-94-9);
6. N-Nonanoylmorpholine, (MPA) (CAS 5299-64-9);

Note 1:
2-7.d. does not control "riot control agents" individually packaged for personal self defence purposes.

Note 2:
2-7.d. does not control active constituent chemicals, and combinations thereof identified and packaged for food production or medical purposes.

e. Equipment specially designed or modified for military use, for the dissemination of any of the following and specially designed components therefor:
1. Materials or agents controlled by 2-7.a., 2-7.b. or 2-7.d.; **or**
2. CW made up of precursors controlled by 2-7.c.

f. Protective and decontamination equipment, specially designed components therefor, and specially formulated chemical mixtures, as follows:
1. Equipment, specially designed or modified for military use, for defence against materials controlled by 2-7.a., 2-7.b. or 2-7.d. and specially designed components therefor;
2. Equipment, specially designed or modified for military use, for the decontamination of objects contaminated with materials controlled by 2-7.a. or 2-7.b. and specially designed components therefor;
3. Chemical mixtures specially developed/formulated for the decontamination of objects contaminated with materials controlled by 2-7.a. or 2-7.b.;

Note:
2-7.f.1. includes:
a. Air conditioning units specially designed or modified for nuclear, biological or chemical filtration;
b. Protective clothing.

N.B.:
For civil gas masks, protective and decontamination equipment see, also entry 1-1.A.4. on the Dual-Use List.

g. Equipment, specially designed or modified for military use, for the detection or identification of materials controlled by 2-7.a., 2-7.b. or 2-7.d. and specially designed components therefor;

Note:
2-7.g. does not control personal radiation monitoring dosimeters.

N.B.:
See also entry 1-1.A.4. on the Dual-Use List.

h. "Biopolymers" specially designed or processed for the detection or identification of CW agents controlled by 2-7.b., and the cultures of specific cells used to produce them;

i. "Biocatalysts" for the decontamination or degradation of CW agents, and biological systems therefor, as follows:
1. "Biocatalysts" specially designed for the decontamination or degradation of CW agents controlled by 2-7.b. resulting from directed laboratory selection or genetic manipulation of biological systems;
2. Biological systems, as follows: "expression vectors", viruses or cultures of cells containing the genetic information specific to the production of "biocatalysts" controlled by 2-7.i.1.

Note 1:
2-7.b. and 2-7.d. do not control:
a. Cyanogen chloride (CAS 506-77-4);
b. Hydrocyanic acid (CAS 74-90-8);
c. Chlorine (CAS 7782-50-5);
d. Carbonyl chloride (phosgene) (CAS 75-44-5);
e. Diphosgene (trichloromethyl-chloroformate) (CAS 503-38-8);
f. Deleted;
g. Xylyl bromide, ortho: (CAS 89-92-9), meta: (CAS 620-13-3), para: (CAS 104-81-4);
h. Benzyl bromide (CAS 100-39-0);
i. Benzyl iodide (CAS 620-05-3);
j. Bromo acetone (CAS 598-31-2);
k. Cyanogen bromide (CAS 506-68-3);
l. Bromo methylethylketone (CAS 816-40-0);
m. Chloro acetone (CAS 78-95-5);
n. Ethyl iodoacetate (CAS 623-48-3);
o. Iodo acetone (CAS 3019-04-3);
p. Chloropicrin (CAS 76-06-2).

Note 2:
The cultures of cells and biological systems listed in 2-7.h. and 2-7.i.2. are exclusive and these sub-items do not control cells or biological systems for civil purposes, such as agricultural, pharmaceutical, medical, veterinary, environmental, waste management, or in the food industry.

2-8. "Energetic materials", and related substances, as follows:

N.B.:
See also 1-1.C.11. on the Dual-Use List

Technical Notes:

1. For the purposes of this entry, mixture refers to a composition of two or more substances with at least one substance being listed in the 2-8. sub-items.
2. Any substance listed in the 2-8. sub-items is controlled by this list, even when utilized in an application other than that indicated. (e.g., TAGN is predominantly used as an explosive but can also be used either as a fuel or an oxidizer.)

a. "Explosives", as follows, and mixtures thereof:
   1. ADNBF (aminodinitrobenzofuroxan or 7-amino-4,6-dinitrobenzofurazane-1-oxide) (CAS 97096-78-1);
   2. BNCP (cis-bis (5-nitrotetrazolato) tetra amine-cobalt (III) perchlorate) (CAS 117412-28-9);
   3. CL-14 (diamino dinitrobenzofuroxan or 5,7-diamino-4,6-dinitrobenzofurazane-1-oxide) (CAS 117907-74-1);
   4. CL-20 (HNIW or Hexanitrohexaazaisowurtzitane) (CAS 135285-90-4); chlathrates of CL-20 (see also 2-8.g.3. and 2-8.g.4. for its "precursors");
   5. CP (2-(5-cyanotetrazolato) penta amine-cobalt (III) perchlorate) (CAS 70247-32-4);
   6. DADE (1,1-diamino-2,2-dinitroethylene, FOX7);
   7. DATB (diaminotrinitrobenzene) (CAS 1630-08-6);
   8. DDFP (1,4-dinitrodifurazanopiperazine);
   9. DDPO (2,6-diamino-3,5-dinitropyrazine-1-oxide, PZO) (CAS 194486-77-6);
   10. DIPAM (3,3'-diamino-2,2',4,4',6,6'-hexanitrobiphenyl or dipicramide) (CAS 17215-44-0);
   11. DNGU (DINGU or dinitroglycoluril) (CAS 55510-04-8);
   12. Furazans, as follows:
       a. DAAOF (diaminoazoxyfurazan);
       b. DAAzF (diaminoazofurazan) (CAS 78644-90-3);
   13. HMX and derivatives (see also 2-8.g.5. for its "precursors"), as follows:
       a. HMX (Cyclotetramethylenetetranitramine, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazine, 1,3,5,7-tetranitro-1,3,5,7-tetraza-cyclooctane, octogen or octogene) (CAS 2691-41-0);
       b. difluoroaminated analogs of HMX;
       c. K-55 (2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo [3,3,0]-octanone-3, tetranitrosemiglycouril or keto-bicyclic HMX) (CAS 130256-72-3);
   14. HNAD (hexanitroadamantane) (CAS 143850-71-9);
   15. HNS (hexanitrostilbene) (CAS 20062-22-0);
   16. Imidazoles, as follows:
       a. BNNII (Octahydro-2,5-bis(nitroimino)imidazo [4,5-d]imidazole);
       b. DNI (2,4-dinitroimidazole) (CAS 5213-49-0);
       c. FDIA (1-fluoro-2,4-dinitroimidazole);
       d. NTDNIA (N-(2-nitrotriazolo)-2,4-dinitroimidazole);
       e. PTIA (1-picryl-2,4,5-trinitroimidazole);
   17. NTNMH (1-(2-nitrotriazolo)-2-dinitromethylene hydrazine);
   18. NTO (ONTA or 3-nitro-1,2,4-triazol-5-one) (CAS 932-64-9);
   19. Polynitrocubanes with more than four nitro groups;
   20. PYX (2,6-Bis(picrylamino)-3,5-dinitropyridine) (CAS 38082-89-2);
   21. RDX and derivatives, as follows:
       a. RDX (cyclotrimethylenetrinitramine, cyclonite, T4, hexahydro-1,3,5-trinitro-1,3,5-triazine, 1,3,5-trinitro-1,3,5-triaza-cyclohexane, hexogen or hexogene) (CAS 121-82-4);
       b. Keto-RDX (K-6 or 2,4,6-trinitro-2,4,6-triazacyclohexanone) (CAS 115029-35-1);
   22. TAGN (triaminoguanidinenitrate) (CAS 4000-16-2);
   23. TATB (triaminotrinitrobenzene) (CAS 3058-38-6) (see also 2-8.g.7. for its "precursors");
   24. TEDDZ (3,3,7,7-tetrabis(difluoroamine) octahydro-1,5-dinitro-1,5-diazocine);
   25. Tetrazoles, as follows:
       a. NTAT (nitrotriazol aminotetrazole);
       b. NTNT (1-N-(2-nitrotriazolo)-4-nitrotetrazole);
   26. Tetryl (trinitrophenylmethylnitramine) (CAS 479-45-8);
   27. TNAD (1,4,5,8-tetranitro-1,4,5,8-tetraazadecalin) (CAS 135877-16-6) (see also 2-8.g.6. for its "precursors");
   28. TNAZ (1,3,3-trinitroazetidine) (CAS 97645-24-4) (see also 2-8.g.2. for its "precursors");
   29. TNGU (SORGUYL or tetranitroglycoluril) (CAS 55510-03-7);
   30. TNP (1,4,5,8-tetranitro-pyridazino[4,5-d]pyridazine) (CAS 229176-04-9);
   31. Triazines, as follows:
       a. DNAM (2-oxy-4,6-dinitroamino-s-triazine) (CAS 19899-80-0);
       b. NNHT (2-nitroimino-5-nitro-hexahydro-1,3,5-triazine) (CAS 130400-13-4);
   32. Triazoles, as follows:
       a. 5-azido-2-nitrotriazole;
       b. ADHTDN (4-amino-3,5-dihydrazino-1,2,4-triazole dinitramide) (CAS 1614-08-0);
       c. ADNT (1-amino-3,5-dinitro-1,2,4-triazole);
       d. BDNTA ([bis-dinitrotriazole]amine);
       e. DBT (3,3'-dinitro-5,5-bi-1,2,4-triazole) (CAS 30003-46-4);
       f. DNBT (dinitrobistriazole) (CAS 70890-46-9);
       g. NTDNA (2-nitrotriazole 5-dinitramide) (CAS 75393-84-9);
       h. NTDNT (1-N-(2-nitrotriazolo) 3,5-dinitrotriazole);
       i. PDNT (1-picryl-3,5-dinitrotriazole);
       j. TACOT (tetranitrobenzotriazolobenzotriazole) (CAS 25243-36-1);
   33. Any explosive not listed elsewhere in 2-8.a. with a detonation velocity exceeding 8,700 m/s at maximum density or a detonation pressure exceeding 34 GPa (340 kbar);
   34. Other organic explosives not listed elsewhere in 2-8.a. yielding detonation pressures of 25 GPa (250 kbar) or more that will remain stable at temperatures of 523K (250°C) or higher for periods of 5 minutes or longer.

b. "Propellants", as follows:
   1. Any United Nations (UN) Class 1.1 solid "propellant" with a theoretical specific impulse (under standard conditions) of more than 250 seconds for non-metallized, or more than 270 seconds for aluminized compositions;

2. Any UN Class 1.3 solid "propellant" with a theoretical specific impulse (under standard conditions) of more than 230 seconds for non-halogenized, 250 seconds for non-metallized compositions and 266 seconds for metallized compositions;
3. "Propellants" having a force constant of more than 1,200 kJ/kg;
4. "Propellants" that can sustain a steady-state linear burning rate of more than 38 mm/s under standard conditions (as measured in the form of an inhibited single strand) of 6.89 MPa (68.9 bar) pressure and 294K (21°C);
5. Elastomer modified cast double base (EMCDB) "propellants" with extensibility at maximum stress of more than 5% at 233K (-40°C);
6. Any "propellant" containing substances listed in 2-8.a.

c. "Pyrotechnics", fuels and related substances, as follows, and mixtures thereof:
   1. Aircraft fuels specially formulated for military purposes;
   2. Alane (aluminum hydride) (CAS 7784-21-6);
   3. Carboranes; decaborane (CAS 17702-41-9); pentaboranes (CAS 19624-22-7 and 18433-84-6) and their derivatives;
   4. Hydrazine and derivatives, as follows (see also 2-8.d.8. and 2-8.d.9. for oxidising hydrazine derivatives):
      a. Hydrazine (CAS 302-01-2) in concentrations of 70% or more;
      b. Monomethyl hydrazine (CAS 60-34-4);
      c. Symmetrical dimethyl hydrazine (CAS 540-73-8);
      d. Unsymmetrical dimethyl hydrazine (CAS 57-14-7);
   5. Metal fuels in particle form whether spherical, atomized, spheroidal, flaked or ground, manufactured from material consisting of 99 % or more of any of the following:
      a. Metals and mixtures thereof, as follows:
         1. Beryllium (CAS 7440-41-7) in particle sizes of less than 60 µm;
         2. Iron powder (CAS 7439-89-6) with particle size of 3 µm or less produced by reduction of iron oxide with hydrogen;
      b. Mixtures, which contain any of the following:
         1. Zirconium (CAS 7440-67-7), magnesium (CAS 7439-95-4) or alloys of these in particle sizes of less than 60 µm;
         2. Boron (CAS 7440-42-8) or boron carbide (CAS 12069-32-8) fuels of 85% purity or higher and particle sizes of less than 60 µm;
   6. Military materials containing thickeners for hydrocarbon fuels specially formulated for use in flame throwers or incendiary munitions, such as metal stearates or palmates (e.g. octal (CAS 637-12-7)) and M1, M2, and M3 thickeners;
   7. Perchlorates, chlorates and chromates composited with powdered metal or other high energy fuel components;
   8. Spherical aluminum powder (CAS 7429-90-5) with a particle size of 60 µm or less, manufactured from material with an aluminum content of 99% or more;
   9. Titanium subhydride (TiH_n) of stoichiometry equivalent to n= 0.65-1.68.

Note 1:
Aircraft fuels controlled by 2-8.c.1. are finished products not their constituents.

Note 2:
2-8.c.4.a. does not control hydrazine mixtures specially formulated for corrosion control.

Note 3:
Explosives and fuels containing the metals or alloys listed in 2-8.c.5. are controlled whether or not the metals or alloys are encapsulated in aluminum, magnesium, zirconium, or beryllium.

Note 4:
2-8.c.5.b.2. does not control boron and boron carbide enriched with boron-10 (20% or more of total boron-10 content.)

d. Oxidizers, as follows, and mixtures thereof:
   1. ADN (ammonium dinitramide or SR 12) (CAS 140456-78-6);
   2. AP (ammonium perchlorate) (CAS 7790-98-9);
   3. Compounds composed of fluorine and any of the following:
      a. Other halogens;
      b. Oxygen; **or**
      c. Nitrogen;

      Note 1:
      2-8.d.3. does not control chlorine trifluoride.

      Note 2:
      2-8.d.3. does not control nitrogen trifluoride in its gaseous state.
   4. DNAD (1,3-dinitro-1,3-diazetidine) (CAS 78246-06-7);
   5. HAN (hydroxylammonium nitrate) (CAS 13465-08-2);
   6. HAP (hydroxylammonium perchlorate) (CAS 15588-62-2);
   7. HNF (hydrazinium nitroformate) (CAS 20773-28-8);
   8. Hydrazine nitrate (CAS 37836-27-4);
   9. Hydrazine perchlorate (CAS 27978-54-7);
   10. Liquid oxidisers comprised of or containing inhibited red fuming nitric acid (IRFNA) (CAS 8007-58-7).

      Note:
      2-8.d.10. does not control non-inhibited fuming nitric acid.

e. Binders, plasticizers, monomers, polymers, as follows:
   1. AMMO (azidomethylmethyloxetane and its polymers) (CAS 90683-29-7) (see also 2-8.g.1. for its "precursors");
   2. BAMO (bisazidomethyloxetane and its polymers) (CAS 17607-20-4) (see also 2-8.g.1. for its "precursors");
   3. BDNPA (bis (2,2-dinitropropyl)acetal) (CAS 5108-69-0);
   4. BDNPF (bis (2,2-dinitropropyl)formal) (CAS 5917-61-3);
   5. BTTN (butanetrioltrinitrate) (CAS 6659-60-5) (see also 2-8.g.8. for its "precursors");
   6. Energetic monomers, plasticizers and polymers containing nitro, azido, nitrate, nitraza or difluoroamino groups specially formulated for military use;
   7. FAMAO (3-difluoroaminomethyl-3-azidomethyl oxetane) and its polymers;
   8. FEFO (bis-(2-fluoro-2,2-dinitroethyl) formal) (CAS 17003-79-1);
   9. FPF-1 (poly-2,2,3,3,4,4-hexafluoropentane-1,5-diol formal) (CAS 376-90-9);
   10. FPF-3 (poly-2,4,4,5,5,6,6-heptafluoro-2-tri-fluoromethyl-3-oxaheptane-1,7-diol formal);
   11. GAP (glycidylazide polymer) (CAS 143178-24-9) and its derivatives;
   12. HTPB (hydroxyl terminated polybutadiene) with a hydroxyl functionality equal to or greater than 2.2 and less than or equal to 2.4, a hydroxyl value of less than 0.77 meq/g, and a viscosity at 30°C of less than 47 poise (CAS 69102-90-5);
   13. Low (less then 10,000) molecular weight, alcohol functionalised, poly(epichlorohydrin); poly(epichlorohydrin-diol) and triol;

14. NENAs (nitratoethylnitramine compounds) (CAS 17096-47-8, 85068-73-1, 82486-83-7, 82486-82-6 and 85954-06-9);
15. PGN (poly-GLYN, polyglycidylnitrate or poly(nitratomethyl oxirane) (CAS 27814-48-8);
16. Poly-NIMMO (poly nitratomethylmethyloxetane) or poly-NMMO (poly[3-Nitratomethyl-3-methyloxetane]) (CAS 84051-81-0);
17. Polynitroorthocarbonates;
18. TVOPA (1,2,3-tris[1,2-bis(difluoroamino)ethoxy] propane or tris vinoxy propane adduct) (CAS 53159-39-0).

f. "Additives", as follows:
1. Basic copper salicylate (CAS 62320-94-9);
2. BHEGA (bis-(2-hydroxyethyl) glycolamide) (CAS 17409-41-5);
3. BNO (butadienenitrileoxide) (CAS 9003-18-3);
4. Ferrocene derivatives, as follows:
   a. Butacene (CAS 125856-62-4);
   b. Catocene (2,2-bis-ethylferrocenyl propane) (CAS 37206-42-1);
   c. Ferrocene carboxylic acids;
   d. n-butyl-ferrocene (CAS 31904-29-7);
   e. Other adducted polymer ferrocene derivatives;
5. Lead beta-resorcylate (CAS 20936-32-7);
6. Lead citrate (CAS 14450-60-3);
7. Lead-copper chelates of beta-resorcylate or salicylates (CAS 68411-07-4);
8. Lead maleate (CAS 19136-34-6);
9. Lead salicylate (CAS 15748-73-9);
10. Lead stannate (CAS 12036-31-6);
11. MAPO (tris-1-(2-methyl)aziridinyl phosphine oxide) (CAS 57-39-6); BOBBA 8 (bis(2-methyl aziridinyl) 2-(2-hydroxypropanoxy) propylamino phosphine oxide); and other MAPO derivatives;
12. Methyl BAPO (bis(2-methyl aziridinyl) methylamino phosphine oxide) (CAS 85068-72-0);
13. N-methyl-p-nitroaniline (CAS 100-15-2);
14. 3-Nitraza-1,5-pentane diisocyanate (CAS 7406-61-9);
15. Organo-metallic coupling agents, as follows:
   a. Neopentyl[diallyl]oxy, tri[dioctyl]phosphato-titanate (CAS 103850-22-2); also known as titanium IV, 2,2[bis 2-propenolato-methyl, butanolato, tris (dioctyl) phosphato] (CAS 110438-25-0); or LICA 12 (CAS 103850-22-2);
   b. Titanium IV, [(2-propenolato-1) methyl, n-propanolato-methyl] butanolato-1, tris[dioctyl] pyrophosphate or KR3538;
   c. Titanium IV, [(2-propenolato-1)methyl, n-propanolato-methyl] butanolato-1, tris(dioctyl)phosphate;
16. Polycyanodifluoroaminoethyleneoxide;
17. Polyfunctional aziridine amides with isophthalic, trimesic (BITA or butylene imine trimesamide), isocyanuric or trimethyladipic backbone structures and 2-methyl or 2-ethyl substitutions on the aziridine ring;
18. Propyleneimine (2-methylaziridine) (CAS 75-55-8);
19. Superfine iron oxide (Fe_2O_3) with a specific surface area more than 250 m^2/g and an average particle size of 3.0 nm or less;
20. TEPAN (tetraethylenepentaamineacrylonitrile) (CAS 68412-45-3); cyanoethylated polyamines and their salts;
21. TEPANOL (tetraethylenepentaamineacrylonitrileglycidol) (CAS 68412-46-4); cyanoethylated polyamines adducted with glycidol and their salts;
22. TPB (triphenyl bismuth) (CAS 603-33-8).

g. "Precursors", as follows:

N.B.:
In 2-8.g. the references are to controlled "Energetic Materials" manufactured from these substances.

1. BCMO (bischloromethyloxetane) (CAS 142173-26-0) (see also 2-8.e.1. and 2-8.e.2.);
2. Dinitroazetidine-t-butyl salt (CAS 125735-38-8) (see also 2-8.a.28.);
3. HBIW (hexabenzylhexaazaisowurtzitane) (CAS 124782-15-6) (see also 2-8.a.4.);
4. TAIW (tetraacetyldibenzylhexaazaisowurtzitane) (see also 2-8.a.4.);
5. TAT (1,3,5,7 tetraacetyl-1,3,5,7,-tetraaza cyclo-octane) (CAS 41378-98-7) (see also 2-8.a.13.);
6. 1,4,5,8-tetraazadecalin (CAS 5409-42-7) (see also 2-8.a.27.);
7. 1,3,5-trichlorobenzene (CAS 108-70-3) (see also 2-8.a.23.);
8. 1,2,4-trihydroxybutane (1,2,4-butanetriol) (CAS 3068-00-6) (see also 2-8.e.5.).

Note 5:
For charges and devices see 2-4.

Note 6:
2-8. does not control the following substances unless they are compounded or mixed with the "energetic material" mentioned in 2-8.a. or powdered metals in 2-8.c.:

a. Ammonium picrate;
b. Black powder;
c. Hexanitrodiphenylamine;
d. Difluoroamine;
e. Nitrostarch;
f. Potassium nitrate;
g. Tetranitronaphthalene;
h. Trinitroanisol;
i. Trinitronaphthalene;
j. Trinitroxylene;
k. N-pyrrolidinone; 1-methyl-2-pyrrolidinone;
l. Dioctylmaleate;
m. Ethylhexylacrylate;
n. Triethylaluminium (TEA), trimethylaluminium (TMA), and other pyrophoric metal alkyls and aryls of lithium, sodium, magnesium, zinc or boron;
o. Nitrocellulose;
p. Nitroglycerin (or glyceroltrinitrate, trinitroglycerine) (NG);
q. 2,4,6-trinitrotoluene (TNT);
r. Ethylenediaminedinitrate (EDDN);
s. Pentaerythritoltetranitrate (PETN);
t. Lead azide, normal and basic lead styphnate, and primary explosives or priming compositions containing azides or azide complexes;
u. Triethyleneglycoldinitrate (TEGDN);
v. 2,4,6-trinitroresorcinol (styphnic acid);
w. Diethyldiphenyl urea; dimethylidiphenyl urea; methylethyldiphenyl urea [Centralites];
x. N,N-diphenylurea (unsymmetrical diphenylurea);
y. Methyl-N,N-diphenylurea (methyl unsymmetrical diphenylurea);
z. Ethyl-N,N-diphenylurea (ethyl unsymmetrical diphenylurea);
aa. 2-Nitrodiphenylamine (2-NDPA);
bb. 4-Nitrodiphenylamine (4-NDPA);
cc. 2,2-dinitropropanol;
dd. Nitroguanidine (see 1-1.C.11.d. on the Dual-Use List).

2-9. Vessels of war, special naval equipment and accessories, as follows, and components therefor, specially designed for military use:

N.B.:
For guidance and navigation equipment, see 2-11., Note 7.

a. Combatant vessels and vessels (surface or underwater) specially designed or modified for offensive or defensive action, whether or not converted to non-military use, regardless of current state of repair or operating condition, and whether or not they contain weapon delivery systems or armour, and hulls or parts of hulls for such vessels;
b. Engines and propulsion systems, as follows:
   1. Diesel engines specially designed for submarines with both of the following characteristics:
      a. A power output of 1.12 MW (1,500 hp.) or more; **and**
      b. A rotary speed of 700 rpm or more;
   2. Electric motors specially designed for submarines having all of the following characteristics:
      a. A power output of more than 0.75 MW (1,000 hp.);
      b. Quick reversing;
      c. Liquid cooled; **and**
      d. Totally enclosed;
   3. Non-magnetic diesel engines specially designed for military use with a power output of 37.3 kW (50 hp.) or more and with a non-magnetic content in excess of 75% of total mass;
   4. Air Independent Propulsion systems specially designed for submarines;

      Technical Note:
      'Air Independent Propulsion' allows a submerged submarine to operate its propulsion system, without access to atmospheric oxygen, for a longer time than the batteries would have otherwise allowed. This does not include nuclear power.

c. Underwater detection devices specially designed for military use and controls thereof;
d. Submarine and torpedo nets;
e. Deleted;
f. Hull penetrators and connectors specially designed for military use that enable interaction with equipment external to a vessel;

   Note:
   2-9.f. includes connectors for vessels which are of the single-conductor, multi-conductor, coaxial or waveguide type, and hull penetrators for vessels, both of which are capable of remaining impervious to leakage from without and of retaining required characteristics at marine depths exceeding 100 m; and fibre-optic connectors and optical hull penetrators specially designed for "laser" beam transmission regardless of depth. It does not include ordinary propulsive shaft and hydrodynamic control-rod hull penetrators.

g. Silent bearings, with gas or magnetic suspension, active signature or vibration suppression controls, and equipment containing those bearings, specially designed for military use.

2-10. "Aircraft", "lighter-than-air vehicles", unmanned airborne vehicles, aero-engines and "aircraft" equipment, related equipment and components, specially designed or modified for military use, as follows:

N.B.:
For guidance and navigation equipment, see 2-11., Note 7.

a. Combat "aircraft" and specially designed components therefor;
b. Other "aircraft" and "lighter-than-air vehicles" specially designed or modified for military use, including military reconnaissance, assault, military training, transporting and airdropping troops or military equipment, logistics support, and specially designed components therefor;
c. Unmanned airborne vehicles and related equipment, specially designed or modified for military use, as follows, and specially designed components therefor:
   1. Unmanned airborne vehicles including remotely piloted air vehicles (RPVs), autonomous programmable vehicles and "lighter-than-air vehicles";
   2. Associated launchers and ground support equipment;
   3. Related equipment for command and control.
d. Aero-engines specially designed or modified for military use, and specially designed components therefor;
e. Airborne equipment, including airborne refuelling equipment, specially designed for use with the "aircraft" controlled by 2-10.a. or 2-10.b. or the aero-engines controlled by 2-10.d., and specially designed components therefor;
f. Pressure refuellers, pressure refuelling equipment, equipment specially designed to facilitate operations in confined areas and ground equipment, developed specially for "aircraft" controlled by 2-10.a. or 2-10.b., or for aero-engines controlled by 2-10.d.;
g. Military crash helmets and protective masks and specially designed components therefor, pressurised breathing equipment and partial pressure suits for use in "aircraft", anti-g suits, liquid oxygen converters used for "aircraft" or missiles, and catapults and cartridge actuated devices for emergency escape of personnel from "aircraft";
h. Parachutes and related equipment, used for combat personnel, cargo dropping or "aircraft" deceleration, as follows, and specially designed components therefor:
   1. Parachutes for:
      a. Pin point dropping of rangers;
      b. Dropping of paratroopers;
   2. Cargo parachutes;
   3. Paragliders, drag parachutes, drogue parachutes for stabilisation and attitude control of dropping bodies, (e.g. recovery capsules, ejection seats, bombs);
   4. Drogue parachutes for use with ejection seat systems for deployment and inflation sequence regulation of emergency parachutes;
   5. Recovery parachutes for guided missiles, drones or space vehicles;

6. Approach parachutes and landing deceleration parachutes;
7. Other military parachutes;
8. Equipment specially designed for high altitude parachutists (e.g., suits, special helmets, breathing systems, navigation equipment);

i. Automatic piloting systems for parachuted loads; equipment specially designed or modified for military use for controlled opening jumps at any height, including oxygen equipment.

Note 1:

2-10.b. does not control "aircraft" or variants of those "aircraft" specially designed for military use which:

a. Are not configured for military use and are not fitted with equipment or attachments specially designed or modified for military use; **and**
b. Have been certified for civil use by the civil aviation authority in a participating state.

Note 2:

2-10.d. does not control:

a. Aero-engines designed or modified for military use which have been certified by civil aviation authorities in a participating state for use in "civil aircraft", or specially designed components therefor;
b. Reciprocating engines or specially designed components therefor, except those specially designed for unmanned airborne vehicles.

Note 3:

The control in 2-10.b. and 2-10.d. on specially designed components and related equipment for non-military "aircraft" or aero-engines modified for military use applies only to those military components and to military related equipment required for the modification to military use.

2-11. Electronic equipment, not controlled elsewhere on the Munitions List as follows, and specially designed components therefor:

a. Electronic equipment specially designed for military use.

Note:

2-11.a. includes:

1. Electronic countermeasure and electronic counter-countermeasure equipment (i.e., equipment designed to introduce extraneous or erroneous signals into radar or radio communication receivers or otherwise hinder the reception, operation or effectiveness of adversary electronic receivers including their countermeasure equipment), including jamming and counter-jamming equipment;
2. Frequency agile tubes;
3. Electronic systems or equipment designed either for surveillance and monitoring of the electro-magnetic spectrum for military intelligence or security purposes or for counteracting such surveillance and monitoring;
4. Underwater countermeasures, including acoustic and magnetic jamming and decoy, equipment designed to introduce extraneous or erroneous signals into sonar receivers;
5. Data processing security equipment, data security equipment and transmission and signalling line security equipment, using ciphering processes;
6. Identification, authentification and keyloader equipment and key management, manufacturing and distribution equipment.
7. Guidance and navigation equipment;
8. Digital troposcatter-radio communications transmission equipment;
9. Digital demodulators specially designed for signals intelligence.

b. Global Navigation Satellite Systems (GNSS) jamming equipment.

2-12. High velocity kinetic energy weapon systems and related equipment, as follows, and specially designed components therefor:

a. Kinetic energy weapon systems specially designed for destruction or effecting mission-abort of a target;
b. Specially designed test and evaluation facilities and test models, including diagnostic instrumentation and targets, for dynamic testing of kinetic energy projectiles and systems.

N.B.:

For weapon systems using sub-calibre ammunition or employing solely chemical propulsion, and ammunition therefor, see 2-1. to 2-4.

Note 1:

2-12. includes the following when specially designed for kinetic energy weapon systems:

a. Launch propulsion systems capable of accelerating masses larger than 0.1 g to velocities in excess of 1.6 km/s, in single or rapid fire modes;
b. Prime power generation, electric armour, energy storage, thermal management, conditioning, switching or fuel-handling equipment; and electrical interfaces between power supply, gun and other turret electric drive functions;
c. Target acquisition, tracking, fire control or damage assessment systems;
d. Homing seeker, guidance or divert propulsion (lateral acceleration) systems for projectiles.

Note 2:

2-12. controls weapon systems using any of the following methods of propulsion:

a. Electromagnetic;
b. Electrothermal;
c. Plasma;
d. Light gas; **or**
e. Chemical (when used in combination with any of the above).

2-13. Armoured or protective equipment and constructions and components, as follows:

a. Armoured plate as follows:
   1. Manufactured to comply with a military standard or specification; **or**
   2. Suitable for military use;
b. Constructions of metallic or non-metallic materials or combinations thereof specially designed to provide ballistic protection for military systems, and specially designed components therefor;
c. Helmets manufactured according to military standards or specifications, or comparable national standards, and specially designed components therefor, i.e., helmet shell, liner and comfort pads;
d. Body armour and protective garments manufactured according to military standards or specifications, or equivalent, and specially designed components therefor.

Note 1:

2-13.b. includes materials specially designed to form explosive reactive armour or to construct military shelters.

Note 2:

2-13.c. does not control conventional steel helmets, neither modified or designed to accept, nor equipped with any type of accessory device.

Note 3:
2-13.c. and 2-13.d. do not control helmets, body armour or protective garments when accompanying their user for the user's own personal protection.
Note 4:
The only helmets specially designed for bomb disposal personnel that are controlled by 2-13. are those specially designed for military use.
N.B. 1:
See also entry 1-1.A.5. on the Dual-Use List.
N.B. 2:
For "fibrous or filamentary materials" used in the manufacture of body armour and helmets, see entry 1-1.C.10. on the Dual-Use List.

2-14. Specialised equipment for military training or for simulating military scenarios, simulators specially designed for training in the use of any firearm or weapon controlled by 2-1. or 2-2., and specially designed components and accessories therefor.

Technical Note:
The term 'specialised equipment for military training' includes military types of attack trainers, operational flight trainers, radar target trainers, radar target generators, gunnery training devices, anti-submarine warfare trainers, flight simulators (including human-rated centrifuges for pilot/astronaut training), radar trainers, instrument flight trainers, navigation trainers, missile launch trainers, target equipment, drone "aircraft", armament trainers, pilotless "aircraft" trainers, mobile training units and training equipment for ground military operations.
Note 1:
2-14. includes image generating and interactive environment systems for simulators when specially designed or modified for military use.
Note 2:
2-14. does not control equipment specially designed for training in the use of hunting or sporting weapons.

2-15. Imaging or countermeasure equipment, as follows, specially designed for military use, and specially designed components and accessories therefor:

a. Recorders and image processing equipment;
b. Cameras, photographic equipment and film processing equipment;
c. Image intensifier equipment;
d. Infrared or thermal imaging equipment;
e. Imaging radar sensor equipment;
f. Countermeasure or counter-countermeasure equipment for the equipment controlled by sub-items 2-15.a. to 2-15.e.
   Note:
   2-15.f. includes equipment designed to degrade the operation or effectiveness of military imaging systems or to minimize such degrading effects.

Note 1:
The term 'specially designed components' includes the following when specially designed for military use:
a. Infrared image converter tubes;
b. Image intensifier tubes (other than first generation);
c. Microchannel plates;
d. Low-light-level television camera tubes;
e. Detector arrays (including electronic interconnection or read out systems);
f. Pyroelectric television camera tubes;
g. Cooling systems for imaging systems;
h. Electrically triggered shutters of the photochromic or electro-optical type having a shutter speed of less than 100 µs, except in the case of shutters which are an essential part of a high speed camera;
i. Fibre optic image inverters;
j. Compound semiconductor photocathodes.

Note 2:
2-15 does not control "first generation image intensifier tubes" or equipment specially designed to incorporate "first generation image intensifier tubes".
   N.B.:
   For the status of weapons sights incorporating "first generation image intensifier tubes" see entries 2-1., 2-2. and 2-5.a.

N.B.:
See also entries 1-6.A.2.a.2. and 1-6.A.2.b. on the Dual-Use List.

2-16. Forgings, castings and other unfinished products the use of which in a controlled product is identifiable by material composition, geometry or function, and which are specially designed for any products controlled by 2-1. to 2-4., 2-6., 2-9., 2-10., 2-12. or 2-19.

2-17. Miscellaneous equipment, materials and libraries, as follows, and specially designed components therefor:

a. Self-contained diving and underwater swimming apparatus, as follows:
   1. Closed or semi-closed circuit (rebreathing) apparatus specially designed for military use (i.e. specially designed to be non magnetic);
   2. Specially designed components for use in the conversion of open-circuit apparatus to military use;
   3. Articles designed exclusively for military use with self-contained diving and underwater swimming apparatus;
b. Construction equipment specially designed for military use;
c. Fittings, coatings and treatments for signature suppression, specially designed for military use;
d. Field engineer equipment specially designed for use in a combat zone;
e. "Robots", "robot" controllers and "robot" "end-effectors", having any of the following characteristics:
   1. Specially designed for military use;
   2. Incorporating means of protecting hydraulic lines against externally induced punctures caused by ballistic fragments (e.g., incorporating self-sealing lines) and designed to use hydraulic fluids with flash points higher than 839 K (566°C); **or**
   3. Specially designed or rated for operating in an electro-magnetic pulse (EMP) environment;
f. Libraries (parametric technical databases) specially designed for military use with equipment controlled by the Munitions List;
g. Nuclear power generating equipment or propulsion equipment, including "nuclear reactors", specially designed for military use and components therefor specially designed or modified for military use;
h. Equipment and material, coated or treated for signature suppression, specially designed for military use, other than those controlled elsewhere in the Munitions List;
i. Simulators specially designed for military "nuclear reactors";
j. Mobile repair shops specially designed or modified to service military equipment;

k. Field generators specially designed or modified for military use;
l. Containers specially designed or modified for military use;
m. Ferries, other than those controlled elsewhere in the Munitions List, bridges and pontoons, specially designed for military use;
n. Test models specially designed for the "development" of items controlled by 2-4., 2-6., 2-9. or 2-10.;
o. Laser protection equipment (e.g., eye and sensor protection) specially designed for military use.

Technical Notes:

1. For the purpose of 2-17., the term 'library' (parametric technical database) means a collection of technical information of a military nature, reference to which may enhance the performance of military equipment or systems.
2. For the purpose of 2-17., 'modified' means any structural, electrical, mechanical, or other change that provides a non-military item with military capabilities equivalent to an item which is specially designed for military use.

2-18. Equipment for the production of products controlled by the Munitions List, as follows:

a. Specially designed or modified production equipment for the production of products controlled by the Munitions List, and specially designed components therefor;
b. Specially designed environmental test facilities and specially designed equipment therefor, for the certification, qualification or testing of products controlled by the Munitions List.

Technical Note:

For the purposes of 2-18., the term 'production' includes design, examination, manufacture, testing and checking.

Note:

2-18.a. and 2-18.b. include the following equipment:

a. Continuous nitrators;
b. Centrifugal testing apparatus or equipment having any of the following characteristics:
    1. Driven by a motor or motors having a total rated horsepower of more than 298 kW (400 hp);
    2. Capable of carrying a payload of 113 kg or more; **or**
    3. Capable of exerting a centrifugal acceleration of 8 g or more on a payload of 91 kg or more;
c. Dehydration presses;
d. Screw extruders specially designed or modified for military explosive extrusion;
e. Cutting machines for the sizing of extruded propellants;
f. Sweetie barrels (tumblers) 1.85 m or more in diameter and having over 227 kg product capacity;
g. Continuous mixers for solid propellants;
h. Fluid energy mills for grinding or milling the ingredients of military explosives;
i. Equipment to achieve both sphericity and uniform particle size in metal powder listed in 2-8.c.8.;
j. Convection current converters for the conversion of materials listed in 2-8.c.3.

2-19. Directed energy weapon systems (DEW), related or countermeasure equipment and test models, as follows, and specially designed components therefor:

a. "Laser" systems specially designed for destruction or effecting mission-abort of a target;
b. Particle beam systems capable of destruction or effecting mission-abort of a target;
c. High power radio-frequency (RF) systems capable of destruction or effecting mission-abort of a target;
d. Equipment specially designed for the detection or identification of, or defence against, systems controlled by 2-19.a. to 2-19.c.;
e. Physical test models for the systems, equipment and components controlled by this Item.
f. Continuous wave or pulsed "laser" systems specially designed to cause permanent blindness to unenhanced vision, i.e., to the naked eye or to the eye with corrective eyesight devices.

Note 1:

Directed energy weapon systems controlled by 2-19. include systems whose capability is derived from the controlled application of:

a. "Lasers" of sufficient continuous wave or pulsed power to effect destruction similar to the manner of conventional ammunition;
b. Particle accelerators which project a charged or neutral particle beam with destructive power;
c. High pulsed power or high average power radio frequency beam transmitters which produce fields sufficiently intense to disable electronic circuitry at a distant target.

Note 2:

2-19. includes the following when specially designed for directed energy weapon systems:

a. Prime power generation, energy storage, switching, power conditioning or fuel-handling equipment;
b. Target acquisition or tracking systems;
c. Systems capable of assessing target damage, destruction or mission-abort;
d. Beam-handling, propagation or pointing equipment;
e. Equipment with rapid beam slew capability for rapid multiple target operations;
f. Adaptive optics and phase conjugators;
g. Current injectors for negative hydrogen ion beams;
h. "Space qualified" accelerator components;
i. Negative ion beam funnelling equipment;
j. Equipment for controlling and slewing a high energy ion beam;
k. "Space qualified" foils for neutralising negative hydrogen isotope beams.

2-20. Cryogenic and "superconductive" equipment, as follows, and specially designed components and accessories therefor:

a. Equipment specially designed or configured to be installed in a vehicle for military ground, marine, airborne or space applications, capable of operating while in motion and of producing or maintaining temperatures below 103 K (-170°C);

    Note:

    2-20.a. includes mobile systems incorporating or employing accessories or components manufactured from non-metallic or non-electrical conductive materials, such as plastics or epoxy-impregnated materials.

b. "Superconductive" electrical equipment (rotating machinery and transformers) specially designed or configured to be installed in a vehicle for military ground, marine, airborne or space applications, capable of operating while in motion.

    Note:

    2-20.b. does not control direct-current hybrid homopolar generators that have single-pole normal metal armatures which rotate in a magnetic field produced by superconducting windings, provided those windings are the only superconducting component in the generator.

2-21. "Software", as follows:

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or materials controlled by the Munitions List;
b. Specific "software", as follows:
   1. "Software" specially designed for:
      a. Modelling, simulation or evaluation of military weapon systems;
      b. "Development", monitoring, maintenance or up-dating of "software" embedded in military weapon systems;
      c. Modelling or simulating military operation scenarios;
      d. Command, Communications, Control and Intelligence (C^3I) or Command, Communications, Control, Computer and Intelligence (C^4I) applications;
   2. "Software" for determining the effects of conventional, nuclear, chemical or biological warfare weapons.
   3. "Software", not controlled by 2-21.a., 2-21.b.1. or 2-21.b.2., specially designed or modified to enable equipment not controlled by the Munitions List to perform the military functions of equipment controlled by the Munitions List.

2-22. "Technology" as follows:

a. "Technology", other than specified in 2-22.b., which is "required" for the "development", "production" or "use" of items controlled in the Munitions List.
b. "Technology" as follows:
   1. "Technology" "required" for the design of, the assembly of components into, and the operation, maintenance and repair of complete production installations for items controlled in the Munitions List, even if the components of such production installations are not controlled;
   2. "Technology" "required" for the "development" and "production" of small arms even if used to produce reproductions of antique small arms;
   3. "Technology" "required" for the "development", "production" or "use" of toxicological agents, related equipment or components controlled by 2-7.a. to 2-7.g.;
   4. "Technology" "required" for the "development", "production" or "use" of "biopolymers" or cultures of specific cells controlled by 2-7.h.;
   5. "Technology" "required" exclusively for the incorporation of "biocatalysts", controlled by 2-7.i.1., into military carrier substances or military material.

Note 1:
"Technology" "required" for the "development", "production" or "use" of items controlled in the Munitions List remains under control even when applicable to any uncontrolled item.

Note 2:
2-22. does not control "technology" as follows:
a. Which is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which are not controlled or whose export has been authorised;
b. Which is "in the public domain", "basic scientific research" or the minimum necessary information for patent applications;
c. For magnetic induction for continuous propulsion of civil transport devices.

Definitions of Terms Used in Groups 1 and 2

This document contains the definitions of the terms used in Groups 1 and 2, in alphabetical order.

Note 1:
Definitions apply throughout Groups 1 and 2. The references are purely advisory and have no effect on the universal application of defined terms throughout Groups 1 and 2.
Note 2:
Words and terms contained in the List of Definitions only take the defined meaning where this is indicated by their being enclosed in quotations marks (" "). Elsewhere, words and terms take their commonly accepted (dictionary) meanings, unless a local definition for a particular control is given.

Cat 2/Cat 6 – "Accuracy"
(Usually measured in terms of inaccuracy) is the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

Cat 7 – "Active flight control systems"
Function to prevent undesirable "aircraft" and missile motions or structural loads by autonomously processing outputs from multiple sensors and then providing necessary preventive commands to effect automatic control.

Cat 6/Cat 8 – "Active pixel"
A minimum (single) element of the solid state array which has a photoelectric transfer function when exposed to light (electromagnetic) radiation.

Cat 1/2-7 – "Adapted for use in war"
Any modification or selection (such as altering purity, shelf life, virulence, dissemination characteristics, or resistance to UV radiation) designed to increase the effectiveness in producing casualties in humans or animals, degrading equipment or damaging crops or the environment.

2-8. – "Additives"
Substances used in explosive formulations to improve their properties.

Cat 1/Cat 7 & 9/2-8, 9 & 10 – "Aircraft"
A fixed wing, swivel wing, rotary wing (helicopter), tilt rotor or tilt-wing airborne vehicle.

Cat 2 – "All compensations available"
"All compensations available" means after all feasible measures available to the manufacturer to minimise all systematic positioning errors for the particular machine-tool model are considered.

Cat 3/Cat 5 P1 – "Allocated by the ITU"
The allocation of frequency bands according to the current edition of the ITU Radio Regulations for primary, permitted and secondary services.
N.B.:
Additional and alternative allocations are not included.

Cat 7 – "Angle random walk"
The angular error build up with time that is due to white noise in angular rate. (IEEE STD 528-2001)

Cat 2 – "Angular position deviation"
The maximum difference between angular position and the actual, very accurately measured angular position after the workpiece mount of the table has been turned out of its initial position. (Reference: VDI/VDE 2617, Draft: 'Rotary tables on coordinate measuring machines').

Cat 5 – "Asymmetric algorithm"
A cryptographic algorithm using different, mathematically-related keys for encryption and decryption.
Technical Note:
A common use of "asymmetric algorithms" is key management.

Cat 6 – "Automatic target tracking"
A processing technique that automatically determines and provides as output an extrapolated value of the most probable position of the target in real time.

Cat 6 – "Average output power"
The total "laser" output energy in joules divided by the "laser duration" in seconds.

Cat 3 – "Basic gate propagation delay time"
The propagation delay time value corresponding to the basic gate used in a "monolithic integrated circuit". For a 'family' of "monolithic integrated circuits", this may be specified either as the propagation delay time per typical gate within the given 'family' or as the typical propagation delay time per gate within the given 'family'.
Technical Notes:
1. "Basic gate propagation delay time" is not to be confused with the input/output delay time of a complex "monolithic integrated circuit".
2. 'Family' consists of all integrated circuits to which all of the following are applied as their manufacturing methodology and specifications except their respective functions:
   a. The common hardware and software architecture;
   b. The common design and process technology; **and**
   c. The common basic characteristics.

GTN – "Basic scientific research"
Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena or observable facts, not primarily directed towards a specific practical aim or objective.

Cat 7 – "Bias" (accelerometer)
An accelerometer output when no acceleration is applied.

2-7/2-22 – "Biocatalysts"
Enzymes for specific chemical or biochemical reactions or other biological compounds which bind to and accelerate the degradation of CW agents.
Technical Note:
'Enzymes' means "biocatalysts" for specific chemical or biochemical reactions.

2-7/2-22 – "Biopolymers"
Biological macromolecules as follows:
a. Enzymes for specific chemical or biochemical reactions;
b. Antibodies, monoclonal, polyclonal or anti-idiotypic;
c. Specially designed or specially processed receptors;

Technical Notes:

1. 'Anti-idiotypic antibodies' means antibodies which bind to the specific antigen binding sites of other antibodies;
2. 'Monoclonal antibodies' means proteins which bind to one antigenic site and are produced by a single clone of cells;
3. 'Polyclonal antibodies' means a mixture of proteins which bind to the specific antigen and are produced by more than one clone of cells;
4. 'Receptors' means biological macromolecular structures capable of binding ligands, the binding of which affects physiological functions.

Cat 2 – "Camming" (axial displacement)

Axial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle faceplate, at a point next to the circumference of the spindle faceplate (Reference: ISO 230/1 1986, paragraph 5.63).

Cat 1 – "Carbon fibre preforms"

An ordered arrangement of uncoated or coated fibres intended to constitute a framework of a part before the "matrix" is introduced to form a "composite".

Cat 4 – "CE"

"CE" is equivalent to "computing element".

Cat 6 – "Chemical Laser"

A "laser" in which the excited species is produced by the output energy from a chemical reaction.

"Circuit element"

A single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.

Cat 7 – "Circulation-controlled anti-torque or circulation-controlled direction control systems"

Control systems using air blown over aerodynamic surfaces to increase or control the forces generated by the surfaces.

Cat 1/Cat 7/Cat 9/2-10 – "Civil aircraft"

Those "aircraft" listed by designation in published airworthiness certification lists by the civil aviation authorities to fly commercial civil internal and external routes or for legitimate civil, private or business use.

Cat 1 – "Commingled"

Filament to filament blending of thermoplastic fibres and reinforcement fibres in order to produce a fibre reinforcement "matrix" mix in total fibre form.

Cat 1 – "Comminution"

A process to reduce a material to particles by crushing or grinding.

Cat 5 – "Common channel signalling"

A signalling method in which a single channel between exchanges conveys, by means of labelled messages, signalling information relating to a multiplicity of circuits or calls and other information such as that used for network management.

Cat 4 – "Communications channel controller"

The physical interface which controls the flow of synchronous or asynchronous digital information. It is an assembly that can be integrated into computer or telecommunications equipment to provide communications access.

Cat 6 – "Compensation systems"

Consist of the primary scalar sensor, one or more reference sensors (e.g. vector magnetometers) together with software that permit reduction of rigid body rotation noise of the platform.

Cat 1/Cat 2/Cat 6/Cat 8/Cat 9 – "Composite"

A "matrix" and an additional phase or additional phases consisting of particles, whiskers, fibres or any combination thereof, present for a specific purpose or purposes.

Cat 2 – "Compound rotary table"

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

Cat 4 – "Computing element" ("CE")

The smallest computational unit that produces an arithmetic or logic result.

Cat 2 – "Contouring control"

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

Cat 1/Cat 3/Cat 6 – "Critical temperature"

(sometimes referred to as the transition temperature) of a specific "superconductive" material is the temperature at which the material loses all resistance to the flow of direct electrical current.

Cat 5 – "Cryptography"

The discipline which embodies principles, means and methods for the transformation of data in order to hide its information content, prevent its undetected modification or prevent its unauthorized use. "Cryptography" is limited to the transformation of information using one or more secret parameters (e.g., crypto variables) or associated key management.

Technical Note:

'Secret parameter': a constant or key kept from the knowledge of others or shared only within a group.

Cat 6 – "CW Laser"

A "laser" that produces a nominally constant output energy for greater than 0.25 seconds.

Cat 7 – "Data-Based Referenced Navigation" ("DBRN") Systems

Systems which use various sources of previously measured geo-mapping data integrated to provide accurate navigation information under dynamic conditions. Data sources include bathymetric maps, stellar maps, gravity maps, magnetic maps or 3-D digital terrain maps.

Cat 5 – "Data signalling rate"

The rate, as defined in ITU Recommendation 53-36, taking into account that, for non-binary modulation, baud and bit per second are not equal. Bits for coding, checking and synchronisation functions are to be included.

Note:

When determining the "data signalling rate", servicing and administrative channels shall be excluded.

Technical Note:

It is the maximum one-way rate, i.e., the maximum rate in either transmission or reception.

Cat 6 – "Deformable Mirrors"

Mirrors:

a. Having a single continuous optical reflecting surface which is dynamically deformed by the application of individual torques or forces to compensate for distortions in the optical waveform incident upon the mirror; **or**
b. Having multiple optical reflecting elements that can be individually and dynamically repositioned by the application of torques or forces to compensate for distortions in the optical waveform incident upon the mirror.

"Deformable mirrors" are also known as adaptive optic mirrors.

GTN/ Both Lists – "Development"

Is related to all stages prior to serial production, such as: design, design research, design analyses, design concepts, assembly and testing of prototypes, pilot production schemes, design data, process of transforming design data into a product, configuration design, integration design, layouts.

Cat 1 /Cat 2/Cat 9 – "Diffusion bonding"

A solid state molecular joining of at least two separate metals into a single piece with a joint strength equivalent to that of the weakest material.

Cat 4/Cat 5 – "Digital computer"

Equipment which can, in the form of one or more discrete variables, perform all of the following:

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

Technical Note:

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

Cat 5 – "Digital transfer rate"

The total bit rate of the information that is directly transferred on any type of medium. (See also "total digital transfer rate").

Cat 2 – "Direct-acting hydraulic pressing"

A deformation process which uses a fluid-filled flexible bladder in direct contact with the workpiece.

"Discrete component"

A separately packaged "circuit element" with its own external connections.

Cat 7 – "Drift rate" (gyro)

The component of gyro output that is functionally independent of input rotation. It is expressed as an angular rate. (IEEE STD 528-2001)

Cat 5 – "Dynamic adaptive routing"

Automatic rerouting of traffic based on sensing and analysis of current actual network conditions.

Note:

This does not include cases of routing decisions taken on predefined information.

Cat 3 – "Dynamic signal analysers"

"Signal analysers" which use digital sampling and transformation techniques to form a Fourier spectrum display of the given waveform including amplitude and phase information.

Cat 1 – "Effective gram"

"Effective gram" for plutonium isotope is defined as the isotope weight in grams.

Cat 5/Cat 6 – "Electronically steerable phased array antenna"

An antenna which forms a beam by means of phase coupling, (i.e., the beam direction is controlled by the complex excitation coefficients of the radiating elements) and the direction of that beam can be varied (both in transmission and reception) in azimuth or in elevation, or both, by application of an electrical signal.

Cat 2/Cat 3/Cat 4/Cat 5 – "Electronic assembly"

A number of electronic components (i.e., "circuit elements", "discrete components", integrated circuits, etc.) connected together to perform (a) specific function(s), replaceable as an entity and normally capable of being disassembled.

Cat 2/2-17 – "End-effectors"

Grippers, active tooling units and any other tooling that is attached to the baseplate on the end of a "robot" manipulator arm.

Technical Note:

'Active tooling units' are devices for applying motive power, process energy or sensing to a workpiece.

2-4/2-8 – "Energetic materials"

Substances or mixtures that react chemically to release energy required for their intended application. "Explosives", "pyrotechnics" and "propellants" are subclasses of energetic materials.

Cat 6 – "Equivalent Density"

The mass of an optic per unit optical area projected onto the optical surface.

Cat 4/Cat 7 – "Expert systems"

Systems providing results by application of rules to data which are stored independently of the "programme" and capable of any of the following:

a. Modifying automatically the "source code" introduced by the user;
b. Providing knowledge linked to a class of problems in quasi-natural language; **or**
c. Acquiring the knowledge required for their development (symbolic training).

2-8/2-18 – "Explosives"

Solid, liquid or gaseous substances or mixtures of substances which, in their application as primary, booster, or main charges in warheads, demolition and other applications, are required to detonate.

2-7 – "Expression Vectors"

Carriers (e.g., plasmid or virus) used to introduce genetic material into host cells.

Cat 7/Cat 9 – "FADEC"

Full Authority Digital Engine Control (FADEC) - an electronic control system for gas turbine or combined cycle engines utilising a digital computer to control the variables required to regulate engine thrust or shaft power output throughout the engine operating range from the beginning of fuel metering to fuel shutoff.

Cat 4 – "Fault tolerance"

The capability of a computer system, after any malfunction of any of its hardware or "software" components, to continue to operate without human intervention, at a given level of service that provides continuity of operation, data integrity and recovery of service within a given time.

Cat 1/Cat 8 – "Fibrous or filamentary materials"

Include:

a. Continuous monofilaments;
b. Continuous yarns and rovings;
c. Tapes, fabrics, random mats and braids;

d. Chopped fibres, staple fibres and coherent fibre blankets;
e. Whiskers, either monocrystalline or polycrystalline, of any length;
f. Aromatic polyamide pulp.

Cat 3 – "Film type integrated circuit"
An array of "circuit elements" and metallic interconnections formed by deposition of a thick or thin film on an insulating "substrate".

2-15 – "First generation image intensifier tubes"
Electrostatically focused tubes, employing input and output fibre optic or glass face plates, multi-alkali photocathodes (S-20 or S-25), but not microchannel plate amplifiers.

Cat 5 – "Fixed"
The coding or compression algorithm cannot accept externally supplied parameters (e.g., cryptographic or key variables) and cannot be modified by the user.

Cat 7 – "Flight control optical sensor array"
A network of distributed optical sensors, using "laser" beams, to provide real-time flight control data for on-board processing.

Cat 7 – "Flight path optimization"
A procedure that minimizes deviations from a four-dimensional (space and time) desired trajectory based on maximizing performance or effectiveness for mission tasks.

Cat 6 – "Focal plane array"
A linear or two-dimensional planar layer, or combination of planar layers, of individual detector elements, with or without readout electronics, which work in the focal plane.

Note:
This definition does not include a stack of single detector elements or any two, three or four element detectors provided time delay and integration is not performed within the element.

Cat 3 – "Fractional bandwidth"
The "instantaneous bandwidth" divided by the centre frequency, expressed as a percentage.

Cat 5 – "Frequency hopping "
A form of "spread spectrum" in which the transmission frequency of a single communication channel is made to change by a random or pseudo-random sequence of discrete steps.

Cat 3/Cat 5 – "Frequency switching time"
The maximum time (i.e., delay) taken by a signal, when switched from one selected output frequency to another selected output frequency, to reach any of the following:
a. A frequency within 100 Hz of the final frequency; **or**
b. An output level within 1 dB of the final output level.

Cat 3 – "Frequency synthesiser"
Any kind of frequency source or signal generator, regardless of the actual technique used, providing a multiplicity of simultaneous or alternative output frequencies, from one or more outputs, controlled by, derived from or disciplined by a lesser number of standard (or master) frequencies.

Cat 1 – "Gas atomisation"
A process to reduce a molten stream of metal alloy to droplets of 500 µm diameter or less by a high pressure gas stream.

Cat 6 – "Geographically dispersed"
Sensors are considered "geographically dispersed" when each location is distant from any other more than 1,500 m in any direction. Mobile sensors are always considered "geographically dispersed".

Cat 2 – "Hot isostatic densification"
A process of pressurising a casting at temperatures exceeding 375 K (102°C) in a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal force in all directions to reduce or eliminate internal voids in the casting.

Cat 4 – "Hybrid computer"
Equipment which can perform all of the following:
a. Accept data;
b. Process data, in both analogue and digital representations; **and**
c. Provide output of data.

Cat 3 – "Hybrid integrated circuit"
Any combination of integrated circuit(s), or integrated circuit with "circuit elements" or "discrete components" connected together to perform (a) specific function(s), and having all of the following characteristics:
a. Containing at least one unencapsulated device;
b. Connected together using typical IC production methods;
c. Replaceable as an entity; **and**
d. Not normally capable of being disassembled.

Cat 4 – "Image enhancement"
The processing of externally derived information-bearing images by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform). This does not include algorithms using only linear or rotational transformation of a single image, such as translation, feature extraction, registration or false coloration.

Cat 5 – "Information security"
All the means and functions ensuring the accessibility, confidentiality or integrity of information or communications, excluding the means and functions intended to safeguard against malfunctions. This includes "cryptography", cryptanalysis, protection against compromising emanations and computer security.

Technical Note:
'Cryptanalysis': the analysis of a cryptographic system or its inputs and outputs to derive confidential variables or sensitive data, including clear text. (ISO 7498-2-1988 (E), paragraph 3.3.18).

Cat 3/Cat 5P1 – "Instantaneous bandwidth"
The bandwidth over which output power remains constant within 3 dB without adjustment of other operating parameters.

Cat 6 – "Instrumented range"
The specified unambiguous display range of a radar.

Cat 6 – "Interconnected radar sensors"
Two or more radar sensors are interconnected when they mutually exchange data in real time.

GTN/GSN/2-22 – "In the public domain"
This means "technology" or "software" which has been made available without restrictions upon its further dissemination.

Note:
Copyright restrictions do not remove "technology" or "software" from being "in the public domain".

Cat 6 – "Intrinsic magnetic gradiometer"
A single magnetic field gradient sensing element and associated electronics the output of which is a measure of magnetic field gradient.

Cat 2 – "Isostatic presses"

Equipment capable of pressurising 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.

Cat 2/Cat 3/Cat 5/Cat 6/Cat 9/2-9/2-19 – "Laser"

An assembly of components which produce both spatially and temporally coherent light that is amplified by stimulated emission of radiation.

2-10 – "Lighter-than-air vehicles"

Balloons and airships that rely on hot air or on lighter-than-air gases such as helium or hydrogen for their lift.

Cat 6 – "Laser duration"

The time over which a "laser" emits "laser" radiation, which for "pulsed lasers" corresponds to the time over which a single pulse or series of consecutive pulses is emitted.

Cat 2 – "Linearity"

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

Cat 4 – "Local area network"

A data communication system having all of the following characteristics:

a. Allows an arbitrary number of independent data devices to communicate directly with each other; **and**
b. Is confined to a geographical area of moderate size (e.g., office building, plant, campus, warehouse).

Technical Note:

'Data device' means equipment capable of transmitting or receiving sequences of digital information.

Cat 6 – "Magnetic gradiometers"

Are designed to detect the spatial variation of magnetic fields from sources external to the instrument. They consist of multiple "magnetometers" and associated electronics the output of which is a measure of magnetic field gradient. (See also "Intrinsic Magnetic Gradiometer")

Cat 6 – "Magnetometers"

Are designed to detect magnetic fields from sources external to the instrument. They consist of a single magnetic field sensing element and associated electronics the output of which is a measure of the magnetic field.

Cat 4 – "Main storage"

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

Cat 1/Cat 2/Cat 8/Cat 9 – "Matrix"

A substantially continuous phase that fills the space between particles, whiskers or fibres.

Cat 2 – "Measurement uncertainty"

The characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95%. It includes the uncorrected systematic deviations, the uncorrected backlash and the random deviations (Reference: ISO 10360-2, or VDI/VDE 2617).

Cat 1 – "Mechanical alloying"

An alloying process resulting from the bonding, fracturing and rebonding of elemental and master alloy powders by mechanical impact. Non-metallic particles may be incorporated in the alloy by addition of the appropriate powders.

Cat 1 – "Melt extraction"

A process to "solidify rapidly" and extract a ribbon-like alloy product by the insertion of a short segment of a rotating chilled block into a bath of a molten metal alloy.

Cat 1 – "Melt spinning"

A process to "solidify rapidly" a molten metal stream impinging upon a rotating chilled block, forming a flake, ribbon or rod-like product.

Cat 3 – "Microcomputer microcircuit"

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing general purpose instructions from an internal storage, on data contained in the internal storage.

Technical Note:

The internal storage may be augmented by an external storage.

Cat 3 – "Microprocessor microcircuit"

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing a series of general purpose instructions from an external storage.

Technical Note:

The "microprocessor microcircuit" normally does not contain integral user-accessible storage, although storage present on-the-chip may be used in performing its logic function.

Note:

This definition includes chip sets which are designed to operate together to provide the function of a "microprocessor microcircuit".

"Microprogramme"

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

Cat 3 – "Monolithic integrated circuit"

A combination of passive or active "circuit elements" or both which:

a. Are formed by means of diffusion processes, implantation processes or deposition processes in or on a single semiconducting piece of material, a so-called 'chip';
b. Can be considered as indivisibly associated; **and**
c. Perform the function(s) of a circuit.

Cat 6 – "Monospectral imaging sensors"

Are capable of acquisition of imaging data from one discrete spectral band.

Cat 3 – "Multichip integrated circuit"

Two or more "monolithic integrated circuits" bonded to a common "substrate".

Cat 4 – "Multi-data-stream processing"

The "microprogramme" or equipment architecture technique which permits simultaneous processing of two or more data sequences under the control of one or more instruction sequences by means such as:

a. Single Instruction Multiple Data (SIMD) architectures such as vector or array processors;

b. Multiple Single Instruction Multiple Data (MSIMD) architectures;
c. Multiple Instruction Multiple Data (MIMD) architectures, including those which are tightly coupled, closely coupled or loosely coupled; **or**
d. Structured arrays of processing elements, including systolic arrays.

Cat 5 – “Multilevel security”

A class of system containing information with different sensitivities that simultaneously permits access by users with different security clearances and needs-to-know, but prevents users from obtaining access to information for which they lack authorization.

Technical Note:

“Multilevel security” is computer security and not computer reliability which deals with equipment fault prevention or human error prevention in general.

Cat 6 – “Multispectral imaging sensors”

Are capable of simultaneous or serial acquisition of imaging data from two or more discrete spectral bands. Sensors having more than twenty discrete spectral bands are sometimes referred to as hyperspectral imaging sensors.

Cat 4 – “Network access controller”

A physical interface to a distributed switching network. It uses a common medium which operates throughout at the same “digital transfer rate” using arbitration (e.g., token or carrier sense) for transmission. Independently from any other, it selects data packets or data groups (e.g., IEEE 802) addressed to it. It is an assembly that can be integrated into computer or telecommunications equipment to provide communications access.

Cat 4 – “Neural computer”

A computational device designed or modified to mimic the behaviour of a neuron or a collection of neurons, i.e., a computational device which is distinguished by its hardware capability to modulate the weights and numbers of the interconnections of a multiplicity of computational components based on previous data.

Cat 6 – “Noise level”

An electrical signal given in terms of power spectral density. The relation between “noise level” expressed in peak-to-peak is given by S^2 pp = $8N_o(f_2\text{-}f_1)$, where Spp is the peak-to-peak value of the signal (e.g., nanoteslas), N_o is the power spectral density (e.g., $(\text{nanotesla})^2/\text{Hz}$) and $(f_2\text{-}f_1)$ defines the bandwidth of interest.

2-17 – “Nuclear reactor”

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 into direct contact with or control the primary coolant of the reactor core.

Cat 2 – “Numerical control”

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

Cat 4/Cat 9 – “Object code”

“Object code”: An equipment executable form of a convenient expression of one or more processes (“source code” (or source language)) which has been converted by a programming system.

Cat 5 – “Optical amplification”

In optical communications, an amplification technique that introduces a gain of optical signals that have been generated by a separate optical source, without conversion to electrical signals, i.e., using semiconductor optical amplifiers, optical fibre luminescent amplifiers.

Cat 4 – “Optical computer”

A computer designed or modified to use light to represent data and whose computational logic elements are based on directly coupled optical devices.

Cat 3 – “Optical integrated circuit”

A “monolithic integrated circuit” or a “hybrid integrated circuit”, containing one or more parts designed to function as a photosensor or photoemitter or to perform (an) optical or (an) electro-optical function(s).

Cat 5 – “Optical switching”

The routing of or switching of signals in optical form without conversion to electrical signals.

Cat 3 – “Overall current density”

The total number of ampere-turns in the coil (i.e., the sum of the number of turns multiplied by the maximum current carried by each turn) divided by the total cross-section of the coil (comprising the superconducting filaments, the metallic matrix in which the superconducting filaments are embedded, the encapsulating material, any cooling channels, etc.).

Cat 6 – “Peak power”

The highest level of power attained in the “laser duration”.

Cat 5 – “Personalised smart card”

A smart card containing a microcircuit which has been programmed for a specific application and cannot be reprogrammed for any other application by the user.

Cat 7 – “Power management”

Changing the transmitted power of the altimeter signal so that received power at the “aircraft” altitude is always at the minimum necessary to determine the altitude.

2-8 – “Precursors”

Speciality chemicals used in the manufacture of explosives.

Cat 1 – “Previously separated”

The application of any process intended to increase the concentration of the controlled isotope.

Cat 7 – “Primary flight control”

“Aircraft” stability or manoeuvering control using force/moment generators, i.e. aerodynamic control surfaces or propulsive thrust vectoring.

Cat 4 – “Principal element”

An element is a “principal element” when its replacement value is more than 35% of the total value of the system of which it is an element. Element value is the price paid for the element by the manufacturer of the system, or by the system integrator. Total value is the normal international selling price to unrelated parties at the point of manufacture or consolidation of shipment.

GTN/Both Lists – “Production”

Means all production stages, such as: product engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

Cat 2/Cat 4/Cat 5/Cat 6 – "Programme"

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

2-8 – "Propellants"

Substances or mixtures that react chemically to produce large volumes of hot gases at controlled rates to perform mechanical work.

Cat 6 – "Pulse compression"

The coding and processing of a radar signal pulse of long time duration to one of short time duration, while maintaining the benefits of high pulse energy.

Cat 6 – "Pulse duration"

Duration of a "laser" pulse measured at Full Width Half Intensity (FWHI) levels.

Cat 6 – "Pulsed laser"

A "laser" having a "pulse duration" that is less than or equal to 0.25 seconds.

2-4/2-8 – "Pyrotechnic(s)"

Mixtures of solid or liquid fuels and oxidizers which, when ignited, undergo an energetic chemical reaction at a controlled rate intended to produce specific time delays, or quantities of heat, noise, smoke, visible light or infrared radiation. Pyrophorics are a subclass of pyrotechnics, which contain no oxidizers but ignite spontaneously on contact with air.

Cat 5P2 – "Quantum cryptography"

A family of techniques for the establishment of a shared key for "cryptography" by measuring the quantum-mechanical properties of a physical system (including those physical properties explicitly governed by quantum optics, quantum field theory, or quantum electrodynamics).

Cat 6 – "Q-switched laser"

A "laser" in which the energy is stored in the population inversion or in the optical resonator and subsequently emitted in a pulse.

Cat 6 – "Radar frequency agility"

Any technique which changes, in a pseudo-random sequence, the carrier frequency of a pulsed radar transmitter between pulses or between groups of pulses by an amount equal to or larger than the pulse bandwidth.

Cat 6 – "Radar spread spectrum"

Any modulation technique for spreading energy originating from a signal with a relatively narrow frequency band, over a much wider band of frequencies, by using random or pseudo-random coding.

Cat 7 – "Repeatability"

The closeness of agreement among repeated measurements of the same variable under the same operating conditions when changes in conditions or non-operating periods occur between measurements. (Reference: IEEE STD 528-2001 (one sigma standard deviation))

Cat 3 – "Real-time bandwidth"

For "dynamic signal analysers", the widest frequency range which the analyser can output to display or mass storage without causing any discontinuity in the analysis of the input data. For analysers with more than one channel, the channel configuration yielding the widest "real-time bandwidth" shall be used to make the calculation.

Cat 2/Cat 6/Cat 7 – "Real time processing"

The processing of data by a computer system providing a required level of service, as a function of available resources, within a guaranteed response time, regardless of the load of the system, when stimulated by an external event.

Cat 5/Cat 6/Cat 9/GTN/2-22 – "Required"

As applied to "technology", refers to only that portion of "technology" which is peculiarly responsible for achieving or exceeding the controlled performance levels, characteristics or functions. Such "required" "technology" may be shared by different products.

Cat 2 – "Resolution"

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

2-7 – "Riot control agents"

Substances which, under the expected conditions of use for riot control purposes, produce rapidly in humans sensory irritation or disabling physical effects which disappear within a short time following termination of exposure. (Tear gases are a subset of "riot control agents".)

Cat 2/Cat 8/2-17 – "Robot"

A manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use sensors, and has all the following characteristics:

a. Is multifunctional;
b. Is capable of positioning or orienting material, parts, tools or special devices through variable movements in three dimensional space;
c. Incorporates three or more closed or open loop servo-devices which may include stepping motors; **and**
d. Has "user-accessible programmability" by means of the teach/playback method or by means of an electronic computer which may be a programmable logic controller, i.e., without mechanical intervention.

Note:

The above definition does not include the following devices:

1. Manipulation mechanisms which are only manually/ teleoperator controllable;
2. Fixed sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic or electrical means;
3. Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme 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 programme pattern. Variations or modifications of the programme pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;
4. Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;
5. 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.

Cat 1 – “Rotary atomisation”
A process to reduce a stream or pool of molten metal to droplets to a diameter of 500 µm or less by centrifugal force.

Cat 2 – “Run out” (out-of-true running)
Radial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle axis at a point on the external or internal revolving surface to be tested (Reference: ISO 230/1-1986, paragraph 5.61).

Cat 7 – “Scale factor” (gyro or accelerometer)
The ratio of change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data obtained by varying the input cyclically over the input range.

Cat 3 – “Settling time”
The time required for the output to come within one-half bit of the final value when switching between any two levels of the converter.

Cat 6 – “SHPL”
“SHPL” is equivalent to “Super High Power Laser”.

Cat 3 – “Signal analysers”
Apparatus capable of measuring and displaying basic properties of the single-frequency components of multi-frequency signals.

Cat 3/Cat 4/Cat 5/Cat 6 – “Signal processing”
The processing of externally derived information-bearing signals by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform).

Both Lists – “Software”
A collection of one or more “programmes” or “micro-programmes” fixed in any tangible medium of expression.

“Solidify rapidly”
A process involving the solidification of molten material at cooling rates exceeding 1 000 K/sec.

Cat 4/Cat 5/Cat 6/Cat 7/Cat 9 – “Source code”
A convenient expression of one or more processes which may be turned by a programming system into equipment executable form (“object code” (or object language)).

Cat 7/Cat 9 – “Spacecraft”
Active and passive satellites and space probes.

Cat 3/Cat 6 – “Space qualified”
Products designed, manufactured and tested to meet the special electrical, mechanical or environmental requirements for use in the launch and deployment of satellites or high altitude flight systems operating at altitudes of 100 km or higher.

Cat 1 – “Splat quenching”
A process to “solidify rapidly” a molten metal stream impinging upon a chilled block, forming a flake-like product.

Cat 5 – “Spread spectrum”
The technique whereby energy in a relatively narrow-band communication channel is spread over a much wider energy spectrum.

Cat 6 – “Spread spectrum” radar - see “Radar spread spectrum”

Cat 7 – “Stability”
Standard deviation (1 sigma) of the variation of a particular parameter from its calibrated value measured under stable temperature conditions. This can be expressed as a function of time.

Cat 3 – “Substrate”
A sheet of base material with or without an interconnection pattern and on which or within which “discrete components” or integrated circuits or both can be located.

Cat 6 – “Substrate blanks”
Monolithic compounds with dimensions suitable for the production of optical elements such as mirrors or optical windows.

Cat 2/Cat 9 – “Superalloy”
Nickel-, cobalt- or iron-base alloys having strengths superior to any alloys in the AISI 300 series at temperatures over 922 K (649°C) under severe environmental and operating conditions.

Cat 1/Cat 3/ Cat 6/Cat 8/2-18/2-20 – “Superconductive”
Refers to materials,(i.e., metals, alloys or compounds) which can lose all electrical resistance (i.e., which can attain infinite electrical conductivity and carry very large electrical currents without Joule heating).

Technical Note:
The “superconductive” state of a material is individually characterised by a “critical temperature”, a critical magnetic field, which is a function of temperature, and a critical current density which is, however, a function of both magnetic field and temperature.

Cat 6 – “Super High Power Laser” (“SHPL”)
A “laser” capable of delivering (the total or any portion of) the output energy exceeding 1 kJ within 50 ms or having an average or CW power exceeding 20 kW.

Cat 1/Cat 2 – “Superplastic forming”
A deformation process using heat for metals that are normally characterised by low values of elongation (less than 20%) at the breaking point as determined at room temperature by conventional tensile strength testing, in order to achieve elongations during processing which are at least 2 times those values.

Cat 5 – “ Symmetric algorithm “
A cryptographic algorithm using an identical key for both encryption and decryption.

Technical Note:
A common use of “symmetric algorithms” is confidentiality of data.

Cat 6 – “System tracks”
Processed, correlated (fusion of radar target data to flight plan position) and updated aircraft flight position report available to the Air Traffic Control centre controllers.

Cat 4 – “Systolic array computer”
A computer where the flow and modification of the data is dynamically controllable at the logic gate level by the user.

GTN & Both Lists – “Technology”
Specific information necessary for the “development”, “production” or “use” of a product. The information takes the form of technical data or technical assistance. Controlled “technology” for the Dual-Use List is defined in the General Technology Note and in the Dual-Use List. Controlled “technology” for the Munitions List is specified in 2-22.

Technical Notes:
1. ‘Technical data’ may take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.

2. ‘Technical assistance’ may take forms such as instruction, skills, training, working knowledge, consulting services. ‘Technical assistance’ may involve transfer of ‘technical data’.

Cat 4 – “Terminal interface equipment”

Equipment at which information enters or leaves the telecommunication system, e.g., telephone, data device, computer, facsimile device.

Cat 4 – “Three dimensional Vector Rate”

The number of vectors generated per second which have 10 pixel poly line vectors, clip tested, randomly oriented, with either integer or floating point X-Y-Z coordinate values (whichever produces the maximum rate).

Cat 2 – “Tilting spindle”

A tool-holding spindle which alters, during the machining process, the angular position of its centre line with respect to any other axis.

Cat 6 – “Time constant”

The time taken from the application of a light stimulus for the current increment to reach a value of 1-1/e times the final value (i.e., 63% of the final value).

Cat 7 – “Total control of flight”

Automated control of “aircraft” state variables and flight path to meet mission objectives responding to real time changes in data regarding objectives, hazards or other “aircraft”.

Cat 5 – “Total digital transfer rate”

The number of bits, including line coding, overhead and so forth per unit time passing between corresponding equipment in a digital transmission system. (See also “digital transfer rate”)

Cat 6 – “Transfer laser”

A “laser” in which the lasing species is excited through the transfer of energy by collision of a non-lasing atom or molecule with a lasing atom or molecule species.

Cat 6 – “Tunable”

The ability of a “laser” to produce a continuous output at all wavelengths over a range of several “laser” transitions. A line selectable “laser” produces discrete wavelengths within one “laser” transition and is not considered “tunable”.

Cat 9 – “Unmanned aerial vehicle” (“UAV”)

Any “aircraft” capable of initiating flight and sustaining controlled flight and navigation without any human presence on board.

GTN/Cat 1/Cat 2/Cat 4/Cat 5/Cat 6/Cat 7/Cat 8/Cat 9/2-21/2-22 – “Use”

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

Cat 4/Cat 5/Cat 6 – “User-accessible programmability”

The facility allowing a user to insert, modify or replace “programmes” by means other than:

a. A physical change in wiring or interconnections; **or**
b. The setting of function controls including entry of parameters.

Cat 1 – “Vacuum atomisation”

A process to reduce a molten stream of metal to droplets of a diameter of 500 µm or less by the rapid evolution of a dissolved gas upon exposure to a vacuum.

Cat 7 – “Variable geometry airfoils”

Use trailing edge flaps or tabs, or leading edge slats or pivoted nose droop, the position of which can be controlled in flight.

Acronyms and Abbreviations Used in Groups 1 and 2

An acronym or abbreviation, when used as a defined term, will be found in ‘Definitions of Terms used in Groups 1 and 2’.

ABEC	Annular Bearing Engineers Committee
AGMA	American Gear Manufacturers’ Association
AHRS	attitude and heading reference systems
ALU	arithmetic logic unit
ATC	air traffic control
C3I	command, communications, control & intelligence
CAD	computer-aided-design
CAS	Chemical Abstracts Service
CDU	control and display unit
CEP	circular error probable
CNTD	controlled nucleation thermal deposition
CVD	chemical vapour deposition
CW	chemical warfare
CW (for lasers)	continuous wave
DEW	directed energy weapon systems
DME	distance measuring equipment
DS	directionally solidified
EB-PVD	electron beam physical vapour deposition
EBU	European Broadcasting Union
ECM	electro-chemical machining
ECR	electron cyclotron resonance
EDM	electrical discharge machines
EEPROMS	electrically erasable programmable read only memory
EIA	Electronic Industries Association
EMC	electromagnetic compatibility
EMCDB	elastomer modified cast double based propellants
FFT	Fast Fourier Transform
GLONASS	global navigation satellite system
GPS	global positioning system
HBT	hetero-bipolar transistors
HDDR	high density digital recording
HEMT	high electron mobility transistors
ICAO	International Civil Aviation Organisation
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFOV	instantaneous-field-of-view
ILS	instrument landing system
IRIG	inter-range instrumentation group
ISAR	inverse synthetic aperture radar
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JIS	Japanese Industrial Standard
JT	Joule-Thomson
LIDAR	light detection and ranging
LRU	line replaceable unit
MAC	message authentication code
Mach	ratio of speed of an object to speed of sound (after Ernst Mach)
MLS	microwave landing systems
MOCVD	metal organic chemical vapour deposition
MRI	magnetic resonance imaging
MTBF	mean-time-between-failures
Mtops	million theoretical operations per second
MTTF	mean-time-to-failure
NBC	Nuclear, Biological and Chemical
NDT	non-destructive test
PAR	precision approach radar
PIN	personal identification number
ppm	parts per million
PSD	power spectral density
QAM	quadrature-amplitude-modulation
RF	radio frequency
RPV	remotely piloted air vehicles
SACMA	Suppliers of Advanced Composite Materials Association
SAR	synthetic aperture radar
SC	single crystal
SLAR	sidelooking airborne radar
SMPTE	Society of Motion Picture and Television Engineers
SRA	shop replaceable assembly
SRAM	static random access memory
SRM	SACMA Recommended Methods
SSB	single sideband
SSR	secondary surveillance radar
TCSEC	trusted computer system evaluation criteria
TIR	total indicated reading
UTS	ultimate tensile strength
VOR	very high frequency omni-directional range
YAG	yttrium/aluminum garnet

Group 3 – Non-Proliferation List

(All destinations. All destinations applies to all Group 3 Items.)

Note:
Terms in 'single quotations' are usually defined within each entry of the list.
Terms in "double quotations" are defined at the end of Group 4.
Canadian Nuclear Safety Commission (CNSC) Note:
The export of nuclear and nuclear-related items is also controlled by the CNSC under the Nuclear Safety and Control Act (NSCA) and Regulations. Therefore, the export of nuclear and nuclear-related items, not listed in Group 3 or which meet the specific Group 3 decontrol notes may still require a license from the CNSC. Information on export licensing requirements under the NSCA may be obtained by contacting the CNSC.
Nuclear Technology Note:
The "technology" directly associated with any items controlled in Group 3 is controlled according to the provisions of Group 3.
"Technology" for the "development", "production" or "use" of items under control remains under control even when applicable to non-controlled items.
The approval of items for export also authorizes the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance and repair of the items.
Controls on "technology" transfer, do not apply to information "in the public domain" or to "basic scientific research".
General Software Note:
Group 3 does not control "software" which is either:
1. Generally available to the public by being:
   a. Sold from stock at retail selling points, without restriction, by means of:
   1. Over-the-counter transactions;
   2. Mail order transactions;
   3. Electronic transactions; **or**
   4. Telephone call transactions; **and**
   b. Designed for installation by the user without further substantial support by the supplier; **or**
2. "In the public domain".

3-1. Source and special fissionable materials

3-1.1 Source materials

Source materials in the form of metal, alloy, chemical compound, concentrate, or that are incorporated in any material or substance and in which the concentration of source material is greater than 0.05 weight %, as follows:
1. Natural uranium (i.e. containing the mixture of isotopes occurring in nature);
2. Depleted uranium (i.e. depleted in the isotope 235 below that occurring in nature); **and**
3. Thorium.

Note:
3-1.1 does not control the following:
a. Four grams or less of natural uranium or depleted uranium when contained in a sensing component in instruments;
b. Alloys containing less than 5% thorium;
c. Ceramic products containing thorium, which have been manufactured for non-nuclear use;
d. Medicinal substances;
e. Trace amounts found on contaminated items such as clothing, shielding or packaging; **and**
f. Source material which the Government is satisfied is to be used only in civil non-nuclear applications, such as shielding, packaging, ballasts, counter-weights or the production of alloys and ceramics (For the purpose of export control, the Export Controls Division at International Trade Canada, will determine whether or not the exports of source material meeting the above specifications are for non-nuclear applications).

3-1.2 Special fissionable materials

1. Plutonium of all isotopes and any alloy, compound or material containing plutonium;
2. Uranium-233; uranium enriched in the isotopes 233 or 235; or any alloy, compound or material containing one or more of the foregoing;

Note:
3-1.2 does not control the following:
a. Four 'effective grams' or less of special fissionable material when contained in a sensing component in instruments;
b. Trace amounts found on contaminated items such as clothing, shielding or packaging; and
c. Plutonium 238 that is contained in heart pacemakers.

Technical Note:
'Effective gram' means:
a. For plutonium isotopes and uranium-233, the isotope weight in grams;
b. For uranium enriched 1 percent or greater in the isotope uranium-235, the element weight in grams multiplied by the square of its enrichment expressed as a decimal weight fraction; and
c. For uranium enriched below 1 percent in the isotope uranium-235, the element weight in grams multiplied by 0.0001.

3-2. Equipment and Non-nuclear Materials

3-2.1 Nuclear reactors and especially designed or prepared equipment and components therefor, including:

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.
2. Nuclear reactor vessels
   Metal vessels, or major shop-fabricated parts therefor, especially designed or prepared to contain the core of a nuclear reactor as defined in item 3-2.1.1. above, as well as relevant reactor internals as defined in item 3-2.1.8. below.
   Explanatory Note:
   The reactor vessel head is covered by item 3-2.1.2. as a major shop-fabricated part of a reactor vessel.
3. Nuclear reactor fuel charging and discharging machines
   Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor as defined in item 3-2.1.1. above.

Explanatory Note:
The items noted above are capable of on-load operation or at employing technically sophisticated positioning or alignment features to allow complex off-load fueling operations such as those in which direct viewing of or access to the fuel is not normally available.

4. Nuclear reactor control rods and equipment
   Especially designed or prepared rods, support or suspension structures therefor, rod drive mechanisms or rod guide tubes to control the fission process in a nuclear reactor as defined in item 3-2.1.1. above.

5. Nuclear reactor pressure tubes
   Tubes which are especially designed or prepared to contain fuel elements and the primary coolant in a reactor as defined in item 3-2.1.1. above at an operating pressure in excess of 50 atmospheres.

6. Zirconium tubes
   Zirconium metal and alloys in the form of tubes or assemblies of tubes, especially designed or prepared for use in a reactor as defined in item 3-2.1.1. above, and in which the relation of hafnium to zirconium is less than 1:500 parts by weight.

7. Primary coolant pumps
   Pumps especially designed or prepared for circulating the primary coolant for nuclear reactors as defined in item 3-2.1.1. 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 Section III, Division I, Subsection NB (Class 1 components) of the American Society of Mechanical Engineers (ASME) Code, or equivalent standards.

8. Nuclear reactor internals
   'Nuclear reactor internals' especially designed or prepared for use in a nuclear reactor as defined in item 3-2.1.1. above, including support columns for the core, fuel channels, thermal shields, baffles, core grid plates, and diffuser plates.
   Explanatory Note:
   'Nuclear reactor internals' are major structures within a reactor vessel which have one or more functions such as supporting the core, maintaining fuel alignment, directing primary coolant flow, providing radiation shields for the reactor vessel, and guiding in-core instrumentation.

9. Heat exchangers
   Heat exchangers (steam generators) especially designed or prepared for use in the primary coolant circuit of a nuclear reactor as defined in item 3-2.1.1. above.
   Explanatory Note:
   Steam generators are especially designed or prepared to transfer the heat generated in the reactor (primary side) to the feed water (secondary side) for steam generation. In the case of a liquid metal fast breeder reactor for which an intermediate liquid metal coolant loop is also present, the heat exchangers for transferring heat from the primary side to the intermediate coolant circuit are understood to be within the scope of control in addition to the steam generator. The scope of control for this entry does not include heat exchangers for the emergency cooling system or the decay heat cooling system.

10. Neutron detection and measuring instruments
    Especially designed or prepared neutron detection and measuring instruments for determining neutron flux levels within the core of a reactor as defined in item 3-2.1.1. above.
    Explanatory Note:
    The scope of this entry encompasses in-core and ex-core instrumentation which measure flux levels in a large range, typically from 10^4 neutrons per cm^2 per second to 10^{10} neutrons per cm^2 per second or more. Ex-core refers to those instruments outside the core of a reactor as defined in item 3-2.1.1. above, but located within the biological shielding.

3-2.2 Non-nuclear materials for reactors;

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 item 3-2.1.1. above.
   Explanatory Note:
   For the purpose of export control, the Export Controls Division at International Trade Canada, will determine whether or not the exports of deuterium and deuterium compounds meeting the above specifications are for nuclear reactor use.

2. Nuclear grade graphite
   Graphite having a purity level better (less) than 5 parts per million 'boron equivalent' and with a density greater than 1.50 g/cm^3 for use in a nuclear reactor as defined in item 3-2.1.1. above.
   Explanatory Note:
   For the purpose of export control, the Export Controls Division at International Trade Canada will determine whether or not the exports of graphite meeting the above specifications are for nuclear reactor use.
   'Boron equivalent' (BE) may be determined experimentally or is calculated as the sum of BE_z for impurities (excluding BE_{carbon} since carbon is not considered an impurity) including boron, where:
   BE_z (ppm) = CF x concentration of element Z (in ppm);
   CF is the conversion factor: (σ_z x A_B) divided by (σ_B x A_z);
   σ_B and σ_z are the thermal neutron capture cross sections (in barns) for naturally occurring boron and element Z respectively; **and**
   A_B and A_z are the atomic masses of naturally occurring boron and element Z respectively.

3-2.3 Plants for the reprocessing of irradiated fuel elements, equipment and components especially designed or prepared therefor, including:

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:

1. Irradiated fuel element chopping machines

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

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

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. 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.

4. Chemical Holding or Storage Vessels

   Introductory Note:
   Three main process liquor streams result from the solvent extraction step. Holding or storage vessels are used in the further processing of all three streams, as follows:
   a. The pure uranium nitrate solution is concentrated by evaporation and passed to a denitration process where it is converted to uranium oxide. This oxide is re-used in the nuclear fuel cycle.
   b. The intensely radioactive fission products solution is normally concentrated by evaporation and stored as a liquor concentrate. This concentrate may be subsequently evaporated and converted to a form suitable for storage or disposal.
   c. The pure plutonium nitrate solution is concentrated and stored pending its transfer to further process steps. In particular, holding or storage vessels for plutonium solutions are designed to avoid criticality problems resulting from changes in concentration and form of this stream.

   Especially designed or prepared holding or storage vessels for use in a plant for the reprocessing of irradiated fuel. The holding or storage vessels must be resistant to the corrosive effect of nitric acid. The holding or storage vessels are normally fabricated of materials such as low carbon stainless steels, titanium or zirconium, or other high quality materials. Holding or storage vessels may be designed for remote operation and maintenance and may have the following features for control of nuclear criticality:
   1. walls or internal structures with a boron equivalent of at least two per cent, **or**
   2. a maximum diameter of 175 mm (7 in) for cylindrical vessels, **or**
   3. a maximum width of 75 mm (3 in) for either a slab or annular vessel.

3-2.4 Plants for the fabrication of nuclear reactor fuel elements, equipment and components especially designed or prepared therefor:

Introductory Note:
Nuclear fuel elements are manufactured from one or more of the source or special fissionable materials mentioned in Item 3-1. For oxide fuels, the most common type of fuel, equipment for pressing pellets, sintering, grinding and grading will be present. Mixed oxide fuels are handled in glove boxes (or equivalent containment) until they are sealed in the cladding. In all cases, the fuel is hermetically sealed inside a suitable cladding which is designed to be the primary envelope encasing the fuel so as to provide suitable performance and safety during reactor operation. Also, in all cases, precise control of processes, procedures and equipment to extremely high standards is necessary in order to ensure predictable and safe fuel performance.

Explanatory Note:
Items of equipment that are considered to fall within the meaning of the phrase 'and equipment especially designed or prepared' for the fabrication of fuel elements include equipment which:
a. normally comes in direct contact with, or directly processes, or controls, the production flow of nuclear material;
b. seals the nuclear material within the cladding;
c. checks the integrity of the cladding or the seal; **or**
d. checks the finish treatment of the sealed fuel.

Such equipment or systems of equipment may include, for example:
1. fully automatic pellet inspection stations especially designed or prepared for checking final dimensions and surface defects of the fuel pellets;
2. automatic welding machines especially designed or prepared for welding end caps onto the fuel pins (or rods);
3. automatic test and inspection stations especially designed or prepared for checking the integrity of completed fuel pins (or rods).
   Item 3 typically includes equipment for: a) x-ray examination of pin (or rod) end cap welds, b) helium leak detection from pressurized pins (or rods), and c) gamma-ray scanning of the pins (or rods) to check for correct loading of the fuel pellets inside.

3-2.5 Plants for the separation of isotopes of natural uranium, depleted uranium or special fissionable material and equipment and components, other than analytical instruments, especially designed or prepared therefor, including:

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.

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 3-2.5.1.1.c. following. The rotor is fitted with an internal baffle(s) and end caps, as described in section 3-2.5.1.1.d. and 3-2.5.1.1.e. following, if in final form. However the complete assembly may be delivered only partly assembled.
   b. Rotor tubes:
   Especially designed or prepared thin-walled cylinders with thickness of 12 mm (0.5 in) or less, a diameter of between 75 mm (3 in) and 400 mm (16 in), and manufactured from one 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_6 gas circulation within the main separation chamber of the rotor tube, and manufactured from one of the high strength to density ratio materials described in the Explanatory Note to this Section.
   e. Top caps/Bottom caps:
   Disc-shaped components of between 75 mm (3 in) and 400 mm (16 in) diameter especially designed or prepared to fit to the ends of the rotor tube, and so contain the UF_6 within the rotor tube, and in some cases to support, retain or contain as an integrated part an element of the upper bearing (top cap) or to carry the rotating elements of the motor and lower bearing (bottom cap), and manufactured from one of the high strength to density ratio materials described in the Explanatory Note to this Section.

Explanatory Note:

The materials used for centrifuge rotating components are:

a. Maraging steel capable of an ultimate tensile strength of 2.05×10^9 N/m^2 (300,000 psi) or more;
b. Aluminium alloys capable of an ultimate tensile strength of 0.46×10^9 N/m^2 (67,000 psi) or more;
c. “Fibrous or Filamentary materials” suitable for use in composite structures and having a ‘specific modulus’ of 3.18×10^6 m or greater and a ‘specific ultimate tensile strength’ of 7.62×10^4 m or greater (‘Specific Modulus’ is the Young’s Modulus in N/m^2 divided by the specific weight in N/m^3; ‘Specific Ultimate Tensile Strength’ is the ultimate tensile strength in N/m2 divided by the specific weight in N/m3).

2. Static components
   a. Magnetic suspension bearings:
   Especially designed or prepared bearing assemblies consisting of an annular magnet suspended within a housing containing a damping medium. The housing will be manufactured from a UF_6-resistant material (see Explanatory Note to Section 3-2.5.2.). The magnet couples with a pole piece or a second magnet fitted to the top cap described in Section 3-2.5.1.1.e. The magnet may be ring-shaped with a relation between outer and inner diameter smaller or equal to 1.6:1. The magnet may be in a form having an initial permeability of 0.15 H/m (120,000 in CGS units) or more, or a remanence of 98.5% or more, or an energy product of greater than 80 kJ/m^3 (10^7 gauss-oersteds). In addition to the usual material properties, it is a prerequisite that the deviation of the magnetic axes from the geometrical axes is limited to very small tolerances (lower than 0.1 mm or 0.004 in) or that homogeneity of the material of the magnet is specially called for.
   b. Bearings/Dampers:
   Especially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper. The pivot is normally a hardened steel shaft with a hemisphere at one end with a means of attachment to the bottom cap described in section 3-2.5.1.1.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_6.

f. Scoops:
Especially designed or prepared tubes of up to 12 mm (0.5 in) internal diameter for the extraction of UF_6 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_6.

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

Introductory Note:

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

Normally UF_6 is evaporated from the solid using heated autoclaves and is distributed in gaseous form to the centrifuges by way of cascade header pipework. The product and tails UF6 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.

1. Feed systems/product and tails withdrawal systems
Especially designed or prepared process systems including:
   a. Feed autoclaves (or stations), used for passing UF_6 to the centrifuge cascades at up to 100 kPa (15 psi) and at a rate of 1 kg/h or more;
   b. Desublimers (or cold traps) used to remove UF_6 from the cascades at up to 3 kPa (0.5 psi) pressure. The desublimers are capable of being chilled to 203 K (-70 ºC) and heated to 343 K (70 ºC);
   c. Product and Tails stations used for trapping UF_6 into containers.
   This plant, equipment and pipework is wholly made of or lined with UF_6 resistant materials (see Explanatory Note to this section) and is fabricated to very high vacuum and cleanliness standards.

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

3. Special Shut-off and control valves
Especially designed or prepared bellows-sealed valves, manual or automated, shut-off or control, made of or protected by materials resistant to corrosion by UF_6, with a diameter of 10 to 160 mm, for use in main or auxiliary systems of gas centrifuge enrichment plants.

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

5. Frequency changers
Frequency changers (also known as converters or invertors) especially designed or prepared to supply motor stators as defined under 3-2.5.1.2.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 UF6 process gas or directly control the centrifuges and the passage of the gas from centrifuge to centrifuge and cascade to cascade.

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

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. In as much as gaseous diffusion technology uses uranium hexafluoride (UF_6), all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that remain stable in contact with UF_6. A gaseous diffusion facility requires a number of these assemblies, so that quantities can provide an important indication of end use.

1. Gaseous diffusion barriers
   a. Especially designed or prepared thin, porous filters, with a pore size of 100 - 1,000 Å (angstroms), a thickness of 5 mm (0.2 in) or less, and for tubular forms, a diameter of 25 mm (1 in) or less, made of metallic, polymer or ceramic materials resistant to corrosion by UF_6; **and**
   b. Especially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60 per cent or more nickel, aluminium oxide, or UF_6-resistant fully fluorinated hydrocarbon polymers having a purity of 99.9 per cent or more, a particle size less than 10 microns, and a high degree of particle size uniformity, which are especially prepared for the manufacture of gaseous diffusion barriers.

2. Diffuser housings

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

3. Compressors and gas blowers

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

4. Rotary shaft seals

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

5. Heat exchangers for cooling UF_6

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

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

Introductory Note:

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

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

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:
   a. Feed autoclaves (or systems), used for passing UF_6 to the gaseous diffusion cascades;
   b. Desublimers (or cold traps) used to remove UF_6 from diffusion cascades;
   c. Liquefaction stations where UF_6 gas from the cascade is compressed and cooled to form liquid UF_6;
   d. Product or tails stations used for transferring UF_6 into containers.

2. Header piping systems

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

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

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

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

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

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

5. 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_6 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 aerodynamic plant requires a number of these stages, so that quantities can provide an important indication of end use. Since aerodynamic processes use UF_6, all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that remain stable in contact with UF_6.

Explanatory Note:
The items listed in this section either come into direct contact with the UF_6 process gas or directly control the flow within the cascade. All surfaces which come into contact with the process gas are wholly made of or protected by UF_6-resistant materials. For the purposes of the section relating to aerodynamic enrichment items, the materials resistant to corrosion by UF_6 include copper, stainless steel, aluminum, aluminum alloys, nickel or alloys containing 60% or more nickel and UF_6-resistant fully fluorinated hydrocarbon polymers.

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_6 and having a knife-edge within the nozzle that separates the gas flowing through the nozzle into two fractions.

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_6, 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.

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_6 and with a suction volume capacity of 2 m^3/min or more of UF_6/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.

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 the inner chamber of the compressor or gas blower which is filled with a UF_6/carrier gas mixture.

5. Heat exchangers for gas cooling
Especially designed or prepared heat exchangers made of or protected by materials resistant to corrosion by UF_6.

6. Separation element housings
Especially designed or prepared separation element housings, made of or protected by materials resistant to corrosion by UF_6, 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.

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_6, including:

a. Feed autoclaves, ovens, or systems used for passing UF_6 to the enrichment process;
b. Desublimers (or cold traps) used to remove UF_6 from the enrichment process for subsequent transfer upon heating;
c. Solidification or liquefaction stations used to remove UF_6 from the enrichment process by compressing and converting UF_6 to a liquid or solid form;
d. Product or tails stations used for transferring UF_6 into containers.

8. Header piping systems

Especially designed or prepared header piping systems, made of or protected by materials resistant to corrosion by UF_6, for handling UF_6 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.

9. Vacuum systems and pumps

a. Especially designed or prepared vacuum systems having a suction capacity of 5 m^3/min or more, consisting of vacuum manifolds, vacuum headers and vacuum pumps, and designed for service in UF_6-bearing atmospheres;
b. Vacuum pumps especially designed or prepared for service in UF_6-bearing atmospheres and made of or protected by materials resistant to corrosion by UF_6. These pumps may use fluorocarbon seals and special working fluids.

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_6 with a diameter of 40 to 1500 mm for installation in main and auxiliary systems of aerodynamic enrichment plants.

11. UF_6 mass spectrometers/Ion sources

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

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

12. UF_6/carrier gas separation systems

Especially designed or prepared process systems for separating UF_6 from carrier gas (hydrogen or helium).

Explanatory Note:

These systems are designed to reduce the UF_6 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_6 from carrier gas; **or**
d. UF_6 cold traps capable of temperatures of -20 °C or less.

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 counter currently 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.

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.

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 polymers) or glass. The stage residence time of the columns is designed to be short (30 seconds or less).

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).

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.

      Explanatory Note:
      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).

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. 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,
   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.

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.

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 psi).

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}.

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 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 UF6 or a mixture of UF6 and other gases. All surfaces that come into contact with the uranium or UF6 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 UF6 include copper, stainless steel, aluminum, aluminum alloys, nickel or alloys containing 60% or more nickel and UF6-resistant fully fluorinated hydrocarbon polymers.

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.

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 (see Group 4) or mixtures thereof.

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:

   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.

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. 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.

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.

7. UF6/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.

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.

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 UF5 powder to UF6 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 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_6 are used.

10. UF_6 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_6 gas streams and having all of the following characteristics:
    1. Unit resolution for mass greater than 320;
    2. Ion sources constructed of or lined with nichrome or monel or nickel plated;
    3. Electron bombardment ionization sources;
    4. Collector system suitable for isotopic analysis.

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_6, including:
    a. Feed autoclaves, ovens, or systems used for passing UF_6 to the enrichment process;
    b. Desublimers (or cold traps) used to remove UF_6 from the enrichment process for subsequent transfer upon heating;
    c. Solidification or liquefaction stations used to remove UF_6 from the enrichment process by compressing and converting UF_6 to a liquid or solid form;
    d. Product or tails stations used for transferring UF_6 into containers.

12. UF_6/carrier gas separation systems (MLIS)
    Especially designed or prepared process systems for separating UF_6 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_6 cold traps capable of temperatures of -20°C or less.

13. Laser systems (AVLIS, MLIS and CRISLA)
    Lasers or laser systems especially designed or prepared for the separation of uranium isotopes.
    Explanatory Note:
    The lasers and laser components of importance in laser-based enrichment processes include those identified in Group 4. 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_2 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.

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 orbit. 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 (see Group 4), and metal removal systems for the collection of product and tails.

   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.

   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.

   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.

   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 (see Group 4) or mixtures thereof.

   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.

   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.

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 UCI4) 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.

   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:
         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.

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.

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.

3-2.6 Plants for the production or concentration of heavy water, deuterium and deuterium compounds and equipment and components especially designed or prepared therefor, including:

Introductory Note:

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

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

The ammonia-hydrogen exchange process can extract deuterium from synthesis gas through contact with liquid ammonia in the presence of a catalyst. The synthesis gas is fed into exchange towers and to an ammonia converter. Inside the towers the gas flows from the bottom to the top while the liquid ammonia flows from the top to the bottom. The deuterium is stripped 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 processes, items of equipment which individually are not especially designed or prepared for heavy water production can be assembled into systems which are especially designed or prepared for producing heavy water. The catalyst production system used in the ammonia-hydrogen exchange process and water distillation systems used for the final concentration of heavy water to reactor-grade in either process are examples of such systems.

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

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.

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

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.

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.

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

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.

8. Complete heavy water upgrade systems or columns therefor
   Complete heavy water upgrade systems, or columns therefor, especially designed or prepared for the upgrade of heavy water to reactor-grade deuterium concentration.
   Explanatory Note:
   These systems, which usually employ water distillation to separate heavy water from light water, are especially designed or prepared to produce reactor-grade heavy water (i.e., typically 99.75% deuterium oxide) from heavy water feedstock of lesser concentration.

3-2.7 Plants for the conversion of uranium and plutonium for use in the fabrication of fuel elements and the separation of uranium isotopes as defined in Items 3-2.4. and 3-2.5. respectively, and equipment and components especially designed or prepared therefor, including:

1. 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_3, conversion of UO_3 to UO_2, conversion of uranium oxides to UF_4, UF_6, or UCl_4, conversion of UF_4 to UF_6, conversion of UF_6 to UF_4, conversion of UF_4 to uranium metal, and conversion of uranium fluorides to UO_2. 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 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_2, ClF_3, and uranium fluorides) as well as nuclear criticality concerns. 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.

   1. Especially designed or prepared systems for the conversion of uranium ore concentrates to UO_3
      Explanatory Note:
      Conversion of uranium ore concentrates to UO_3 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_3 either by concentration and denitration or by neutralization with gaseous ammonia to produce ammonium diuranate with subsequent filtering, drying, and calcining.

   2. Especially designed or prepared systems for the conversion of UO_3 to UF_6
      Explanatory Note:
      Conversion of UO_3 to UF_6 can be performed directly by fluorination. The process requires a source of fluorine gas or chlorine trifluoride.

   3. Especially designed or prepared systems for the conversion of UO_3 to UO_2
      Explanatory Note:
      Conversion of UO_3 to UO_2 can be performed through reduction of UO_3 with cracked ammonia gas or hydrogen.

   4. Especially designed or prepared systems for the conversion of UO_2 to UF_4
      Explanatory Note:
      Conversion of UO_2 to UF_4 can be performed by reacting UO_2 with hydrogen fluoride gas (HF) at 300-500°C.

   5. Especially designed or prepared systems for the conversion of UF_4 to UF_6
      Explanatory Note:
      Conversion of UF_4 to UF_6 is performed by exothermic reaction with fluorine in a tower reactor. UF_6 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.

   6. Especially designed or prepared systems for the conversion of UF_4 to U metal
      Explanatory Note:
      Conversion of UF_4 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. Especially designed or prepared systems for the conversion of UF_6 to UO_2
      Explanatory Note:
      Conversion of UF_6 to UO_2 can be performed by one of three processes. In the first, UF_6 is reduced and hydrolyzed to UO_2 using hydrogen and steam. In the second, UF_6 is hydrolyzed by solution in water, ammonia is added to precipitate ammonium diuranate, and the diuranate is reduced to UO_2 with hydrogen at 820°C. In the third process, gaseous UF_6, CO_2, and NH_3 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_2. UF_6 to UO_2 conversion is often performed as the first stage of a fuel fabrication plant.

   8. Especially designed or prepared systems for the conversion of UF_6 to UF_4
      Explanatory Note:
      Conversion of UF_6 to UF_4 is performed by reduction with hydrogen.

   9. Especially designed or prepared systems for the conversion of UO_2 to UCl_4
      Explanatory Note:
      Conversion of UO_2 to UCl_4 can be performed by one of two processes. In the first, UO_2 is reacted with carbon tetrachloride (CCl_4) at approximately 400°C. In the second, UO_2 is reacted at approximately 700°C in the presence of carbon black (CAS 1333-86-4), carbon monoxide, and chlorine to yield UCl_4.

2. Plants for the conversion of plutonium and equipment especially designed or prepared therefor

   Introductory Note:

   Plutonium conversion plants and systems perform one or more transformations from one plutonium chemical species to another, including: conversion of plutonium nitrate to PuO_2, conversion of PuO_2 to PuF_4, and conversion of PuF_4 to plutonium metal. Plutonium conversion plants are usually associated with reprocessing facilities, but may also be associated with plutonium fuel fabrication facilities. Many of the key equipment items for plutonium conversion plants are common to several segments of the chemical process industry. For example, the types of equipment employed in these processes may include: furnaces, rotary kilns, fluidized bed reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. Hot cells, glove boxes and remote manipulators may also be required. However, few of the items are available off-the-shelf; most would be prepared according to the requirements and specifications of the customer. Particular care in designing for the special radiological, toxicity and criticality hazards associated with plutonium is essential. In some instances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (e.g. HF). Finally, it should be noted that, for all plutonium conversion processes, items of equipment which individually are not especially designed or prepared for plutonium conversion can be assembled into systems which are especially designed or prepared for use in plutonium conversion.

   1. Especially designed or prepared systems for the conversion of plutonium nitrate to oxide

      Explanatory Note:

      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. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. In most reprocessing facilities, this process involves the conversion of plutonium nitrate to plutonium dioxide. Other processes can involve the precipitation of plutonium oxalate or plutonium peroxide.

   2. Especially designed or prepared systems for plutonium metal production

      Explanatory Note:

      This process usually 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. The process systems are, particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. Other, processes include the fluorination of plutonium oxalate or plutonium peroxide followed by a reduction to metal.

3-3. Software

"Software" especially designed or modified for the "development", "production", or "use" of items specified in Group 3.

3-4. Technology

"Technology" according to the Nuclear Technology Note for the "development", "production", or "use" of items specified in Group 3.

Group 4 – Nuclear-Related Dual-Use List

(All destinations. All destinations applies to all Group 4 Items.)

Note:
Terms in 'single quotations' are usually defined within each entry of the list.
Terms in "double quotations" are defined at the end of Group 4.

***Canadian Nuclear Safety Commission (CNSC) Note*:**
The export of nuclear and nuclear-related items is also controlled by the CNSC under the Nuclear Safety and Control Act (NSCA) and Regulations. Therefore, the export of nuclear and nuclear-related items, not listed in Group 4 or which meet the specific Group 4 decontrol notes may still require a license from the CNSC. Information on export licensing requirements under the NSCA may be obtained by contacting the CNSC.

General Technology Note:
The export of "technology" required for the "development", "production" or "use" of items controlled in Group 4, is controlled according to the provisions of Group 4. This "technology" remains under control even when applicable to non-controlled items.
The approval of items for export also authorizes the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance and repair of the items.
Controls on "technology" transfer, do not apply to information "in the public domain" or to "basic scientific research".

General Software Note:
The export of "software" is controlled according to the provisions of Group 4. Group 4 does not control "software" which is either:
1. Generally available to the public by being:
   a. Sold from stock at retail selling points, without restriction, by means of:
      1. Over-the-counter transactions;
      2. Mail order transactions;
      3. Electronic Transactions; **or**
      4. Telephone call transactions; **and**
   b. Designed for installation by the user without further substantial support by the supplier; **or**
2. "In the public domain".

4-1. Industrial Equipment

4-1.A Equipment, Assemblies and Components

1. 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; **and**
   c. A thickness of 100 mm or greater.

   Technical Note:
   In Item 4-1.A.1.a. the term 'cold area' means the viewing area of the window exposed to the lowest level of radiation in the design application.

2. Radiation-hardened TV cameras, or lenses therefor, 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.

3. "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 (for example, 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 Item 4-1.A.3.a.

   Note:
   Item 4-1.A.3. does not control "robots" specially designed for non-nuclear industrial applications such as automobile paint-spraying booths.

4. 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 0.6 m or more of hot cell wall (through-the-wall operation); **or**
   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 or keypad.

4-1.B. Test and Production Equipment

1. 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. Which, 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.

   Note:
   Item 4-1.B.1. includes machines which have only a single roller designed to deform metal plus two auxiliary rollers which support the mandrel, but do not participate directly in the deformation process.

2. 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;

   N.B.:
   For "numerical control" units controlled by their associated "software", see Item 4-1.D.3.

   a. Machine tools for turning, that have "positioning accuracies" with all compensations available better (less) than 6 μm according to ISO 230/2 (1988) along any linear axis (overall positioning) for machines capable of machining diameters greater than 35 mm;

Note:
Item 4-1.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 is 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 230/2 (1988) along any linear axis (overall positioning);
   2. Two or more contouring rotary axes; **or**
   3. Five or more axes which can be coordinated simultaneously for "contouring control".

Note:
Item 4-1.B.2.b. does not control milling machines having both of the following characteristics:
1. X-axis travel greater than 2 m; **and**
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; **or**
   3. Five or more axes which can be coordinated simultaneously for "contouring control".

Note:
Item 4-1.B.2.c. does not control grinding machines as follows:
1. Cylindrical external, internal, and external-internal grinding machines having all the following characteristics:
   a. Limited to a maximum workpiece capacity of 150 mm outside diameter or length; **and**
   b. 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" 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 that can be coordinated simultaneously for "contouring control".

Notes:
1. Stated "positioning accuracy" levels derived under the following procedures from measurements made 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.
   Stated "positioning accuracy" are to be derived as follows:
   a. Select five machines of a model to be evaluated;
   b. Measure the linear axis accuracies according to ISO 230/2 (1988);
   c. Determine the accuracy values (A) for each axis of each machine. The method of calculating the accuracy value is described in the ISO 230/2 (1988) standard;
   d. Determine the average accuracy value of each axis. This average value becomes the stated "positioning accuracy" of each axis for the model (Âx, Ây...);
   e. Since Item 4-1.B.2. refers to each linear axis, there will be as many stated "positioning accuracy" values as there are linear axes;
   f. If any axis of a machine tool not controlled by Items 4-1.B.2.a., 4-1.B.2.b., or 4-1.B.2.c. has a stated "positioning accuracy" of 6 µm or better (less) for grinding machines, and 8 µm or better (less) for milling and turning machines, both according to ISO 230/2 (1988), then the builder should be required to reaffirm the accuracy level once every eighteen months.
2. Item 4-1.B.2. does not control special purpose machine tools limited to the manufacture of any of the following parts;
   a. Gears
   b. Crankshafts or cam shafts
   c. Tools or cutters
   d. 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 4-1.B.2. the number of axes which can be coordinated simultaneously for "contouring control" is the number of axes along or around which, during processing of the workpiece, simultaneous and interrelated motions are performed between the workpiece and a tool. 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, 4-1.B.2.a., 4-1.B.2.b. and 4-1.B.2.c.
6. Items 4-1.B.2.b.3. and 4-1.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.

3. Dimensional inspection machines, instruments, or systems, as follows:
   a. Computer controlled or numerically controlled dimensional inspection machines having both of the following characteristics:
      1. Two or more axes; **and**
      2. A one-dimensional length "measurement uncertainty" equal to or better (less) than (1.25 + L/ 1000) µm tested with a probe of an "accuracy" of better (less) than 0.2 µm (L is the measured length in millimeters) (Ref.: VDI/VDE 2617 parts 1 and 2);
   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; **and**
         b. Drift equal to or better (less) than 0.1% per day at a standard ambient test room temperature ±1K;
      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; **and**
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 4-1.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 4-1.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 4-1.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°.

Notes:
1. Item 4-1.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 4-1.B.3. are controlled if they exceed the threshold specified anywhere within their operating range.

Technical Notes:
1. The probe used in determining the "measurement uncertainty" of a dimensional inspection system shall be as described in VDI/VDE 2617 parts 2, 3 and 4.
2. All parameters of measurement values in this item represent plus/minus, i.e., not total band.

4. 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 5 kW or more;

      Note:
      Item 4-1.B.4.a. does not control furnaces designed for the processing of semiconductor wafers.

   b. Power supplies, with a specified output power of 5 kW or more, specially designed for furnaces specified in Item 4-1.B.4.a.
5. '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 4-1.B.5.a.

Technical Notes:
1. In Item 4-1.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 4-1.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.

6. 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 4-1.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 4-1.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 4-1.B.6.a.

Technical Note:
In Item 4-1.B.6. 'bare table' means a flat table, or surface, with no fixtures or fittings.

7. 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 cm^3; **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 4-1.B.7.a. or 4-1.B.7.b.

4-1.C. Materials

None.

4-1.D. Software

1. “Software” specially designed for the “use” of equipment specified in Item 4-1.A.3., 4-1.B.1., 4-1.B.3., 4-1.B.5., 4-1.B.6.a., 4-1.B.6.b., 4-1.B.6.d., or 4-1.B.7.

   Note:
   “Software” specially designed for systems specified in Item 4-1.B.3.d. includes “software” for simultaneous measurements of wall thickness and contour.

2. “Software” specially designed or modified for the “development”, “production”, or “use” of equipment specified in Item 4-1.B.2.
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 4-1.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 4-1.B.2.

4-1.E. Technology

1. “Technology” according to the General Technology Note for the “development”, “production” or “use” of equipment, material or “software” specified in 4-1.A. through 4-1.D.

4-2. Materials

4-2.A. Equipment, Assemblies and Components

1. Crucibles made of materials resistant to liquid actinide metals, as follows:
   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 (CaF_2);
         b. Calcium zirconate (metazirconate) ($CaZrO_3$);
         c. Cerium sulfide (Ce_2S_3);
         d. Erbium oxide (erbia) (Er_2O_3);
         e. Hafnium oxide (hafnia) (HfO_2);
         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) (ZrO_2);
   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.
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.
3. Composite structures in the form of tubes having both of the following characteristics:
   a. An inside diameter of between 75 and 400 mm; **and**
   b. Made with any of the “fibrous or filamentary materials” specified in Item 4-2.C.7.a. or carbon prepreg materials specified in Item 4-2.C.7.c.

4-2.B. Test and Production Equipment

1. Tritium facilities or plants, for the production, recovery, extraction, concentration or handling of tritium, tritium compounds or mixtures, and equipment especially designed or prepared, including equipment for:
   a. Hydrogen or helium refrigeration units capable of cooling to 23 K (-250°C) or less, with heat removal capacity greater than 150 W;
   b. Hydrogen isotope storage or purification systems using metal hydrides as the storage or purification medium.
2. Lithium isotope separation facilities or plants, and equipment therefor, 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.

4-2.C. Materials

1. 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); **and**
   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 4-2.C.1. the phrase ‘capable of’ encompasses aluminum alloys before or after heat treatment.

2. Beryllium metal, alloys containing more than 50% beryllium by weight, beryllium compounds, manufactures thereof, and waste or scrap of any of the foregoing.

   Note:
   Item 4-2.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. Beryl (silicate of beryllium and aluminum) in the form of emeralds or aquamarines.

3. Bismuth having both of the following characteristics:
   a. A purity of 99.99% or greater by weight; **and**
   b. Containing less than 10 parts per million by weight of silver.
4. Boron enriched in the boron-10 (^{10}B) 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 foregoing.
   Note:
   In Item 4-2.C.4. mixtures containing boron include boron loaded materials.
   Technical Note:
   The natural isotopic abundance of boron-10 is approximately 18.5 weight percent (20 atom percent).

5. 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.
6. Chlorine trifluoride (ClF_3).
7. “Fibrous or filamentary materials”, and prepregs, 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 x 10^4 m or greater;
      Note:
      Item 4-2.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:
      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;
   c. 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 4-2.C.7.a. or Item 4-2.C.7.b.
      Technical Note:
      The resin forms the matrix of the composite.

   Technical Notes:
   1. In Item 4-2.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%.
   2. In Item 4-2.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%.

8. 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 foregoing.

9. Lithium enriched in the lithium-6 (^{6}Li) 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 foregoing.
   Note:
   Item 4-2.C.9. does not control thermoluminescent dosimeters.
   Technical Note:
   The natural isotopic abundance of lithium-6 is approximately 6.5 weight percent (7.5 atom percent).

10. 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.

11. Maraging steel ‘capable of’ an ultimate tensile strength of 2050 MPa or more at 293 K (20°C).
    Note:
    Item 4-2.C.11. does not control forms in which all linear dimensions are 75 mm or less.
    Technical Note:
    In Item 4-2.C.11. the phrase ‘capable of’ encompasses maraging steel before or after heat treatment.

12. Radium-226 (^{226}Ra), radium-226 alloys, radium-226 compounds, mixtures containing radium-226, manufactures thereof, and products or devices containing any of the foregoing.
    Note:
    Item 4-2.C.12. does not control the following:
    a. Medical applicators;
    b. A product or device containing less than 0.37 GBq of radium-226.

13. 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); **and**
    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 4-2.C.13 the phrase ‘capable of’ encompasses titanium alloys before or after heat treatment.

14. 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 4-2.C.14. does not control manufactures specially designed as weights or gamma-ray collimators.

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, waste or scrap of any of the foregoing.
    Note:
    Item 4-2.C.15. does not control zirconium in the form of foil having a thickness of 0.10 mm or less.

16. Nickel powder and porous nickel metal, as follows:
    N.B.
    For nickel powders which are especially prepared for the manufacture of gaseous diffusion barriers see Group 3, Item 3-2.5.3.

    a. Nickel powder having both of 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 4-2.C.16.a.

Technical Note:

Item 4-2.C.16.b. refers to porous metal formed by compacting and sintering the material in Item 4-2.C.16.a. to form a metal material with fine pores interconnected throughout the structure.

Note:

Item 4-2.C.16. does not control the following:

a. Filamentary nickel powders;

b. Single porous nickel metal sheets with an area of 1000 cm^2 per sheet or less.

17. 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 foregoing.

Note:

Item 4-2.C.17. does not control a product or device containing less than 1.48×10^3 GBq of tritium.

18. Helium-3 (^{3}He), mixtures containing helium-3, and products or devices containing any of the foregoing.

Note:

Item 4-2.C.18. does not control a product or device containing less than 1 g of helium-3.

19. 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 foregoing.

Note:

Item 4-2.C.19. does not control a product or device containing less than 3.7 GBq of alpha activity.

4-2.D. Software

None

4-2.E. Technology

1. “Technology” according to the General Technology Note for the “development”, “production” or “use” of equipment, material or “software” specified in 4-2.A. through 4-2.D.

4-3. Uranium Isotope Separation Equipment and Components (Other than listed in Group 3)

4-3.A. Equipment, Assemblies and Components

1. Frequency changers or generators having all of the following characteristics:

N.B.:

Frequency changers and generators especially designed or prepared for the gas centrifuge process are controlled under Group 3, Item 3-2.5.1.

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 4-3.A.1. are also known as converters or inverters.

2. Lasers, 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 4-3.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 4-3.A.2.g. does not control the higher power (typically 1 to 5 kW) industrial CO_2 lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width 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. 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 4-3.A.3.a. refers to the smallest diameter.

4. 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 4-3.A.4 does not control magnets specially designed for and exported ‘as part of’ medical nuclear magnetic resonance (NMR) imaging systems.
N.B.
‘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.

5. 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.

6. 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.

7. 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; **or**
      2. A full scale of 13 kPa or greater and an “accuracy” of better than ± 130 Pa.

Technical Notes:
1. In Item 4-3.A.7. pressure transducers are devices that convert pressure measurements into an electrical signal.
2. In Item 4-3.A.7. “accuracy” includes non-linearity, hysteresis and repeatability at ambient temperature.

8. 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 15 m^3/s; and
   c. Capable of producing an ultimate vacuum better than 13.3 mPa.

Technical Notes:
1. The pumping speed is determined at the measurement point with nitrogen gas or air.
2. The ultimate vacuum is determined at the input of the pump with the input of the pump blocked off.

4-3.B. Test and Production Equipment

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

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 4-3.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 4-3.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 4-3.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. Centrifugal multiplane balancing machines, fixed or portable, horizontal or vertical, as follows:
   a. Centrifugal balancing machines designed for balancing flexible rotors having a length of 600 mm or more and having all of the following characteristics:
      1. 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.

4. 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 4-3.B.4.a.;
   c. Precision mandrels for the filament winding machines specified in Item 4-3.B.4.a.

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.

Notes:

1. Item 4-3.B.5. includes separators capable of enriching stable isotopes as well as those for uranium.

   N.B:

   A separator capable of separating the isotopes of lead with a one-mass unit difference is inherently capable of enriching the isotopes of uranium with a three-unit mass difference.
2. Item 4-3.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.

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:

N.B.:

Mass spectrometers especially designed or prepared for analyzing on-line samples of uranium hexafluoride are controlled under Group 3.

   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 UF_6;
   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 UF_6;
   f. Mass spectrometers equipped with a microfluorination ion source designed for actinides or actinide fluorides.

4-3.C. Materials

None.

4-3.D. Software

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

4-3.E. Technology

1. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-3.A. through 4-3.D.

4-4. Heavy Water Production Plant Related Equipment (Other than listed in Group 3)

4-4.A. Equipment, Assemblies and Components

1. Specialized packings 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.

2. Pumps capable of circulating solutions of concentrated or dilute potassium amide catalyst in liquid ammonia (KNH_2/NH_3), having all of the following characteristics:
   a. Airtight (i.e., hermetically sealed);
   b. A capacity greater than 8.5 m^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; **or**
      2. For dilute potassium amide solutions (less than 1%), an operating pressure of 20 to 60 MPa.

3. 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.

4-4.B. Test and Production Equipment

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

   N.B.:

   For columns which are especially designed or prepared for the production of heavy water, see Group 3.

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 4-4.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.

2. 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 H_2-compatible; **and**
   d. With internal diameters of 1 m or greater and effective lengths of 5 m or greater.

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 said column.

4-4.C. Materials

None.

4-4.D. Software

None.

4-4.E. Technology

1. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-4.A. through 4-4.D.

4-5. Test and Measurement Equipment for the Development of Nuclear Explosive Devices

4-5.A. Equipment, Assemblies and Components

1. 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.

4-5.B. Test and Production Equipment

1. 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 4-5.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 Notes:
   1. The figure of merit K is defined as: $K=1.7 \times 10^3 V^{2.65}Q$. 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.
   2. Peak power = (peak potential in volts) x (peak beam current in amperes).
   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.
   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.

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.

3. 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 4-5.B.3. components of such cameras include their synchronizing electronics units and rotor assemblies consisting of turbines, mirrors, and bearings.

4. 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 4-5.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 4-5.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. Keff 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 4-5.B.4.c.

5. 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;
      Note:
      Item 4-5.B.5.a. includes velocity interferometers such as VISARs (Velocity interferometer systems for any reflector) and DLIs (Doppler laser interferometers).

   b. Manganin gauges for pressures greater than 10 GPa;
   c. Quartz pressure transducers for pressures greater than 10 GPa.

6. High-speed pulse generators having both of 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 4-5.B.6.b. 'pulse transition time' is defined as the time interval between 10% and 90% voltage amplitude.

4-5.C. Materials

None.

4-5.D. Software

None.

4-5.E. Technology

"Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-5.A. through 4-5.D.

4-6. Components for Nuclear Explosive Devices

4-6.A. Equipment, Assemblies and Components

1. 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 (EPI);
   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 4-6.A.1. does not control detonators using only primary explosives, such as lead azide.
Technical Note:
In Item 4-6.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.

2. Firing sets and equivalent high-current pulse generators, as follows:
   a. Explosive detonator firing sets designed to drive multiple controlled detonators specified by Item 4-6.A.1. above;
   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 4-6.A.2.b. includes xenon flashlamp drivers.
      Technical Note:
      In Item 4-6.A.2.b.5. 'rise time' is defined as the time interval from 10% to 90% current amplitude when driving a resistive load.

3. 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 4-6.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.

4. 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.

5. 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.

4-6.B. Test and Production Equipment

None.

4-6.C. Materials

1. 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.

4-6.D. Software

None.

4-6.E. Technology

1. “Technology” according to the General Technology Note for the “development”, “production” or “use” of equipment, material or “software” specified in 4-6.A. through 4-6.D.

Definitions of Terms used in Groups 3 and 4

"Accuracy"

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

"Active tooling unit"

Device for applying motive power, procress energy or sensing to the workpiece.

"Angular position deviation"

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

"Basic scientific research"

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

"Contouring control"

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

"Development"

Is related to all phases prior to "production", such as: design, design research, design analysis, design concepts, assembly and testing of prototypes, pilot production schemes, design data, process of transforming design data into a product, configuration design, integration design, layouts.

"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.

"Fibrous or filamentary materials"

Means continuous 'filament', 'monofilaments', 'yarns', 'rovings', 'tows', or 'tapes'.

N.B.:

'Filament' or 'monofilament' is the smallest increment of fibre, usually several µm in diameter.

'Roving' is a bundle (typically 12-120) of approximately parallel 'strands'.

'Strand' is a bundle of 'filaments' (typically over 200) arranged approximately parallel.

'Tape' is a material constructed of interlaced or unidirectional 'filaments', 'strands', 'rovings', 'tows', or 'yarns', etc., usually preimpregnated with resin.

'Tow' is a bundle of 'filaments', usually approximately parallel.

'Yarn' is a bundle of twisted 'strands'.

"In the public domain"

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

"Linearity"

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

"Measurement uncertainty"

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

"Microprogram"

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

"Numerical control"

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

"Positioning accuracy"

Of "numerically controlled" machine tools is to be determined and presented in accordance with Item 4-1.B.2., in conjunction with the requirements below:

a. Test conditions (ISO 230/2 (1988), paragraph 3):
   1. For 12 hours before and during measurements, the machine tool and accuracy measuring equipment will be kept at the same ambient temperature. During the premeasurement time, the slides of the machine will be continuously cycled identically to the way they will be cycled during the accuracy measurements;
   2. The machine shall be equipped with any mechanical, electronic, or "software" compensation to be exported with the machine;
   3. Accuracy of measuring equipment for the measurements shall be at least four times more accurate than the expected machine tool accuracy;
   4. Power supply for slide drives shall be as follows:
      a. Line voltage variation shall not be greater than ±10% of nominal rated voltage;
      b. Frequency variation shall not be greater than ±2 Hz of normal frequency;
      c. Lineouts or interrupted service are not permitted.
b. Test Program (paragraph 4):
   1. Feed rate (velocity of slides) during measurement shall be the rapid traverse rate;

      N.B.:

      In the case of machine tools which generate optical quality surfaces, the feed rate shall be equal to or less than 50 mm per minute;

   2. Measurements shall be made in an incremental manner from one limit of the axis travel to the other without returning to the starting position for each move to the target position;

3. Axes not being measured shall be retained at mid-travel during test of an axis.

c. Presentation of test results (paragraph 2): The results of the measurements must include:
1. "positioning accuracy" (A) **and**
2. The mean reversal error (B).

"Production"

Means all production phases, such as: construction, production engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

"Program"

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

"Resolution"

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

"Robot"

A manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use "sensors" and has all the following characteristics:

a. Is multifunctional;
b. Is capable of positioning or orienting material, parts, tools or special devices through variable movements in three-dimensional space;
c. Incorporates three or more closed or open loop servo-devices which may include stepping motors; and
d. Has "user-accessible programmability" by means of teach/playback method or by means of an electronic computer which may be a programmable logic controlled, (i.e. without mechanical intervention).

N.B.:

The above definition does not include the following devices:

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

"Roving"

See "Fibrous and filamentary materials".

"Sensors"

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

"Software"

A collection of one or more "programs" or "microprograms" fixed in any tangible medium of expression.

"Tape"

See "Fibrous or filamentary materials".

"Technical assistance"

May take forms, such as: instruction, skills, training, working knowledge, consulting services.

N.B.:

"Technical assistance" may involve transfer of "technical data".

"Technical data"

May take forms such as blueprints, plans, drawings, photoprints or negatives, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions, whether in written form or recorded on other media or devices such as disk, tape, read-only memories.

"Technology"

Specific information required for the "development", "production" or "use", of an item. This information may take the form of "technical data" or "technical assistance".

"Tow"

See "Fibrous and filamentary materials".

"Use"

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

"User-accessible programmability"

The facility allowing a user to insert, modify of 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.

"Yarn"

See "Fibrous and filamentary materials".

Group 5 – Miscellaneous Goods and Technology

Medical Products

5001. Pancreas glands of cattle and calves. *(All destinations)*

5011. Human serum albumin. *(All destinations)*

Forest Products

5101. Logs of all species of wood. *(All destinations)*

5102. Pulpwood of all species of wood. *(All destinations)*

5103. Blocks, bolts, blanks, boards and any other material or product of red cedar that is suitable for use in the manufacture of shakes or shingles. *(All destinations)*

5104. Softwood Lumber Products

1. Softwood lumber products set out in Annex 1A to the softwood lumber agreement, excluding item 5(e). *(United States)*
2. The references to the Harmonized Tariff Schedule of the United States (HTSUS) tariff classifications in Annex 1A to the softwood lumber agreement are to be read as references to the corresponding tariff classifications according to the Canadian Table of Concordance in Annex 1B to that agreement.
3. The references to “imported” and “importation” in Annex 1A to the softwood lumber agreement are to be read as “exported” and “exportation”, respectively, and the reference to “importés” in Annex 1B to the French version of that agreement is to be read as “exportés”.

Agriculture and Food Products

5201. Peanut Butter that is classified under tariff item No. 2008.11.10 in the list of Tariff Provisions set out in the schedule to the *Customs Tariff*.
(All destinations)

5202. Roe Herring *(All destinations)*

Roe herring from which the roe has not been extracted and that were caught in those parts of the following areas adjacent to the coast of British Columbia:

a. the territorial sea of Canada as determined under section 4 of the *Oceans Act*;
b. the internal waters of Canada as determined under section 6 of that Act; **or**
c. the fishing zones of Canada as determined under section 16 of that Act and prescribed by regulations made under paragraph 25(b) of that Act.

5203. Sugar-containing Products

Sugar-containing products that are classified under subheadings 1701.91.54, 1704.90.74, 1806.20.75, 1806.20.95, 1806.90.55, 1901.90.56, 2101.12.54, 2101.20.54, 2106.90.78 and 2106.90.95 of the *Harmonised Tariff Schedule of the United States* (1999) (United States International Trade Commission Pub. 2831, 19 U.S.C. § 1202 (1988)). *(United States)*

5204. Sugars, Syrups and Molasses

Sugars, Syrups and Molasses that are classified under subheadings 1701.12.10, 1701.91.10, 1701.99.10, 1702.90.10, and 2106.90.44 of the *Harmonised Tariff Schedule of the United States* (1995) (United States International Trade Commission Pub. 2831, 19 U.S.C. § 1202 (1988)). *(United States)*

Foreign Origin Goods and Technology

United States Origin Goods and Technology

5400. United States Origin Goods and Technology

All goods and technology of United States origin, unless they are included elsewhere in this List, whether in bond or cleared by the Canada Border Services Agency, other than goods or technology that have been further processed or manufactured outside the United States so as to result in a substantial change in value, form or use of the goods or technology or in the production of new goods or technology.
(All destinations other than the United States)

Goods and Technology in Transit

5401. Goods and Technology in Transit

1. All goods and technology that originate outside Canada that are included in this List, whether in bond or cleared by the Canada Border Services Agency, other than goods or technology that are in transit on a through journey on a billing that originates outside Canada if the billing

a. indicates that the ultimate destination of the goods or technology is a country other than Canada; *(All destinations other than the United States)* **and**
b. in the case of goods or technology that are shipped from the United States, is accompanied by a certified true copy of the United States *Shipper's Export Declaration*, and that Declaration does not contain terms that conflict with those of the billing and is presented to the Canada Border Services Agency. *(All destinations other than the United States)*

Other Military and Strategic Goods and Technology

5501. Blinding Laser Weapons.

Laser weapons that are specifically designed, as their sole combat function or as one of their combat functions, to cause permanent blindness to the naked eye or to the eye with corrective eyesight devices.
(All destinations).

5502. Nuclear Fusion Reactors.

1. Subject to subitem 2., systems, equipment, material, components, software and technology for use in research, development, design, testing, demonstration, or training related to nuclear fusion or the construction and operation of a nuclear fusion reactor, including:
   a. reactor assemblies incorporating toroidal and poloidal field coils;
   b. independent electrical and magnet power supply systems;
   c. high-power microwave radio frequency systems; **and**
   d. feedback, control and data acquisition systems.

(All destinations)

2. This item does not apply to data:
   a. that is contained in published books or periodicals or that is otherwise available to the public; **or**
   b. that has been made available without restrictions on its further dissemination.

5503. Anti-personnel Mines.

Anti-personnel mines as defined in section 2 of the *Anti-Personnel Mines Convention Implementation Act.*
(All destinations)

5504. Strategic Goods and Technology

1. In this item the terms “development”, “production”, “software”, “spacecraft”, “technology” and “use” have the same meaning as in the provision entitled “Definitions for Terms in Groups 1 and 2” of the Guide.
2. Strategic goods and technology as follows:
   a. goods and technology referred to in Group 1 of the Guide as follows:
      i. Global navigation satellite systems receiving equipment referred to in item 1-7.A.5. of the Guide, the associated software referred to in item 1-7.D. of the Guide, and the associated technology referred to in item 1-7.E. of the Guide, **and**
      ii. propulsion and space-related equipment referred to in items 1-9.A.4. to 1-9.A.11. of the Guide, the associated software referred to in item 1-9.D. of the Guide, and the associated technology referred to in item 1-9.E. of the Guide;
   b. subject to the General Software Note in Group 1 of the Guide, software that is specially designed or modified for the development or use of the goods or technology referred to in paragraphs d. to i.;
   c. subject to the General Technology Note in Group 1 of the Guide, technology that is specially designed or modified for the development or production of the goods or technology referred to in paragraphs d. to i.;
   d. payloads specially designed or modified for “spacecraft”, and specially designed components therefor not controlled elsewhere by Group 1 of the Guide;
   e. ground control stations for telemetry, tracking and control of space launch vehicles or “spacecraft”, and specially designed components therefor;
   f. chemiluminescent compounds specially designed or modified for military use, and specially designed components therefor;
   g. radiation-hardened microelectronic circuits that meet or exceed all of the following, and specially designed components therefor, namely:
      i. a total dose of 5×10^5 Rads (SI);
      ii. a dose rate upset of 5×10^8 Rads (SI)/s;
      iii. a neutron dose of 1×10^{14} N/cm^2;
      iv. a single event upset of 1×10^{-7} or less error/bit/day; **and**
      v. single event latch-up free and having a dose rate latch-up of 5×10^8 Rads (SI)/s or greater;

(All destinations other than United States)

   h. nuclear weapons design and test equipment, as follows:
      i. any article, material, equipment or device which is specially designed or modified for use in the design, development or fabrication of nuclear weapons or nuclear explosive devices;
      (All destinations)
      ii. any article, material, equipment or device which is specially designed or modified for use in the devising, carrying out or evaluating of nuclear weapons tests or other nuclear explosions;
      (All destinations)
      and
   i. any other articles not specifically set out in paragraphs a. to h. or in Group 2 or Group 6 that are United States origin goods or technology, which have been determined under Parts 120 to 130 of Title 22 of the International Traffic in Arms Regulations of the Code of Federal Regulations (United States) as having substantial military applicability, and which have been specially designed or modified for military purposes.

(All destinations other than United States)

5505. Goods and Technology for Certain Uses (Catch-all)

All goods and technology not listed elsewhere in this List

a. that are intended for use in
    i. the development, production, handling, operation, maintenance, storage, detection, identification or dissemination of chemical, biological or nuclear weapons, or of materials or equipment that could be used in such weapons,
    ii. the development, production, handling, operation, maintenance or storage of missiles capable of delivering chemical, biological or nuclear weapons, or of materials or equipment that could be used in such missiles, **or**
    iii. any chemical, biological or nuclear weapons facility or missile facility; **or**
b. in respect of which there are reasonable grounds to suspect that the goods or technology are intended for use in
    i. the development, production, handling, operation, maintenance, storage, detection, identification or dissemination of chemical, biological or nuclear weapons, or of materials or equipment that could be used in such weapons,
    ii. the development, production, handling, operation, maintenance or storage of missiles capable of delivering chemical, biological or nuclear weapons, or of materials or equipment that could be used in such missiles, **or**
    iii. any chemical, biological or nuclear weapons facility or missile facility.

(All destinations other than Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Republic of Korea, Romania, the Russian Federation, the Slovak Republic, South Africa, Spain, Sweden, Switzerland, Ukraine, the United Kingdom, and the United States; provided that the final destination of the goods or technology is one of these countries).

Group 6 – Missile Technology Control Regime List

Note:
Terms in "double quotation marks" are defined terms. Refer to Definitions at the end of Group 6.
***General Technology Note*:**
The transfer of "technology" directly associated with any goods controlled in Group 6 is controlled according to the provisions in each Item to the extent permitted by national legislation. The approval of any Group 6 item for export also authorizes the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance, and repair of the item.
Note:
Controls do not apply to "technology" "in the public domain" or to "basic scientific research".
***General Software Note*:**
Group 6 does not control "software" which is either:

1. Generally available to the public by being:
   a. Sold from stock at retail selling points without restriction, by means of:
      1. Over-the-counter transactions;
      2. Mail order transactions; **or**
      3. Telephone call transactions; **and**

   b. Designed for installation by the user without further substantial support by the supplier; **or**
2. "In the public domain".

Note:
The General Software Note only applies to general purpose, mass market "software".
***Chemical Abstracts Service (CAS) Numbers*:**
In some instances chemicals are listed by name and CAS number. Chemicals of the same structural formula (including hydrates) are controlled regardless of name or CAS number. CAS numbers are shown to assist in identifying whether a particular chemical or mixture is controlled, irrespective of nomenclature. CAS numbers cannot be used as unique identifiers because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.

CATEGORY I

6-1. Complete Delivery Systems

(All destinations. All destinations applies to all 6-1 Items.)

6-1.A. Equipment, Assemblies and Components

1. Complete rocket systems (including ballistic missile systems, space launch vehicles, and sounding rockets) capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km.
2. Complete unmanned aerial vehicle systems (including cruise missile systems, target drones and reconnaissance drones) capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km.

6-1.B. Test and Production Equipment

1. "Production facilities" specially designed for the systems specified in 6-1.A.

6-1.C. Materials

None.

6-1.D. Software

1. "Software" specially designed or modified for the "use" of "production facilities" specified in 6-1.B.
2. "Software" which coordinates the function of more than one subsystem, specially designed or modified for "use" in systems specified in 6-1.A.

6-1.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-1.A., 6-1.B., or 6-1.D.

6-2 Complete Subsystems Usable for Complete Delivery Systems

(All destinations. All destinations applies to all 6-2 Items.)

6-2.A. Equipment, Assemblies and Components

1. Complete subsystems usable in the systems specified in 6-1.A., as follows:
   a. Individual rocket stages usable in the systems specified in 6-1.A.;
   b. Re-entry vehicles, and equipment designed or modified therefor, usable in the systems specified in 6-1.A., as follows, except as provided in the Note below 6-2.A.1. for those designed for non-weapon payloads:
      1. Heat shields, and components thereof, fabricated of ceramic or ablative materials;
      2. Heat sinks and components thereof fabricated of light-weight, high heat capacity materials;
      3. Electronic equipment specially designed for re-entry vehicles;

   c. Solid propellant rocket motors or liquid propellant rocket engines, usable in the systems specified in 6-1.A., having a total impulse capacity equal to or greater than 1.1×10^6 Ns;
      Note:
      Liquid propellant apogee engines specified in 6-2.A.1.c., designed or modified for satellite applications, may be treated as Category II, if the subsystem is exported subject to end-use statements and quantity limits appropriate for the excepted end-use stated above, when having all of the following parameters:
      a. Nozzle throat diameter of 20 mm or less; **and**
      b. Combustion chamber pressure equal to or less than 15 bar.

   d. 'Guidance sets', usable in the systems specified in 6-1.A., capable of achieving system accuracy of 3.33% or less of the "range" (e.g. a 'CEP' of 10 km or less at a "range" of 300 km), except as provided in the Note below 6-2.A.1. for those designed for missiles with a "range" under 300 km or manned aircraft;

Technical Notes:
1. A ´guidance set´ integrates the process of measuring and computing a vehicle's position and velocity (i.e. navigation) with that of computing and sending commands to the vehicle's flight control systems to correct the trajectory.
2. ´CEP´ (circle of equal probability) is a measure of accuracy, defined as the radius of the circle centred at the target, at a specific range, in which 50% of the payloads impact.

e. Thrust vector control sub-systems, usable in the systems specified in 6-1.A., except as provided in the Note below 6-2.A.1. for those designed for rocket systems that do not exceed the "range"/"payload" capability of systems specified in 6-1.A.;

Technical Note:
6-2.A.1.e. includes the following methods of achieving thrust vector control:
a. Flexible nozzle;
b. Fluid or secondary gas injection;
c. Movable engine or nozzle;
d. Deflection of exhaust gas stream (jet vanes or probes);
e. Use of thrust tabs.

f. Weapon or warhead safing, arming, fuzing, and firing mechanisms, usable in the systems specified in 6-1.A., except as provided in the Note below 6-2.A.1. for those designed for systems other than those specified in 6-1.A.

Note:
The exceptions in 6-2.A.1.b., 6-2.A.1.d., 6-2.A.1.e. and 6-2.A.1.f. above may be treated as Category II if the subsystem is exported subject to end-use statements and quantity limits appropriate for the excepted end-use stated above.

6-2.B. Test and Production Equipment

1. "Production facilities" specially designed for the subsystems specified in 6-2.A.
2. "Production equipment" specially designed for the subsystems specified in 6-2.A.

6-2.C. Materials

None.

6-2.D. Software

1. "Software" specially designed or modified for the "use" of "production facilities" specified in 6-2.B.1.
2. "Software" specially designed or modified for the "use" of rocket motors or engines specified in 6-2.A.1.c.
3. "Software", specially designed or modified for the "use" of 'guidance sets' specified in 6-2.A.1.d.

   Note:
   6-2.D.3. includes "software", specially designed or modified to enhance the performance of ´guidance sets´ to achieve or exceed the accuracy specified in 6-2.A.1.d.

4. "Software" specially designed or modified for the "use" of subsystems or equipment specified in 6-2.A.1.b.3.
5. "Software" specially designed or modified for the "use" of systems in 6-2.A.1.e.
6. "Software" specially designed or modified for the "use" of systems in 6-2.A.1.f.

Note:
Subject to end-use statements appropriate for the excepted end-use, "software" controlled by 6-2.D.2. to 6-2.D.6. may be treated as Category II as follows:
1. Under 6-2.D.2. if specially designed or modified for liquid propellant apogee engines, designed or modified for satellite applications as specified in the Note to 6-2.A.1.c.;
2. Under 6-2.D.3. if designed for missiles with a "range" of under 300 km or manned aircraft;
3. Under 6-2.D.4. if specially designed or modified for re-entry vehicles designed for non-weapon payloads;
4. Under 6-2.D.5. if designed for rocket systems that do not exceed the "range" "payload" capability of systems specified in 6-1.A.;
5. Under 6-2.D.6. if designed for systems other than those specified in 6-1.A.

6-2.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-2.A., 6-2.B. or 6-2.D.

CATEGORY II

6-3 Propulsion Components and Equipment

6-3.A. Equipment, Assemblies and Components

1. Turbojet and turbofan engines (including turbocompound engines), as follows:
   a. Engines having both of the following characteristics:
      1. Maximum thrust value greater than 400 N (achieved un-installed) excluding civil certified engines with a maximum thrust value greater than 8.89 kN (achieved un-installed); **and**
      2. Specific fuel consumption of 0.15 kg N^{-1} h^{-1} or less (at maximum continuous power at sea level static and standard conditions);
   b. Engines designed or modified for systems specified in 6-1.A., regardless of thrust or specific fuel consumption.

Note:
Governments may permit the export of engines specified in 6-3.A.1. as part of a manned aircraft or in quantities appropriate for replacement parts for a manned aircraft.

2. Ramjet/scramjet/pulse jet/combined cycle engines, including devices to regulate combustion, and specially designed components therefor, usable in the systems specified in 6-1.A. or 6-19.A.2.
3. Rocket motor cases, 'insulation' components and nozzles therefor, usable in the systems specified in 6-1.A.

   Technical Note:
   In 6-3.A.3. ´insulation´ intended to be applied to the components of a rocket motor, i.e. the case, nozzle inlets, case closures, includes cured or semi-cured compounded rubber components comprising sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps.

Note:
Refer to 6-3.C.2. for ´insulation´ material in bulk or sheet form.

4. Staging mechanisms, separation mechanisms, and interstages therefor, usable in the systems specified in 6-1.A.
5. Liquid and slurry propellant (including oxidisers) control systems, and specially designed components therefor, usable in the systems specified in 6-1.A., designed or modified to operate in vibration environments greater than 10 g rms between 20 Hz and 2 kHz.

Notes:
1. The only servo valves and pumps specified in 6-3.A.5. are the following:
   a. Servo valves designed for flow rates equal to or greater than 24 litres per minute, at an absolute pressure equal to or greater than 7 MPa, that have an actuator response time of less than 100 ms.
   b Pumps, for liquid propellants, with shaft speeds equal to or greater than 8,000 rpm or with discharge pressures equal to or greater than 7 MPa.
2 Governments may permit the export of systems and components specified in 6-3.A.5. as part of a satellite.

6. Hybrid rocket motors and specially designed components therefor, usable in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.
7. Radial ball bearings having all tolerances specified in accordance with ISO 492 Tolerance Class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or other national equivalents), or better and having all the following characteristics:
   a. An inner ring bore diameter between 12 and 50 mm;
   b. An outer ring outside diameter between 25 and 100 mm; **and**
   c. A width between 10 and 20 mm.
8. Liquid propellant tanks specially designed for the propellants controlled in Item 6-4.C. or other liquid propellants used in the systems specified in 6-1.A.1.

6-3.B. Test and Production Equipment

1. "Production facilities" specially designed for equipment or materials specified in 6-3.A.1., 6-3.A.2., 6-3.A.3., 6-3.A.4., 6-3.A.5., 6-3.A.6. or 6-3.C.
2. "Production equipment" specially designed for equipment or materials specified in 6-3.A.1., 6-3.A.2., 6-3.A.3., 6-3.A.4., 6-3.A.5., 6-3.A.6. or 6-3.C.
3. Flow-forming machines, and specially designed components therefor, which:
   a. According to the manufacturers technical specification can be equipped with numerical control units or a computer control, even when not equipped with such units at delivery; **and**
   b. Have more than two axes which can be co-ordinated simultaneously for contouring control.

Technical Note:
Machines combining the function of spin-forming and flow-forming are, for the purpose of this item, regarded as flow-forming machines.

Note:
This item does not include machines that are not usable in the "production" of propulsion components and equipment (e.g. motor cases) for systems specified in 6-1.A.

6-3.C. Materials

1. 'Interior lining' usable for rocket motor cases in the systems specified in 6-1.A. or specially designed for systems specified in 6-19.A.1. or 6-19.A.2.

Technical Note:
In 6-3.C.1. ´interior lining´ suited for the bond interface between the solid propellant and the case or insulating liner is usually a liquid polymer based dispersion of refractory or insulating materials e.g. carbon filled HTPB or other polymer with added curing agents to be sprayed or screeded over a case interior.

2. 'Insulation' material in bulk form usable for rocket motor cases in the systems specified in 6-1.A. or specially designed for systems specified in 6-19.A.1. or 6-19.A.2.

Technical Note:
In 6-3.C.2. ´insulation´ intended to be applied to the components of a rocket motor, i.e. the case, nozzle inlets, case closures, includes cured or semi-cured compounded rubber sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps specified in 6-3.A.3.

6-3.D. Software

1. "Software" specially designed or modified for the "use" of "production facilities" and flow forming machines specified in 6-3.B.1. or 6-3.B.3.
2. "Software" specially designed or modified for the "use" of equipment specified in 6-3.A.1., 6-3.A.2., 6-3.A.4., 6-3.A.5. or 6-3.A.6.

Notes:
1. Governments may permit the export of "software" specially designed or modified for the "use" of engines specified in 6-3.A.1. as part of a manned aircraft or as replacement "software" therefor.
2. Governments may permit the export of "software" specially designed or modified for the "use" of propellant control systems specified in 6-3.A.5. as part of a satellite or as replacement "software" therefor.

3. "Software" specially designed or modified for the "development" of equipment specified in 6-3.A.2., 6-3.A.3. or 6-3.A.4.

6-3.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 6-3.A.1., 6-3.A.2., 6-3.A.3., 6-3.A.4., 6-3.A.5., 6-3.A.6., 6-3.B., 6-3.C. or 6-3.D.

6-4 Propellants, Chemicals and Propellant Production

6-4.A. Equipment, Assemblies and Components

None.

6-4.B. Test and Production Equipment

1. “Production equipment”, and specially designed components therefor, for the “production”, handling or acceptance testing of liquid propellants or propellant constituents specified in 6-4.C.
2. “Production equipment”, other than that described in 6-4.B.3., and specially designed components therefor, for the production, handling, mixing, curing, casting, pressing, machining, extruding or acceptance testing of solid propellants or propellant constituents specified in 6-4.C.
3. Equipment as follows, and specially designed components therefor:
   a. Batch mixers with provision for mixing under vacuum in the range of zero to 13.326 kPa and with temperature control capability of the mixing chamber and having all of the following:
      1. A total volumetric capacity of 110 litres or more; **and**
      2. At least one mixing/kneading shaft mounted off centre;
   b. Continuous mixers with provision for mixing under vacuum in the range of zero to 13.326 kPa and with a temperature control capability of the mixing chamber having any of the following:
      1. Two or more mixing/kneading shafts; **or**
      2. A single rotating shaft which oscillates and having kneading teeth/pins on the shaft as well as inside the casing of the mixing chamber;
   c. Fluid energy mills usable for grinding or milling substances specified in 6-4.C.;
   d. Metal powder “production equipment” usable for the “production”, in a controlled environment, of spherical or atomised materials specified in 6-4.C.2.c., 6-4.C.2.d. or 6-4.C.2.e.

      Note:
      6-4.B.3.d. includes:
      a. Plasma generators (high frequency arc-jet) usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;
      b. Electroburst equipment usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;
      c. Equipment usable for the “production” of spherical aluminium powders by powdering a melt in an inert medium (e.g. nitrogen).

Notes:
1. The only batch mixers, continuous mixers, usable for solid propellants or propellants constituents specified in 6-4.C., and fluid energy mills specified in 6-4.B., are those specified in 6-4.B.3.
2. Forms of metal powder “production equipment” not specified in 6-4.B.3.d. are to be evaluated in accordance with 6-4.B.2.

6-4.C. Materials

1. Composite and composite modified double base propellants.
2. Fuel substances as follows:
   a. Hydrazine (CAS 302-01) with a concentration of more than 70%;
   b. Hydrazine derivatives as follows:
      1. Monomethylhydrazine (MMH) (CAS 60-34);
      2. Unsymmetrical dimethylhydrazine (UDMH) (CAS 57-14-7);
      3. Hydrazine nitrate;
      4. Trimethylhydrazine;
      5. Tetramethylhydrazine;
      6. N,N diallylhydrazine;
      7. Allylhydrazine;
      8. Ethylene dihydrazine;
      9. Monomethylhydrazine dinitrate;
      10. Unsymmetrical dimethylhydrazine nitrate;
      11. Hydrazinium azide;
      12. Dimethylhydrazinium azide;
      13. Hydrazinium nitrate;
      14. Diimido oxalic acid dihydrazine;
      15. 2-hydroxyethylhydrazine nitrate (HEHN);
      16. Hydrazinium perchlorate;
      17. Hydrazinium diperchlorate;
      18. Methylhydrazine nitrate (MHN);
      19. Diethylhydrazine nitrate (DEHN);
      20. 1,4-dihydrazine nitrate (DHTN);
   c. Spherical aluminium powder (CAS 7429-90-5) with particles of uniform diameter of less than 200 x 10^{-6} m (200 µm) and an aluminium content of 97% by weight or more, if at least 10% of the total weight is made up of particles of less than 63 µm, according to ISO 2591:1988 or national equivalents such as JIS Z8820;

      Technical Note:
      A particle size of 63 µm (ISO R-565) corresponds to 250 mesh (Tyler) or 230 mesh (ASTM standard E-11).

   d. Zirconium (CAS 7440-67-7), beryllium (CAS 7440-41-7), magnesium (CAS 7439-95-4) and alloys of these in particle size less than 60 x 10^{-6} m (60 µm), whether spherical, atomised, spheroidal, flaked or ground, consisting of 97% by weight or more of any of the above mentioned metals;

      Technical Note:
      The natural content of hafnium (CAS 7440-58-6) in the zirconium (typically 2% to 7%) is counted with the zirconium.

   e. Boron (CAS 7740-42-8) and boron alloys in particle size less than 60 x 10^{-6} m (60 µm), whether spherical, atomised, spheroidal, flaked or ground with a purity of 85% by weight or more;
   f. High energy density materials such as boron slurry, having an energy density of 40 x 10^{6} J/kg or greater.
3. Oxidisers/Fuels as follows:
   Perchlorates, chlorates or chromates mixed with powdered metals or other high energy fuel components.
4. Oxidiser substances as follows:
   a. Oxidiser substances usable in liquid propellant rocket engines as follows:
      1. Dinitrogen trioxide;
      2. Nitrogen dioxide/dinitrogen tetroxide;
      3. Dinitrogen pentoxide;
      4. Mixed Oxides of Nitrogen (MON);
      5. Inhibited Red Fuming Nitric Acid (IRFNA) (CAS 8007-58-7);
      6. Compounds composed of fluorine and one or more of other halogens, oxygen or nitrogen;

Technical Note:
Mixed Oxides of Nitrogen (MON) are solutions of Nitric Oxide (NO) in Dinitrogen Tetroxide/Nitrogen Dioxide (N_2O_4/NO_2) that can be used in missile systems. There are a range of compositions that can be denoted as MONi or MONij where i and j are integers representing the percentage of Nitric Oxide in the mixture (e.g. MON3 contains 3% Nitric Oxide, MON25 25% Nitric Oxide. An upper limit is MON40, 40% by weight).
Note:
Item 6-4.C.4.a.6. does not control Nitrogen Trifluoride (NF_3) (CAS 7783-54-2) in a gaseous state as it is not usable for missile applications.

b. Oxidiser substances usable in solid propellant rocket motors as follows:
   1. Ammonium perchlorate (AP) (CAS 7790-98-9);
   2. Ammonium dinitramide (ADN) (CAS 140456-78-6);
   3. Nitro-amines (cyclotetramethylene - tetranitramine (HMX) (CAS 2691-41-0); cyclotrimethylene - trinitramine (RDX));
   4. Hydrazinium nitroformate (HNF) (CAS 20773-28-8).

5. Polymeric substances, as follows:
   a. Carboxy - terminated polybutadiene (CTPB);
   b. Hydroxy - terminated polybutadiene (HTPB);
   c. Glycidyl azide polymer (GAP);
   d. Polybutadiene - Acrylic Acid (PBAA);
   e. Polybutadiene - Acrylic Acid - Acrylonitrile (PBAN);
   f. Polytetrahydrofuran polyethylene glycol (TPEG).

Technical Note:
Polytetrahydrofuran polyethylene glycol (TPEG) is a block co-polymer of poly 1,4-Butanediol and polyethylene glycol (PEG).

6. Other propellant additives and agents as follows:
   a. Bonding agents as follows:
      1. Tris (1-(2-methyl)aziridinyl) phosphine oxide (MAPO) (CAS 57-39-6);
      2. 1,1',1"-trimesoyl-tris(2-ethylaziridine) (HX-868, BITA) (CAS 7722-73-8);
      3. Tepanol (HX878), reaction product of tetraethlylene-pentamine, acrylonitrile and glycidol (CAS 68412-46-4);
      4. Tepan (HX-879), reaction product of tetraethlylene-pentamine and acrylonitrile (CAS 68412-45-3);
      5. Polyfunctional aziridine amides with isophthalic, trimesic, isocyanuric, or trimethyladipic backbone also having a 2-methyl or 2-ethyl aziridine group;

Note:
Item 6-4.C.6.a.5. includes:
1. 1,1'-Isophthaloyl-bis(2-methylaziridene) (HX-752) (CAS 7652-64-4);
2. HX-874;
3. HX-877.

   b. Curing reaction catalysts as follows:
      Triphenyl bismuth (TPB) (CAS 603-33-8);
   c. Burning rate modifiers, as follows:
      1. Carboranes, decaboranes, pentaboranes and derivatives thereof;
      2. Ferrocene derivatives, as follows:
         a. Catocene (CAS 37206-42-1);
         b. Ethyl ferrocene;
         c. Propyl ferrocene (CAS 1273-89-8);
         d. n-Butyl ferrocene (CAS 31904-29-7);
         e. Pentyl ferrocene (CAS 1274-00-6);
         f. Dicyclopentyl ferrocene (CAS 20773-28-8);
         g. Dicyclohexyl ferrocene;
         h. Diethyl ferrocene;
         i. Dipropyl ferrocene;
         j. Dibutyl ferrocene (CAS 1274-08-4);
         k. Dihexyl ferrocene (CAS 93894-59-8);
         l. Acetyl ferrocenes;
         m. Ferrocene Carboxylic acids;
         n. Butacene;
         o. Other ferrocene derivatives usable as rocket propellant burning rate modifiers;
   d. Nitrate esters and nitrated plasticisers as follows:
      1. Triethylene glycol dinitrate (TEGDN);
      2. Trimethylolethane trinitrate (TMETN) (CAS 3032-55-1);
      3. 1,2,4-butanetriol trinitrate (BTTN) (CAS 6659-60-5);
      4. Diethylene glycol dinitrate (DEGDN);
   e. Stabilisers as follows:
      1. 2-Nitrodiphenylamine (CAS 119-75-5);
      2. N-methyl-p-nitroaniline (CAS 100-15-2).

6-4.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-4.B. for the "production" and handling of materials specified in 6-4.C.

6-4.E. Technology

1 "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or materials specified in 6-4.B. and 6-4.C.

6-5. RESERVED FOR FUTURE USE

6-6 Production of Structural Composites, Pyrolytic Deposition and Densification, and Structural Materials

6-6.A. Equipment, Assemblies and Components

1. Composite structures, laminates, and manufactures thereof, specially designed for use in the systems specified in 6-1.A. and the subsystems specified in 6-2.A.
2. Resaturated pyrolised (i.e. carbon-carbon) components having all of the following:
   a. Designed for rocket systems; **and**
   b. Usable in the systems specified in 6-1.A.

6-6.B. Test and Production Equipment

1. Equipment for the "production" of structural composites, fibres, prepregs or preforms, usable in the systems specified in 6-1.A., as follows, and specially designed components, and accessories therefor:

a. Filament winding machines of which the motions for positioning, wrapping and winding fibres can be co-ordinated and programmed in three or more axes, designed to fabricate composite structures or laminates from fibrous or filamentary materials, and co-ordinating and programming controls;
b. Tape-laying machines of which the motions for positioning and laying tape and sheets can be co-ordinated and programmed in two or more axes, designed for the manufacture of composite airframes and missile structures;
c. Multi-directional, multi-dimensional weaving machines or interlacing machines, including adapters and modification kits for weaving, interlacing or braiding fibres to manufacture composite structures;

Note:
6-6.B.1.c. does not control textile machinery not modified for the end-uses stated.

d. Equipment designed or modified for the production of fibrous or filamentary materials as follows:
   1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, or polycarbosilane) including special provision to strain the fibre during heating;
   2. Equipment for the vapour deposition of elements or compounds on heated filament substrates;
   3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);
e. Equipment designed or modified for special fibre surface treatment or for producing prepregs and preforms, including rollers, tension stretchers, coating equipment, cutting equipment and clicker dies.

Note:
Examples of components and accessories for the machines specified in 6-6.B.1. are moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.

2. Nozzles specially designed for the processes referred to in 6-6.E.3.
3. Isostatic presses having all of the following characteristics:
   a. Maximum working pressure equal to or greater than 69 MPa;
   b. Designed to achieve and maintain a controlled thermal environment of 600°C or greater; **and**
   c. Possessing a chamber cavity with an inside diameter of 254 mm or greater.
4. Chemical vapour deposition furnaces designed or modified for the densification of carbon-carbon composites.
5. Equipment and process controls, other than those specified in 6-6.B.3. or 6-6.B.4., designed or modified for densification and pyrolysis of structural composite rocket nozzles and re-entry vehicle nose tips.

6-6.C. Materials

1. Resin impregnated fibre prepregs and metal coated fibre preforms, for the goods specified in 6-6.A.1., made either with organic matrix or metal matrix utilising fibrous or filamentary reinforcements having a specific tensile strength greater than 7.62×10^4 m and a specific modulus greater than 3.18×10^6 m.

Note:
The only resin impregnated fibre prepregs specified in 6-6.C.1. are those using resins with a glass transition temperature (Tg), after cure, exceeding 145°C as determined by ASTM D4065 or national equivalents.

Technical Notes:
1. In Item 6-6.C.1. 'specific tensile strength' is the ultimate tensile strength in N/m^2 divided by the specific weight in N/m^3, measured at a temperature of (296 ± 2)K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.
2. In Item 6-6.C.1. 'specific modulus' is the Young's modulus in N/m^2 divided by the specific weight in N/m^3, measured at a temperature of (296 ± 2)K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

2. Resaturated pyrolised (i.e. carbon-carbon) materials having all of the following:
   a. Designed for rocket systems; **and**
   b. Usable in the systems specified in 6-1.A. or 6-19.A.1.
3. Fine grain graphites with a bulk density of at least 1.72 g/cc measured at 15ºC and having a grain size of 100×10^{-6} m (100 µm) or less, usable for rocket nozzles and re-entry vehicle nose tips, which can be machined to any of the following products:
   a. Cylinders having a diameter of 120 mm or greater and a length of 50 mm or greater;
   b. Tubes having an inner diameter of 65 mm or greater and a wall thickness of 25 mm or greater and a length of 50 mm or greater; **or**
   c. Blocks having a size of 120 mm x 120 mm x 50 mm or greater.
4. Pyrolytic or fibrous reinforced graphites usable for rocket nozzles and re-entry vehicle nose tips usable in systems specified in 6-1.A. or 6-19.A.1.
5. Ceramic composite materials (dielectric constant less than 6 at any frequency from 100 MHz to 100 GHz) for use in missile radomes usable in systems specified in 6-1.A. or 6-19.A.1.
6. Silicon-carbide materials as follows:
   a. Bulk machinable silicon-carbide reinforced unfired ceramic usable for nose tips usable in systems specified in 6-1.A. or 6-19.A.1.;
   b. Reinforced silicon-carbide ceramic composites usable for nose tips, re-entry vehicles, nozzle flaps, usable in systems specified in 6-1.A. or 6-19.A.1.
7. Tungsten (CAS 12070-12-1), molybdenum (CAS 1317-33-5), and alloys of these metals in the form of uniform spherical or atomised particles of 500×10^{-6} m (500 µm) diameter or less with a purity of 97% or higher for fabrication of rocket motor components, i.e. heat shields, nozzle substrates, nozzle throats, and thrust vector control surfaces, usable in systems specified in 6-1.A. or 6-19.A.1.
8. Maraging steels having an ultimate tensile strength equal to or greater than 1.5 GPa, measured at 20°C, in the form of sheet, plate or tubing with a wall or plate thickness equal to or less than 5.0 mm usable in systems specified in 6-1.A. or 6-19.A.1.

Technical Note:
Maraging steels are generally characterised by high nickel, very low carbon content and use substitutional elements or precipitates to produce age-hardening.

9. Titanium-stabilized duplex stainless steel (Ti-DSS) usable in the systems specified in 6-1.A. or 6-19.A.1. and having all of the following:
   a. Having all of the following characteristics:

1. Containing 17.0 - 23.0 weight percent chromium and 4.5 - 7.0 weight percent nickel;
2. Having a titanium content of greater than 0.10 weight percent nickel; **and**
3. A ferritic-austenitic microstructure (also referred to as a two-phase microstructure) of which at least 10% is austenite by volume (according to ASTM E-1181-87 or national equivalents); **and**

b. Any of the following forms:
1. Ingots or bars having a size of 100 mm or more in each dimension;
2. Sheets having a width of 600 mm or more and a thickness of 3 mm or less; **or**
3. Tubes having an outer diameter of 600 mm or more and a wall thickness of 3 mm or less.

6-6.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-6.B.1.
2. "Software" specially designed or modified for the equipment specified in 6-6.B.3., 6-6.B.4. or 6-6.B.5.

6-6.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 6-6.A., 6-6.B., 6-6.C. or 6-6.D.
2. "Technical data" (including processing conditions) and procedures for the regulation of temperature, pressures or atmosphere in autoclaves or hydroclaves when used for the production of composites or partially processed composites, usable for equipment or materials specified in 6-6.A. or 6-6.C.
3. "Technology" for producing pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1,300°C to 2,900°C temperature range at pressures of 130 Pa (1 mm Hg) to 20 kPa (150 mm Hg) including "technology" for the composition of precursor gases, flow-rates, and process control schedules and parameters.

6-7. RESERVED FOR FUTURE USE

6-8. RESERVED FOR FUTURE USE

6-9. Instrumentation, Navigation and Direction Finding

6-9.A. Equipment, Assemblies and Components

1. Integrated flight instrument systems which include gyrostabilisers or automatic pilots, designed or modified for use in the systems specified in 6-1.A., or 6-19.A.1. or 6-19.A.2. and specially designed components therefor.
2. Gyro-astro compasses and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, and specially designed components therefor.
3. Linear accelerometers, designed for use in inertial navigation systems or in guidance systems of all types, usable in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2., having all of the following characteristics, and specially designed components therefor:
   a. 'Scale factor' 'repeatability' less (better) than 1250 ppm; **and**
   b. 'Bias' 'repeatability' less (better) than 1250 micro g.

Technical Notes:
1. 'Bias' is defined as the accelerometer output when no acceleration is applied.
2. 'Scale factor' is defined as the ratio of change in output to a change in the input.
3. The measurement of 'bias' and 'scale factor' refers to one sigma standard deviation with respect to a fixed calibration over a period of one year.
4. 'Repeatability' is defined according to IEEE Standard 528-2001 as follows: 'The closeness of agreement among repeated measurements of the same variable under the same operating conditions when changes in conditions or non-operating periods occur between measurements'.

Note:
Item 6-9.A.3. does not control accelerometers specially designed and developed as Measurement While Drilling (MWD) sensors for use in downhole well service operations.

4. All types of gyros usable in the systems specified in 6-1.A., 6-19.A.1 or 6-19.A.2., with a rated 'drift rate' 'stability' of less than 0.5 degrees (1 sigma or rms) per hour in a 1 g environment, and specially designed components therefor.

Technical Notes:
1. 'Drift rate' is defined as the component of gyro output that is functionally independent of input rotation and is expressed as an angular rate. (IEEE STD 528-2001 paragraph 2.56)
2. 'Stability' is defined as a measure of the ability of a specific mechanism or performance coefficient to remain invariant when continuously exposed to a fixed operating condition. (This definition does not refer to dynamic or servo stability.) (IEEE STD 528-2001 paragraph 2.247)

5. Continuous output accelerometers or gyros of any type, specified to function at acceleration levels greater than 100 g, and specially designed components therefor.
6. Inertial or other equipment using accelerometers specified in 6-9.A.3. or 6-9.A.5. or gyros specified in 6-9.A.4. or 6-9.A.5., and systems incorporating such equipment, and specially designed components therefor.
7. 'Integrated navigation systems', designed or modified for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. and capable of providing a navigational accuracy of 200 m CEP or less.

Technical Note:
An 'integrated navigation system' typically incorporates all of the following components:
a. An inertial measurement device (e.g. an attitude and heading reference system, inertial reference unit, or inertial navigation system);
b. One or more external sensors used to update the position and/or velocity, either periodically or continuously throughout the flight (e.g. satellite navigation receiver, radar altimeter, and/or Doppler radar); **and**
c. Integration hardware and software.

N.B.:
For integration "software", see Item 6-9.D.4.

8. Three axis magnetic heading sensors having all of the following characteristics, and specially designed components therefor:

a. Internal tilt compensation in pitch (+/-90 degrees) and roll (+/-180 degrees) axes;
b. Capable of providing azimuthal accuracy better (less) than 0.5 degrees rms at latitudes of +/-80 degrees, referenced to local magnetic field; **and**
c. Designed or modified to be integrated with flight control and navigation systems.

Note:
Flight control and navigation systems in Item 6-9.A.8. include gyrostabilisers, automatic pilots and inertial navigation systems.

6-9.B. Test and Production Equipment

1. "Production equipment", and other test, calibration and alignment equipment, other than that described in 6-9.B.2., designed or modified to be used with equipment specified in 6-9.A.

Note:
Equipment specified in 6-9.B.1. includes the following:
a. For laser gyro equipment, the following equipment used to characterise mirrors, having the threshold accuracy shown or better:
   1. Scatterometer (10 ppm);
   2. Reflectometer (50 ppm);
   3. Profilometer (5 Angstroms);
b. For other inertial equipment:
   1. Inertial Measurement Unit (IMU) Module Tester;
   2. IMU Platform Tester;
   3. IMU Stable Element Handling Fixture;
   4. IMU Platform Balance Fixture;
   5. Gyro Tuning Test Station;
   6. Gyro Dynamic Balance Station;
   7. Gyro Run-In/Motor Test Station;
   8. Gyro Evacuation and Filling Station;
   9. Centrifuge Fixture for Gyro Bearings;
   10. Accelerometer Axis Align Station;
   11. Accelerometer Test Station.

2. Equipment as follows:
   a. Balancing machines having all the following characteristics:
      1. Not capable of balancing rotors/assemblies having a mass greater than 3 kg;
      2. Capable of balancing rotors/assemblies at speeds greater than 12,500 rpm;
      3. Capable of correcting unbalance in two planes or more; **and**
      4. Capable of balancing to a residual specific unbalance of 0.2 g mm per kg of rotor mass;
   b. Indicator heads (sometimes known as balancing instrumentation) designed or modified for use with machines specified in 6-9.B.2.a.;
   c. Motion simulators/rate tables (equipment capable of simulating motion) having all of the following characteristics:
      1. Two axes or more;
      2. Slip rings capable of transmitting electrical power and/or signal information; **and**
      3. Having any of the following characteristics:
         a. For any single axis having all of the following:
            1. Capable of rates of 400 degrees/s or more, or 30 degrees/s or less; **and**
            2. A rate resolution equal to or less than 6 degrees/s and an accuracy equal to or less than 0.6 degrees/s;
         b. Having a worst-case rate stability equal to or better (less) than plus or minus 0.05% averaged over 10 degrees or more; **or**
         c. A positioning accuracy equal to or better than 5 arc second;
   d. Positioning tables (equipment capable of precise rotary positioning in any axes) having the following characteristics:
      1. Two axes or more; **and**
      2. A positioning accuracy equal to or better than 5 arc second;
   e. Centrifuges capable of imparting accelerations above 100 g and having slip rings capable of transmitting electrical power and signal information.

Notes:
1. The only balancing machines, indicator heads, motion simulators, rate tables, positioning tables and centrifuges specified in Item 6-9. are those specified in 6-9.B.2.
2. 6-9.B.2.a. does not control balancing machines designed or modified for dental or other medical equipment.
3. 6-9.B.2.c. and 6-9.B.2.d. do not control rotary tables designed or modified for machine tools or for medical equipment.
4. Rate tables not controlled by 6-9.B.2.c. and providing the characteristics of a positioning table are to be evaluated according to 6-9.B.2.d.
5. Equipment that has the characteristics specified in 6-9.B.2.d. which also meets the characteristics of 6-9.B.2.c. will be treated as equipment specified in 6-9.B.2.c.

6-9.C. Materials

None.

6-9.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-9.A. or 6-9.B.
2. Integration "software" for the equipment specified in 6-9.A.1.
3. Integration "software" specially designed for the equipment specified in 6-9.A.6.
4. Integration "software", designed or modified for the 'integrated navigation systems' specified in 6-9.A.7.

Note:
A common form of integration "software" employs Kalman filtering.

6-9.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-9.A., 6-9.B. or 6-9.D.

Note:
Governments may permit the export of equipment or "software" specified in 6-9.A. or 6-9.D. as part of a manned aircraft, satellite, land vehicle, marine/submarine vessel or geophysical survey equipment or in quantities appropriate for replacement parts for such applications.

6-10. Flight Control

6-10.A. Equipment, Assemblies and Components

1. Hydraulic, mechanical, electro-optical, or electromechanical flight control systems (including fly-by-wire systems) designed or modified for the systems specified in 6-1.A.
2. Attitude control equipment designed or modified for the systems specified in 6-1.A.
3. Flight control servo valves designed or modified for the systems in 6-10.A.1. or 6-10.A.2., and designed or modified to operate in a vibration environment greater than 10 g rms between 20 Hz and 2 kHz.

Note:
Governments may permit the export of systems, equipment or valves specified in 6-10.A. as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

6-10.B. Test and Production Equipment

1. Test, calibration, and alignment equipment specially designed for equipment specified in 6-10.A.

6-10.C. Materials

None.

6-10.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-10.A. or 6-10.B.
   Note:
   Governments may permit the export of "software" specified in 6-10.D.1. as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

6-10.E. Technology

1. Design "technology" for integration of air vehicle fuselage, propulsion system and lifting control surfaces, designed or modified for the systems specified in 6-1.A., to optimise aerodynamic performance throughout the flight regime of an unmanned aerial vehicle.
2. Design "technology" for integration of the flight control, guidance, and propulsion data into a flight management system, designed or modified for the systems specified in 6-1.A., for optimisation of rocket system trajectory.
3. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-10.A., 6-10.B. or 6-10.D.

6-11. Avionics

6-11.A. Equipment, Assemblies and Components

1. Radar and laser radar systems, including altimeters, designed or modified for use in the systems specified in 6-1.A.
   Technical Note:
   Laser radar systems embody specialised transmission, scanning, receiving and signal processing techniques for utilisation of lasers for echo ranging, direction finding and discrimination of targets by location, radial speed and body reflection characteristics.
2. Passive sensors for determining bearings to specific electromagnetic sources (direction finding equipment) or terrain characteristics, designed or modified for use in the systems specified in 6-1.A.
3. Receiving equipment for Global Navigation Satellite Systems (GNSS; e.g. GPS, GLONASS or Galileo), having any of the following characteristics, and specially designed components therefor:
   a. Designed or modified for use in systems specified in 6-1.A.; **or**
   b. Designed or modified for airborne applications and having any of the following:
      1. Capable of providing navigation information at speeds in excess of 600 m/s;
      2. Employing decryption, designed or modified for military or governmental services, to gain access to GNSS secure signal/data; **or**
      3. Being specially designed to employ anti-jam features (e.g. null steering antenna or electronically steerable antenna) to function in an environment of active or passive countermeasures.

      Note:
      6-11.A.3.b.2. and 6-11.A.3.b.3. do not control equipment designed for commercial, civil or 'Safety of Life' (e.g. data integrity, flight safety) GNSS services.
4. Electronic assemblies and components, designed or modified for use in the systems specified in 6-1.A. and specially designed for military use and operation at temperatures in excess of 125°C.

Notes:
1. Equipment specified in 6-11.A. includes the following:
   a. Terrain contour mapping equipment;
   b. Scene mapping and correlation (both digital and analogue) equipment;
   c. Doppler navigation radar equipment;
   d. Passive interferometer equipment;
   e. Imaging sensor equipment (both active and passive).
2. Governments may permit the export of equipment specified in 6-11.A. as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

6-11.B. Test and Production Equipment

None.

6-11.C. Materials

None.

6-11.D. Software

1. “Software” specially designed or modified for the “use” of equipment specified in 6-11.A.1., 6-11.A.2. or 6-11.A.4.
2. “Software” specially designed for the “use” of equipment specified in 6-11.A.3.

6-11.E. Technology

1. Design “technology” for protection of avionics and electrical subsystems against Electromagnetic Pulse (EMP) and Electromagnetic Interference (EMI) hazards from external sources, as follows:
   a. Design “technology” for shielding systems;
   b. Design “technology” for the configuration of hardened electrical circuits and subsystems;
   c. Design “technology” for determination of hardening criteria for the above.
2. “Technology”, in accordance with the General Technology Note, for the “development”, “production” or “use” of equipment or “software” specified in 6-11.A. or 6-11.D.

6-12. Launch Support

6-12.A. Equipment, Assemblies and Components

1. Apparatus and devices, designed or modified for the handling, control, activation and launching of the systems specified in 6-1.A., 6-19.A.1., or 6-19.A.2.
2. Vehicles designed or modified for the transport, handling, control, activation and launching of the systems specified in 6-1.A.
3. Gravity meters (gravimeters), gravity gradiometers, and specially designed components therefor, designed or modified for airborne or marine use, and having a static or operational accuracy of 7 x 10^{-6} m/s^2 (0.7 milligal) or better, with a time to steady-state registration of two minutes or less, usable for systems specified in 6-1.A.
4. Telemetry and telecontrol equipment, including ground equipment, designed or modified for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

   Notes:
   1. 6-12.A.4. does not control equipment designed or modified for manned aircraft or satellites.
   2. 6-12.A.4. does not control ground based equipment designed or modified for terrestrial or marine applications.
   3. 6-12.A.4. does not control equipment designed for commercial, civil or ‘Safety of Life’ (e.g. data integrity, flight safety) GNSS services.

5. Precision tracking systems, usable for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. as follows:
   a. Tracking systems which use a code translator installed on the rocket or unmanned aerial vehicle in conjunction with either surface or airborne references or navigation satellite systems to provide real-time measurements of inflight position and velocity;
   b. Range instrumentation radars including associated optical/infrared trackers with all of the following capabilities:
      1. Angular resolution better than 3 mrad;
      2. Range of 30 km or greater with a range resolution better than 10 m rms; **and**
      3. Velocity resolution better than 3 m/s.
6. Thermal batteries designed or modified for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

   Technical Note:
   Thermal batteries are single use batteries that contain a solid non-conducting inorganic salt as the electrolyte. These batteries incorporate a pyrolytic material that, when ignited, melts the electrolyte and activates the battery.

   Note:
   Item 6-12.A.6. does not control thermal batteries specially designed for rocket systems or unmanned aerial vehicles that are not capable of a “range” equal to or greater than 300 km.

6-12.B. Test and Production Equipment

None.

6-12.C. Materials

None.

6-12.D. Software

1. “Software” specially designed or modified for the “use” of equipment specified in 6-12.A.1.
2. “Software” which processes post-flight, recorded data, enabling determination of vehicle position throughout its flight path, specially designed or modified for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.
3. “Software” specially designed or modified for the “use” of equipment specified in 6-12.A.4. or 6-12.A.5., usable for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

6-12.E. Technology

1. “Technology”, in accordance with the General Technology Note, for the “development”, “production” or “use” of equipment or “software” specified in 6-12.A. or 6-12.D.

6-13. Computers

6-13.A. Equipment, Assemblies and Components

1. Analogue computers, digital computers or digital differential analysers, designed or modified for use in the systems specified in 6-1.A., having any of the following characteristics:
   a. Rated for continuous operation at temperatures from below -45°C to above +55°C; **or**
   b. Designed as ruggedised or “radiation hardened”.

6-13.B. Test and Production Equipment

None.

6-13.C. Materials

None.

6-13.D. Software

None.

6-13.E. Technology

1. “Technology”, in accordance with the General Technology Note, for the “development”, “production” or “use” of equipment specified in 6-13.A.

Note:
Governments may permit the export of Item 6-13. equipment as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.

6-14. Analogue to Digital Converters

6-14.A. Equipment, Assemblies and Components

1. Analogue-to-digital converters, usable in the systems specified in 6-1.A., having any of the following characteristics:
   a. Designed to meet military specifications for ruggedised equipment; **or**
   b. Designed or modified for military use and being any of the following types:
      1. Analogue-to-digital converter “microcircuits”, which are “radiation-hardened” or have all of the following characteristics:
         a. Having a quantisation corresponding to 8 bits or more when coded in the binary system;
         b. Rated for operation in the temperature range from below –54°C to above +125°C; **and**
         c. Hermetically sealed; **or**
      2. Electrical input type analogue-to-digital converter printed circuit boards or modules, having all of the following characteristics:
         a. Having a quantisation corresponding to 8 bits or more when coded in the binary system;
         b. Rated for operation in the temperature range from below –45°C to above +55°C; **and**
         c. Incorporating “microcircuits” specified in 6-14.A.1.b.1.

6-14.B. Test and Production Equipment

None.

6-14.C. Materials

None.

6-14.D. Software

None.

6-14.E. Technology

1. “Technology”, in accordance with the General Technology Note, for the “development”, “production” or “use” of equipment specified in 6-14.A.

6-15. Test Facilities and Equipment

6-15.A. Equipment, Assemblies and Components

None.

6-15.B. Test and Production Equipment

1. Vibration test equipment, usable for the systems specified in 6-1.A. or the subsystems specified in 6-2.A., and components therefor, as follows:
   a. Vibration test systems employing feedback or closed loop techniques and incorporating a digital controller, capable of vibrating a system at an acceleration equal to or greater than 10 g rms between 20 Hz and 2 kHz and imparting forces equal to or greater than 50 kN, measured ‘bare table’;
   b Digital controllers, combined with specially designed vibration test “software”, with a real-time bandwidth greater than 5 kHz and designed for use with vibration test systems specified in 6-15.B.1.a.;
   c. Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force equal to or greater than 50 kN, measured ‘bare table’, and usable in vibration test systems specified in 6-15.B.1.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 equal to or greater than 50 kN, measured ‘bare table’, and usable in vibration test systems specified in 6-15.B.1.a.

   Technical Note:
   Vibration test systems incorporating a digital controller are those systems, the functions of which are, partly or entirely, automatically controlled by stored and digitally coded electrical signals.

2. Wind-tunnels for speeds of Mach 0.9 or more, usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A. or 6-20.A.
3. Test benches/stands, usable for the systems specified in 6-1.A. or the subsystems specified in 6-2.A., which have the capacity to handle solid or liquid propellant rockets, motors or engines having a thrust greater than 68 kN, or which are capable of simultaneously measuring the three axial thrust components.
4. Environmental chambers as follows, usable for the systems specified in 6-1.A. or the subsystems specified in 6-2.A.:

a. Environmental chambers capable of simulating all of the following flight conditions:
   1. Vibration environments equal to or greater than 10 g rms, measured ‘bare table’, between 20 Hz and 2 kHz imparting forces equal to or greater than 5 kN; **and**
   2. Any of the following:
      a. Altitude equal to or greater than 15 km; **or**
      b. Temperature range of at least –50°C to 125°C;

b. Environmental chambers capable of simulating all of the following flight conditions:
   1. Acoustic environments at an overall sound pressure level of 140 dB or greater (referenced to 2 x 10^{-5} N/m^2) or with a total rated acoustic power output of 4 kW or greater; **and**
   2. Any of the following:
      a. Altitude equal to or greater than 15 km; **or**
      b. Temperature range of at least –50°C to 125°C.

Technical Note:
Item 6-15.B.4.a. describes systems that are capable of generating a vibration environment with a single wave (e.g. a sine wave) and systems capable of generating a broad band random vibration (i.e. power spectrum).

5. Accelerators capable of delivering electromagnetic radiation produced by bremsstrahlung from accelerated electrons of 2 MeV or greater, and equipment containing those accelerators, usable for the systems specified in 6-1.A. or the subsystems specified in 6-2.A.
   Note:
   6-15.B.5. does not control equipment specially designed for medical purposes.

Technical Note:
In Item 6-15.B. ‘bare table’ means a flat table, or surface, with no fixture or fittings.

6-15.C. Materials

None.

6-15.D. Software

1. “Software” specially designed or modified for the “use” of equipment specified in 6-15.B. usable for testing systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. or subsystems specified in 6-2.A. or 6-20.A.

6-15.E. Technology

1. “Technology”, in accordance with the General Technology Note, for the “development”, “production” or “use” of equipment or “software” specified in 6-15.B. or 6-15.D.

6-16. Modelling-Simulation and Design Integration

6-16.A. Equipment, Assemblies and Components

1. Specially designed hybrid (combined analogue/digital) computers for modelling, simulation or design integration of systems specified in 6-1.A. or the subsystems specified in 6-2.A.
   Note:
   This control only applies when the equipment is supplied with “software” specified in 6-16.D.1.

6-16.B. Test and Production Equipment

None.

6-16.C. Materials

None.

6-16.D. Software

1. “Software” specially designed for modelling, simulation, or design integration of the systems specified in 6-1.A. or the subsystems specified in 6-2.A.
   Technical Note:
   The modelling includes in particular the aerodynamic and thermodynamic analysis of the systems.

6-16.E. Technology

1. “Technology”, in accordance with the General Technology Note, for the “development”, “production” or “use” of equipment or “software” specified in 6-16.A. or 6-16.D.

6-17. Stealth

6-17.A. Equipment, Assemblies and Components

1. Devices for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A. or 6-20.A.

6-17.B. Test and Production Equipment

1. Systems, specially designed for radar cross section measurement, usable for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. or the subsystems specified in 6-2.A.

6-17.C. Materials

1. Materials for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A.

Notes:

1. 6-17.C.1. includes structural materials and coatings (including paints), specially designed for reduced or tailored reflectivity or emissivity in the microwave, infrared or ultraviolet spectra.
2. 6-17.C.1. does not control coatings (including paints) when specially used for thermal control of satellites.

6-17.D. Software

1. "Software" specially designed for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A.

Note:

6-17.D.1. includes "software" specially designed for analysis of signature reduction.

6-17.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 6-17.A., 6-17.B., 6-17.C. or 6-17.D.

Note:

6-17.E.1. includes databases specially designed for analysis of signature reduction.

6-18. Nuclear Effects Protection

6-18.A. Equipment, Assemblies and Components

1. "Radiation Hardened" "microcircuits" usable in protecting rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 6-1.A.
2. 'Detectors' specially designed or modified to protect rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 6-1.A.

Technical Note:

A ´detector´ is defined as a mechanical, electrical, optical or chemical device that automatically identifies and records, or registers a stimulus such as an environmental change in pressure or temperature, an electrical or electromagnetic signal or radiation from a radioactive material. This includes devices that sense by one time operation or failure.

3. Radomes designed to withstand a combined thermal shock greater than 4.184 x 10^6 J/m^2 accompanied by a peak over pressure of greater than 50 kPa, usable in protecting rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 6-1.A.

6-18.B. Test and Production Equipment

None.

6-18.C. Materials

None.

6-18.D. Software

None.

6-18.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 6-18.A.

6-19. Other Complete Delivery Systems

6-19.A. Equipment, Assemblies and Components

1. Complete rocket systems (including ballistic missile systems, space launch vehicles, and sounding rockets), not specified in 6-1.A.1., capable of a "range" equal to or greater than 300 km.
2. Complete unmanned aerial vehicle systems (including cruise missile systems, target drones and reconnaissance drones), not specified in 6-1.A.2., capable of a "range" equal to or greater than 300 km.
3. Complete unmanned aerial vehicle systems, not specified in 6-1.A.2. or 6-19.A.2., having all of the following:
   a. Having any of the following:
      1. An autonomous flight control and navigation capability; **or**
      2. Capability of controlled flight out of the direct vision range involving a human operator; **and**
   b. Having any of the following:
      1. Incorporating an aerosol dispensing system/mechanism with a capacity greater than 20 litres; **or**
      2. Designed or modified to incorporate an aerosol dispensing system/mechanism with a capacity greater than 20 litres.

Technical Notes:

1. An aerosol consists of particulate or liquids other than fuel components, by-products or additives, as part of the "payload" to be dispersed in the atmosphere. Examples of aerosols include pesticides for crop dusting and dry chemicals for cloud seeding.
2. An aerosol dispensing system/mechanism contains all those devices (mechanical, electrical, hydraulic, etc.), which are necessary for storage and dispersion of an aerosol into the atmosphere. This includes the possibility of aerosol injection into the combustion exhaust vapour and into the propeller slip stream.

Note:

Item 6-19.A.3. does not control model aircraft, specially designed for recreational or competition purposes.

6-19.B. Test and Production Equipment

None.

6-19.C. Materials

None.

6-19.D. Software

1. "Software" which coordinates the function of more than one subsystem, specially designed or modified for "use" in the systems specified in 6-19.A.1. or 6-19.A.2.

6-19.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 6-19.A. 1. or 6-19.A.2.

6-20. Other Complete Subsystems

6-20.A. Equipment, Assemblies and Components

1. Complete subsystems as follows:
   a. Individual rocket stages, not specified in 6-2.A.1., usable in systems specified in 6-19.A.;
   b. Solid propellant rocket motors or liquid propellant rocket engines, not specified in 6-2.A.1., usable in systems specified in 6-19.A., having a total impulse capacity equal to or greater than 8.41×10^5 Ns, but less than 1.1×10^6 Ns.

6-20.B. Test and Production Equipment

1. "Production facilities" specially designed for the subsystems specified in 6-20.A.
2. "Production equipment" specially designed for the subsystems specified in 6-20.A.

6-20.C. Materials

None.

6-20.D. Software

1. "Software" specially designed or modified for the systems specified in 6-20.B.1.
2. "Software", not specified in 6-2.D.2., specially designed or modified for the "use" of rocket motors or engines specified in 6-20.A.1.b.

6-20.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-20.A., 6-20.B. or 6-20.D.

Definitions

For the purpose of Group 6, the following definitions apply:

"Basic scientific research"

Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena or observable facts, not primarily directed towards a specific practical aim or objective.

"Development"

Is related to all phases prior to "production" such as:
- design
- design research
- design analysis
- design concepts
- assembly and testing of prototypes
- pilot production schemes
- design data
- process of transforming design data into a product
- configuration design
- integration design
- layouts

"In the public domain"

This means "software" or "technology" which has been made available without restrictions upon its further dissemination. (Copyright restrictions do not remove "software" or "technology" from being "in the public domain".)

"Microcircuit"

A device in which a number of passive and/or active elements are considered as indivisibly associated on or within a continuous structure to perform the function of a circuit.

"Microprogrammes"

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

"Payload"

The total mass that can be carried or delivered by the specified rocket system or unmanned aerial vehicle (UAV) system that is not used to maintain flight.

Note:

The particular equipment, subsystems, or components to be included in the "payload" depends on the type and configuration of the vehicle under consideration.

Technical Notes:

1. Ballistic Missiles
   a. "Payload" for systems with separating re-entry vehicles (RVs) includes:
      1. The RVs, including:
         a. Dedicated guidance, navigation, and control equipment;
         b. Dedicated countermeasures equipment;
      2. Munitions of any type (e.g. explosive or non-explosive);
      3. Supporting structures and deployment mechanisms for the munitions (e.g. hardware used to attach to, or separate the RV from, the bus/post-boost vehicle) that can be removed without violating the structural integrity of the vehicle;
      4. Mechanisms and devices for safing, arming, fuzing or firing;
      5. Any other countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that separate from the RV bus/post-boost vehicle;
      6. The bus/post-boost vehicle or attitude control/velocity trim module not including systems/subsystems essential to the operation of the other stages.
   b. "Payload" for systems with non-separating re-entry vehicles includes:
      1. Munitions of any type (e.g. explosive or non-explosive);
      2. Supporting structures and deployment mechanisms for the munitions that can be removed without violating the structural integrity of the vehicle;
      3. Mechanisms and devices for safing, arming, fuzing or firing;
      4. Any countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle.
2. Space Launch Vehicles
   "Payload" includes:
   a. Satellites (single or multiple);
   b. Satellite-to-launch vehicle adapters including, if applicable, apogee/perigee kick motors or similar manoeuvering systems.
3. Sounding Rockets
   "Payload" includes:
   a. Equipment required for a mission, such as data gathering, recording or transmitting devices for mission-specific data;
   b. Recovery equipment (e.g. parachutes) that can be removed without violating the structural integrity of the vehicle.
4. Cruise Missiles
   "Payload" includes:
   a. Munitions of any type (e.g. explosive or non-explosive);
   b. Supporting structures and deployment mechanisms for the munitions that can be removed without violating the structural integrity of the vehicle;
   c. Mechanisms and devices for safing, arming, fuzing or firing;
   d. Countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle;
   e. Signature alteration equipment that can be removed without violating the structural integrity of the vehicle.
5. Other UAVs
   "Payload" includes:
   a. Munitions of any type (e.g. explosive or non-explosive);
   b. Mechanisms and devices for safing, arming, fuzing or firing;
   c. Countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle;
   d. Signature alteration equipment that can be removed without violating the structural integrity of the vehicle;
   e. Equipment required for a mission such as data gathering, recording or transmitting devices for mission-specific data;
   f. Recovery equipment (e.g. parachutes) that can be removed without violating the structural integrity of the vehicle.

"Production"

Means all production phases such as:
- production engineering
- manufacture
- integration
- assembly (mounting)
- inspection
- testing
- quality assurance

"Production equipment"

Means tooling, templates, jigs, mandrels, moulds, dies, fixtures, alignment mechanisms, test equipment, other machinery and components therefor, limited to those specially designed or modified for "development" or for one or more phases of "production".

"Production facilities"

Means equipment and specially designed "software" therefor integrated into installations for "development" or for one or more phases of "production".

"Programmes"

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

"Radiation hardened"

Means that the component or equipment is designed or rated to withstand radiation levels which meet or exceed a total irradiation dose of 5×10^5 rads (Si).

"Range"

The maximum distance that the specified rocket system or unmanned aerial vehicle (UAV) system is capable of travelling in the mode of stable flight as measured by the projection of its trajectory over the surface of the Earth.

Technical Notes:

1. The maximum capability based on the design characteristics of the system, when fully loaded with fuel or propellant, will be taken into consideration in determining "range".
2. The "range" for both rocket systems and UAV systems will be determined independently of any external factors such as operational restrictions, limitations imposed by telemetry, data links or other external constraints.
3. For rocket systems, the "range" will be determined using the trajectory that maximises "range", assuming ICAO standard atmosphere with zero wind.
4. For UAV systems, the "range" will be determined for a one-way distance using the most fuel-efficient flight profile (e.g. cruise speed and altitude), assuming ICAO standard atmosphere with zero wind.

"Software"

A collection of one or more "programmes", or "micro-programmes", fixed in any tangible medium of expression.

"Technology"

Means specific information which is required for the "development", "production" or "use" of a product. The information may take the form of "technical data" or "technical assistance".

"Technical assistance"

May take forms such as:
- instruction
- skills
- training
- working knowledge
- consulting services

"Technical data"

May take forms such as:
- blueprints
- plans
- diagrams
- models
- formulae
- engineering designs and specifications
- manuals and instructions written or recorded on other media or devices such as:
- disk
- tape
- read-only memories

"Use"

Means:
- operation
- installation (including on-site installation)
- maintenance
- repair
- overhaul
- refurbishing

Terminology

Where the following terms appear in Group 6, they are to be understood according to the explanations below:

a. "Specially designed" describes equipment, parts, components or "software" which, as a result of "development", have unique properties that distinguish them for certain predetermined purposes. For example, a piece of equipment that is "specially designed" for use in a missile will only be considered so if it has no other function or use. Similarly, a piece of manufacturing equipment that is "specially designed" to produce a certain type of component will only be considered such if it is not capable of producing other types of components.
b. "Designed or modified" describes equipment, parts or components which, as a result of "development," or modification, have specified properties that make them fit for a particular application. " Designed or modified" equipment, parts, components or "software" can be used for other applications. For example, a titanium coated pump designed for a missile may be used with corrosive fluids other than propellants.
c. "Usable in", "usable for", "usable as" or "capable of" describes equipment, parts, components, materials or "software" which are suitable for a particular purpose. There is no need for the equipment, parts, components or "software" to have been configured, modified or specified for the particular purpose. For example, any military specification memory circuit would be "capable of" operation in a guidance system.
d. "Modified" in the context of "software" describes "software" which has been intentionally changed such that it has properties that make it fit for specified purposes or applications. Its properties may also make it suitable for purposes or applications other than those for which it was "modified".

Units, Constants, Acronyms and Abbreviations Used in Group 6

ABEC	Annular Bearing Engineers Committee
ABMA	American Bearing Manufactures Association
ANSI	American National Standards Institute
Angstrom	1 x 10^{-10} metre
ASTM	American Society for Testing and Materials
bar	unit of pressure
°C	degree Celsius
cc	cubic centimetre
CAS	Chemical Abstracts Service
CEP	Circle of Equal Probability
dB	decibel
G	gram; also, acceleration due to gravity
GHz	gigahertz
GNSS	Global Navigation Satellite System e.g. 'Galileo' 'GLONASS' – Global'naya Navigatsionnaya Sputnikovaya Sistema 'GPS' – Global Positioning System
h	hour
Hz	hertz
HTPB	Hydroxy-Terminated Polybutadiene
ICAO	International Civil Aviation Organisation
IEEE	Institute of Electrical and Electronic Engineers
IR	Infrared
ISO	International Organization for Standardization
J	joule
JIS	Japanese Industrial Standard
K	Kelvin
kg	kilogram
kHz	kilohertz
km	kilometre
kN	kilonewton
kPa	kilopascal
kW	kilowatt
m	metre
MeV	million electron volt or mega electron volt
MHz	megahertz
milligal	10^{-5} m/s^2 (also called mGal, mgal or milligalileo)
mm	millimetre
mm Hg	mm of mercury
MPa	megapascal
mrad	milliradian
ms	millisecond
µm	micrometre
N	newton
Pa	pascal
ppm	parts per million
rads (Si)	radiation absorbed dose
RF	radio frequency
rms	root mean square
rpm	revolutions per minute
RV	Re-entry Vehicles
s	second
Tg	glass transition temperature
Tyler	Tyler mesh size, or Tyler standard sieve series
UAV	Unmanned Aerial Vehicle
UV	Ultra violet

Table of Conversions Used in Group 6

Unit (from)	Unit (to)	Conversion
bar	pascal (Pa)	1 bar = 100 kPa
g (gravity)	m/s^2	1 g = 9.80665 m/s^2
mrad (millirad)	degrees (angle)	1 mrad ≈ 0.0573°
rads	ergs/gram of Si	1 rad (Si) = 100 ergs/gram of silicon (= 0.01 gray [Gy])
Tyler 250 mesh	mm	For a Tyler 250 mesh, mesh opening 0.063 mm

Group 7 – Chemical and Biological Weapons Non-Proliferation List

Notes:
1. Terms in “double quotation marks” are defined terms. Refer to “Group 7 - Definitions”.
2. In items 7-3. and 7-4. the numbers in brackets following the chemical name in each item is the Chemical Abstracts Service Registry number for that chemical as listed in the Chemical Abstracts Service Registry Handbook published by the American Chemical Society, Washington, D.C.
3. Mixtures containing any quantity of CWC Schedule 1A and 1B chemicals/precursors (Items 7-3.1. and 7-3.2.) are also controlled.
4. Mixtures containing any quantity of chemicals/precursors listed in the CWC Schedules 2A, 2B, 3A and 3B (items 7-3.3. through 7-3.6.) and Australia Group (item 7-4.) are controlled unless the listed chemical is an ingredient in a product identified as a consumer good packaged for retail sale or packaged for personal use.
5. Items 7-1. and 7-3. are based on the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction. (known as the Chemical Weapons Convention or CWC.) The other items in the Group are based on the Australia Group (AG).

Chemical Weapons

7-1. Equipment, Assemblies and Components

None.

7-2. AG Test, Inspection and Production Equipment, as follows:

Notes:
1. The objective of these controls should not be defeated by the transfer of any non-controlled item containing one or more controlled components where the controlled component or components are the principal element of the item and can feasibly be removed or used for other purposes.

   NB:
   Governments may weigh the factors of quantity, value, and technological know-how involved and other special circumstances which might establish the controlled component or components as the principal element of the item being procured when judging whether the controlled component or components are to be considered the principal element.
2. The objective of these controls should not be defeated by the transfer of a whole plant, on any scale, which has been designed to produce any CW agent or AG-controlled precursor chemical.

1. Reaction Vessels, Reactors or Agitators, Storage Tanks, Containers or Receivers, Heat Exchangers or Condensers, Distillation or Absorption Columns, Valves, Multi-walled Piping, and Pumps, as follows:
   a. Reaction Vessels or Reactors, with or without agitators, with a total internal (geometric) volume greater than 0.1 m^3 (100 l) and less than 20 m^3 (20,000 l);
   b. Agitators for use in reaction vessels or reactors listed in Item 7-2.1.a.; and impellers, blades or shafts for such agitators;
   c. Storage Tanks, Containers or Receivers, with a total internal (geometric) volume greater than 0.1 m^3 (100 l);
   d. Heat exchangers or Condensers with a heat transfer surface area of greater than 0.15 m^2, and less than 20 m^2; and tubes, plates, coils, or blocks (cores) designed for such heat exchangers or condensers;
   e. Distillation or Absorption Columns of internal diameter greater than 0.1 m, and vapour distributors, liquid distributors or liquid collectors designed for such distillation or absorption columns;
   f. Valves with nominal sizes greater than 1.0 cm (3/8”) and casings (valve bodies) or preformed casing liners designed for such valves;
   g. Multi-walled Piping incorporating a leak detection port;
   h. Multiple-seal and seal-less pumps with manufacturer's specified maximum flow-rate greater than 0.6 m^3/h, or vacuum pumps with manufacturer's specified maximum flow-rate greater than 5 m^3/h (under standard temperature (273 K (0°C)) and pressure (101.3 kPa) conditions), and casings (pump bodies), preformed casing liners, impellers, rotors or jet pump nozzles designed for such pumps.

   Technical Note:
   Items listed in 7-2.1.a. through h. are included in this Item only if all surfaces of any of the Items coming in direct contact with the chemical(s) being processed or contained are made from any of the following materials:
   1. Nickel or alloys with more than 40% nickel by weight;
   2. Alloys with more than 25% nickel and 20% chromium by weight;
   3. Fluoropolymers;
   4. Glass or glass-lined (including vitrified or enameled coating);
   5. Graphite or carbon graphite* (applies only to heat exchangers, condensers, distillation and absorption columns, multi-walled piping and pumps);
      *Carbon graphite is a composition consisting of amorphous carbon and graphite, in which the graphite content is 8% or more by weight.
   6. Tantalum or tantalum alloys;
   7. Titanium or titanium alloys;
   8. Zirconium or zirconium alloys;
   9. Ceramics (applies only to pumps);
   10. Ferrosilicon (applies only to pumps);
   11. Silicon carbide (applies only to heat exchanges and condensers); **or**
   12. Titanium carbide (applies only to heat exchanges and condensers).
   13. Niobium (columbium) or niobium alloys.

2. Remotely operated filling equipment in which all surfaces that come into contact with the chemical(s) being processed are made of the following materials:
   a. Nickel or alloys with more than 40% nickel by weight; **or**
   b. Alloys with more than 25% nickel and 20% chromium by weight.

3. Incinerators designed to destroy CW agents, controlled precursors or chemical munitions, possessing all of the following characteristics:
   a. Specially designed waste supply systems;
   b. Special handling facilities; **and**
   c. Average combustion chamber temperature greater than 1000°C.

Technical Note:
Items listed in 7-2.3.a. through 7-2.3.c. are considered to be included only if all surfaces in the waste supply system that come into direct contact with the waste products are made from or lined with any of the following materials:
1. Nickel or alloys with more than 40% nickel by weight;
2. Alloys with more than 25% nickel and 20% chromium by weight; **or**
3. Ceramics.

4. Toxic gas monitoring systems and dedicated detectors:
   a. Designed for continuous operation and useable for the detection of CW agents, or AG-controlled precursors at concentrations of less than 0.3 mg/m^3; **or**
   b. Designed for the detection of cholinesterase-inhibiting activity.

Note:
These controls do not apply to equipment (identified in Item 7-2.) which is specially designed for use in civil applications such as food processing, pulp and paper processing, or water purification and is, by the nature of its design, inappropriate for use in storing, processing, producing or conducting and controlling the flow of chemical weapon agents or any of the precursors chemicals which are included in items 7-3. or 7-4.

(Item 7-2. applies to all destinations except Argentina, Australia, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Latvia, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Cyprus, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.)

7-3. CWC Materials

1. CWC Schedule 1 A Toxic Chemicals:
   a. **O-Alkyl** (equal to or less than C10, including cycloalkyl) alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) - phosphonofluoridate;
      e.g. Sarin (GB):O-Isopropyl methylphosphono-fluoridate, (CAS 107-44-8);
      Soman (GD):O-Pinacolyl methyl-phosphono-fluoridate, (CAS 96-64-0);
   b. **O-Alkyl** (equal to or less than C10, including cycloalkyl) N,N-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphoramidocyanidates, e.g., Tabun: O-Ethyl N,N-dimethylphosphoramidocyanidate, (CAS 77-81-6);
   c. **O-Alkyl** (H or equal to or less than C10, including cycloalkyl) S-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl)-aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonothiolates and corresponding alkylated or protonated salts, e.g., VX: O-Ethyl S-2-diisopropylaminoethyl methylphosphonothiolate, (CAS 50782-69-9);
   d. **Sulphur mustards:**
      2-Chloroethylchloromethylsulphide, (CAS 2625-76-5);
      Mustard gas: Bis(2-chloroethyl) sulphide, (CAS 505-60-2);
      Bis(2-chloroethylthio) methane, (CAS 63869-13-6);
      Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane, (CAS 3563-36-8);
      1,3-Bis(2-chloroethylthio)-n-propane, (CAS 63905-10-2);
      1,4-Bis(2-chloroethylthio)-n-butane, (CAS 142868-93-7);
      1,5-Bis(2-chloroethylthio)-n-pentane, (CAS 142868-94-8);
      Bis (2-chloroethylthiomethyl) ether; (CAS 63918-90-1);
      O-Mustard: Bis(2-chloroethylthioethyl)ether, (CAS 63918-89-8);
   e. **Lewisites:**
      Lewisite 1: 2-Chlorovinyldichloroarsine, (CAS 541-25-3);
      Lewisite 2: Bis(2-chlorovinyl)chloroarsine, (CAS 40334-69-8);
      Lewisite 3: Tris (2-chlorovinyl) arsine, (CAS 40334-70-1);
   f. **Nitrogen mustards:**
      HN1: Bis (2-chloroethyl)ethylamine, (CAS 538-07-8);
      HN2: Bis (2-chloroethyl)methylamine, (CAS 51-75-2);
      HN3: Tris (2-chloroethyl)amine, (CAS 555-77-1);
   g. Saxitoxin, (CAS 35523-89-8);
   h. Ricin, (CAS 9009-86-3).

2. CWC Schedule 1 B Precursors
   a. Alkyl(Me, Et, n-Pr or i-Pr) phosphonyldifluorides e.g., DF: Methylphosphonyldifluoride, (CAS 676-99-3);
   b. O-Alkyl (H equal to or less than C10, including cycloalkyl) O-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonites and corresponding alkylated or protonated salts; e.g., QL: O-Ethyl O-2-diisopropylamino-ethyl methylphosphonite, (CAS 57856-11-8);
   c. Chlorosarin: O-Isopropyl methylphosphonochloridate, (CAS 1445-76-7);
   d. Chlorosoman: O-Pinacolyl methylphosphonochloridate, (CAS 7040-57-5).

3. CWC Schedule 2 A Toxic Chemicals:
   a. Amiton: O,O-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate, (CAS 78-53-5) and corresponding alkylated or protonated salts;
   b. PFIB: 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene, (CAS 382-21-8);
   c. BZ: 3-Quinuclidinyl benzilate, (CAS 6581-06-2).

4. CWC Schedule 2 B Precursors:
   a. Chemicals, except for those listed in Item 7-3.1. or 7-3.2., containing a phosphorus atom to which is bonded one methyl, ethyl or propyl (normal or iso) group but not further carbon atoms, such as:
      1. Dimethyl methylphosphonate, (CAS 756-79-6);
      2. Methylphosphonyl dichloride, (CAS 676-97-1);

      Note:
      This Item does not control Fonofos: O-Ethyl S-phenyl ethylphosphonothionate, (CAS 944-22-9).
   b. N,N-Dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidic dihalides;
   c. Dialkyl (Me, Et, n-Pr or i-Pr) N,N-Dialkyl (Me, Et, n-Pr or i-Pr)-phosphoramidates;
   d. Arsenic trichloride, (CAS 7784-34-1);
   e. 2,2-diphenyl-2-hydroxyacetic acid, (CAS 76-93-7);
   f. Quinuclidin-3-ol, (CAS 1619-34-7);
   g. N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethyl-2-chlorides and corresponding protonated salts;
   h. N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-ols and corresponding protonated salts;

      Note:
      This Item does not control:
      a. N,N-Dimethylaminoethanol, (CAS 108-01-0) and corresponding protonated salts.
      b. N,N-Diethylaminoethanol, (CAS 100-37-8);

   i. N,N-Dialkyl (Me, Et, n-Pr or i-Pr)aminoethane-2-thiols and corresponding protonated salts;
   j. Thiodiglycol: Bis(2-hydroxyethyl)sulfide, (CAS 111-48-8);
   k. Pinacolyl alcohol: 3,3-Dimethylbutan-2-ol, (CAS 464-07-3).

5. CWC Schedule 3 A Toxic Chemicals:
   a. Phosgene: Carbonyl dichloride, (CAS 75-44-5);
   b. Cyanogen chloride, (CAS 506-77-4);
   c. Hydrogen cyanide, (CAS 74-90-8);
   d. Chloropicrin: Trichloronitromethane, (CAS 76-06-2).

6. CWC Schedule 3 B Precursors:
   a. Phosphorus oxychloride, (CAS 10025-87-3);
   b. Phosphorus trichloride, (CAS 7719-12-2);
   c. Phosphorus pentachloride, (CAS 10026-13-8);
   d. Trimethyl phosphite, (CAS 121-45-9);
   e. Triethyl phosphite, (CAS 122-52-1);
   f. Dimethyl phosphite, (CAS 868-85-9);
   g. Diethyl phosphite, (CAS 762-04-9);
   h. Sulphur monochloride, (CAS 10025-67-9);
   i. Sulphur dichloride, (CAS 10545-99-0);
   j. Thionyl chloride, (CAS 7719-09-7);
   k. Ethyldiethanolamine, (CAS 139-87-7);
   l. Methyldiethanolamine, (CAS 105-59-9);
   m. Triethanolamine, (CAS 102-71-6).

(All Destinations)

7-4. AG Materials.

1. Chemical Weapons Precursor Chemicals, as follows:
   a. 3-hydroxy-1-methylpiperidine, (CAS 3554-74-3);
   b. Potassium fluoride, (CAS 7789-23-3);
   c. 2-chloroethanol, (CAS 107-07-3);
   d. Dimethylamine, (CAS 124-40-3);
   e. Dimethylamine hydrochloride, (CAS 506-59-2);
   f. Hydrogen fluoride, (CAS 7664-39-3);
   g. Methyl benzilate, (CAS 76-89-1);
   h. 3-quinuclidone, (CAS 3731-38-2);
   i. Pinacolone, (CAS 75-97-8);
   j. Potassium cyanide, (CAS 151-50-8);
   k. Potassium bifluoride, (CAS 7789-29-9);
   l. Ammonium bifluoride, (CAS 1341-49-7);
   m. Sodium bifluoride, (CAS 1333-83-1);
   n. Sodium fluoride, (CAS 7681-49-4);
   o. Sodium cyanide, (CAS 143-33-9);
   p. Phosphorous pentasulphide, (CAS 1314-80-3);
   q. Di-isopropylamine, (CAS 108-18-9);
   r. Diethylaminoethanol, (CAS 100-37-8);
   s. Sodium sulphide, (CAS 1313-82-2);
   t. Triethanolamine hydrochloride, (CAS 637-39-8);
   u. Triisopropyl phosphite, (CAS 116-17-6);
   v. O,O-Diethyl phosphorothioate, (CAS 2465-65-8);
   w. O,O-Diethyl phosphorodithioate, (CAS 298-06-6);
   x. Sodium hexafluorosilicate, (CAS 16893-85-9).

7-5. Software.

None.

7-6. Technology.

1. The transfer of “technology”, including licenses, directly associated with CW agents, AG-controlled precursors and AG-controlled dual-use equipment in items 7-1. to 7-4.
2. Controls do not apply to that “technology” which is the minimum necessary for the installation, operation, maintenance, and repair of those products for which the export has been authorized.
3. Controls do not apply to information “in the public domain”, or to “basic scientific research”, or the minimum necessary information for patent application.

Biological Weapons

7-11. Equipment, Assemblies and Components

None.

7-12. Biological Test, Inspection and Production Equipment, as follows:

1. Complete containment facilities that meet the criteria for P3 or P4 (BL3, BL4, L3, L4,) containment as specified in the WHO Laboratory Biosafety Manual (Geneva, 1993 - 2nd Edition).
2. Fermenters capable of cultivation of pathogenic micro-organisms, viruses or for toxin production, without the propagation of aerosols, and having a capacity equal to or greater than 20 litres. Fermenters include bioreactors, chemostats and continuous-flow systems.
3. Centrifugal separators capable of the continuous separation of pathogenic microorganisms, without the propagation of aerosols, and having all the following characteristics:
   a. flow rate greater than 100 litres/h;
   b. component of polished stainless steel or titanium;
   c. one or more sealing joints within the steam containment area; **and**
   d. capable of in-situ steam sterilization in a closed state;

   Technical Note:
   For the purposes of Item 7-12.3., centrifugal separators include decanters.

4. Cross (tangential) flow filtration equipment and components as follows:
   a. Cross (tangential) flow filtration equipment and components capable of separation of pathogenic microorganisms, viruses, toxins or cell cultures, without the propagation of aerosols, and having all the following characteristics:
      1. a total filtration area equal to or greater than 1 square metre;
      2. capable of in-situ sterilization;

   N.B.:
   This control excludes reverse osmosis equipment, as specified by the manufacturer.

b. Cross (tangential) flow filtration components (eg. modules, elements, cassettes, cartridges, units or plates) with filtration area equal to or greater than 0.2 square metres for each component and designed for use in cross (tangential) flow filtration equipment as specified by 7-12.4.a.

Technical Note:

In this control, 'sterilized' denotes the elimination of all viable microbes from the equipment through the use of either physical (eg. steam) or chemical agents. 'Disinfected' denotes the destruction of potential microbial infectivity in the equipment through the use of chemical agents with a germicidal effect. 'Disinfection' and 'sterilization' are distinct from 'sanitization', the latter referring to cleaning procedures designed to lower the microbial content of quipment without necessarily achieving elimination of all microbial infectivity or viability.

5. Steam sterilizable freeze-drying equipment with a condenser capacity of 10 kg of ice or greater in 24 hours and less than 1000 kg of ice in 24 hours;
6. Protective and containment equipment as follows:
   a. protective full or half suits, or hoods dependent upon a tethered external air supply and operating under positive pressure;

      Technical Note:

      This does not control suits designed to be worn with self-contained breathing apparatus.

   b. Class III biological safety cabinets or isolators with similar performance standards. [e.g. flexible isolators, dry boxes, anaerobic chambers, glove boxes, or laminar flow hoods(closed with vertical flow)]
7. Aerosol inhalation chambers designed for aerosol challenge testing with microorganisms, viruses or toxins and having a capacity of 1 m^3 or greater.
8. Spraying or fogging systems and components therefore, as follows:
   a. Complete spraying or fogging systems, specially designed or modified for fitting to aircraft, lighter than air vehicles or UAVs, capable of delivering, from a liquid suspension, an initial droplet “VMD” of less than 50 microns at a flow rate of greater than two litres per minute.
   b. Spray booms or arrays of aerosol generating units, specially designed or modified for fitting to aircraft, lighter than air vehicles or UAVs, capable of delivering, from a liquid suspension, an initial droplet “VMD” of less than 50 microns at a flow rate of greater than two litres per minute.
   c. Aerosol generating units specially designed for fitting to systems that fulfill all the criteria specified in paragraphs 7-12.8.a. and 7-12.8.b.

      Technical Notes:

      Aerosol generating units are devices specially designed or modified for fitting to aircraft such as nozzles, rotary drum atomisers and similar devices.

      This entry does not control spraying or fogging systems and components as specified in paragraph 7-12.8 above that are demonstrated not to be capable of delivering biological agents in the form of infectious aerosols.

      Pending definition of international standards, the following guidelines should be followed:

      Droplet size for spray equipment or nozzles specially designed for use on aircraft or UAVs should be measured using either of the following methods:

      a. Doppler laser method
      b. Forward laser diffraction method

(Item 7-12. applies to all destinations except Argentina, Australia, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Latvia, Luxembourg, Malta, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Cyprus, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.)

7-13. Materials.

Biological Weapon Agents

1. Human Pathogens, as follows:

   Note:

   Except where the agent is in the form of a vaccine.

   a. Viruses:
      1. Chikungunya virus;
      2. Congo-Crimean haemorrhagic fever virus;
      3. Dengue fever virus;
      4. Eastern equine encephalitis virus;
      5. Ebola virus;
      6. Hantaan virus;
      7. Junin virus;
      8. Lassa fever virus;
      9. Lymphocytic choriomeningitis virus;
      10. Machupo virus;
      11. Marburg virus;
      12. Monkey pox virus;
      13. Rift Valley fever virus;
      14. Tick-borne encephalitis virus (Russian Spring-Summer encephalitis virus);
      15. Variola virus;
      16. Venezuelan equine encephalitis virus;
      17. Western equine encephalitis virus;
      18. White pox;
      19. Yellow fever virus;
      20. Japanese encephalitis virus;
      21. Kyasanur Forest virus;
      22. Louping ill virus;
      23. Murray Valley encephalitis virus;
      24. Omsk haemorrhagic fever virus;
      25. Oropouche virus;
      26. Powassan virus;
      27. Rocio virus;
      28. St. Louis encephalitis virus;
      29. Hendra virus (Equine morbilivirus);
      30. South American haemorrhagic fever (Sabia, Flexal, Guanarito);
      31. Pulmonary & renal syndrome-haemorrhagic fever viruses (Seoul, Dobrava, Puumala, Sin Nombre);
      32. Nipah virus;

   b. Rickettsiae:
      1. Coxiella burnetii;
      2. Bartonella Quintana (Rickettsiae quintana, Rochalimea quintana);
      3. Rickettsia prowazeki;
      4. Rickettsia rickettsii;

c. Bacteria:
1. Bacillus anthracis;
2. Brucella abortus;
3. Brucella melitensis;
4. Brucella suis;
5. Chlamydia psittaci;
6. Clostridium botulinum;
7. Francisella tularensis;
8. Burkholderia mallei (Pseudomonas mallei);
9. Burkholderia pseudomallei (Pseudomonas pseudomallei);
10. Salmonella typhi;
11. Shigella dysenteriae;
12. Vibrio cholerae;
13. Yersinia pestis;
14. Clostridium perfringens, epsilon toxin producing types;

Note:
7-13.1.c.14 does not control Clostridium perfringens strains other than epsilon toxin producing strains used as positive control cultures for food testing and quality control.

15. Enterohaemorrhagic Escherichia coli, serotype 0157 and other verotoxin producing serotypes;

d. Toxins as follow and sub units thereof:

Note:
7-13.1.d does not control immunotoxins.

1. Botulinum toxins;

Note:
7-13.1.d.1 does not control botulinum toxins and conotoxins in product form meeting all of the following criteria:
a. pharmaceutical formulations designed for human administration in the treatment of medical conditions;
b. pre-packaged for distribution as medical products; and
c. authorized by a state authority to be marketed as clinical or medical products.

2. Clostridium perfringens toxins;
3. Conotoxin;
4. Ricin;
5. Saxitoxin;
6. Shiga toxin;
7. Staphylococcus aureus toxins;
8. Tetrodotoxin;
9. Verotoxin and shiga-like ribosome inactivating proteins;
10. Microcystin (Cyanginosin);
11. Aflatoxins;
12. Abrin;
13. Cholera toxin;
14. Diacetoxyscirpenol toxin;
15. T-2 toxin;
16. HT-2 toxin;
17. Modeccin toxin;
18. Volkensin toxin;
19. Viscum Album Lectin 1 (Viscumin);

e. Fungi:
1. Coccidioides immitis;
2. Coccidioides posadasii;

f. Genetic Elements and Genetically-modified Organisms:
1. Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in items 7-13.1.a. through 7-13.1.e.;
2. Genetic elements that contain nucleic acid sequences coding for any of the toxins in item 7-13.1.d. or for their sub-units;
3. Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in items 7-13.1.a. through 7-13.1.e.;
4. Genetically modified organisms that contain nucleic acid sequences coding for any of the toxins in item 7-13.1.d. or for their sub-units.

Technical Note:
These controls do not apply to nucleic acid sequences associated with the pathogenicity of enterohaemorrhagic Escherichia coli, serotype 0157 and other verotoxin producing strains, other than those coding for the verotoxin, or for its sub-units.

2. Animal Pathogens, as follows:

Note:
Except where the agent is in the form of a vaccine.

a. Viruses:
1. African swine fever virus;
2. Avian influenza virus;

Note:
This includes only those Avian influenza viruses of high pathogenicity as defined in EC Directive 92/40/EC:
1. Type A viruses with an IVPI (intravenous pathogenicity index) in 6 week old chickens of greater than 1.2; **or**
2. Type A viruses H5 or H7 subtype for which nucleotide sequencing has demonstrated multiple basic amino acids at the cleavage site of haemegglutinin.

3. Bluetongue virus;
4. Foot and mouth disease virus;
5. Goat pox virus;
6. Herpes virus (Aujeszky's disease);
7. Hog cholera virus (synonym swine fever virus);
8. Lyssa virus;
9. Newcastle disease virus;
10. Peste des petits ruminants virus;
11. Porcine enterovirus type 9 (synonym swine vesicular disease virus);
12. Rinderpest virus;
13. Sheep pox virus;
14. Teschen disease virus;
15. Vesicular stomatitis virus;
16. Lumpy skin disease virus;
17. African horse sickness virus;

b. Rickettsiae - None;

c. Bacteria:
1. Mycoplasma mycoides subspecies mycoides SC (small colony);
2. Mycoplasma capricolum subspecies capripneumoniae (“strain F38”);

d. Genetic Elements and Genetically-modified Organisms:
   1. Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in items 7-13.2.a. through 7-13.2.c.;
   2. Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in items 7-13.2.a. through 7-13.2.c.;

3. Plant Pathogens, as follows:

a. Viruses;
   1. Potato Andean latent tymovirus;
   2. Potato spindle tuber viroid;

b. Rickettsiae - none;

c. Bacteria:
   1. Xanthomonas albilineans;
   2. Xanthomonas campestris pv.citri;
   3. Xanthomonas oryzae pv.oryzae (Pseudomonas campestris pv. oryzae);
   4. Clavibacter michiganensis subsp. sepedonicus (Corynebacterium michiganensis subsp. sepedonicum or Corynebacterium sepedonicum);
   5. Ralstonia solanacearum races 2 and 3 (Pseudomonas solanacearum races 2 and 3 or Burkholderia solanacearum races 2 and 3);

d. Toxins - none;

e. Fungi:
   1. Colletotrichum coffeanum var. virulans (Colletotrichum kahawae);
   2. Cochliobolus miyabeanus (Helminthospo-rium oryzae);
   3. Microcyclus ulei (syn. Dothidella ulei);
   4. Puccinia graminis (syn. Puccinia graminis f.sp. tritici);
   5. Puccinia striiformis (syn. Puccinia glumarum);
   6. Pyricularia grisea/Pyricularia oryzae.

f. Genetic Elements and Genetically-modified Organisms:
   1. Genetic elements that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in items 7-13.3.a. through 7-13.3.e.;
   2. Genetically-modified organisms that contain nucleic acid sequences associated with the pathogenicity of any of the microorganisms in items 7-13.3.a. through 7-13.3.e.;

Technical Note:

1. Genetic elements include inter alia chromosomes, genomes, plasmids, transposons, and vectors whether genetically modified or unmodified.
2. Nucleic acid sequences associated with the pathogenicity of any of the micro-organisms in item 7-13. means any sequence specific to the relevant listed micro-organism:
   - that in itself or through its transcribed or translated products represents a significant hazard to human, animal or plant health; **or**
   - that is known to enhance the ability of a listed micro-organism, or any other organism into which it may be inserted or otherwise integrated, to cause serious harm to human, animal or plant health.
3. Biological agents are controlled when they are an isolated live culture of a pathogen agent, or a preparation of a toxin agent which has been isolated or extracted from any source, or material including living material which has been deliberately inoculated or contaminated with the agent. Isolated live cultures of a pathogen agent include live cultures in dormant form or in dried preparations, whether the agent is natural, enhanced or modified.

   An agent is covered by item 7-13. except when it is in the form of a vaccine. A vaccine is a medicinal product in a pharmaceutical formulation licensed by, or having marketing or clinical trial authorization from, the regulatory authorities of either the country of manufacture or of use, which is intended to stimulate a protective immunological response in humans or animals in order to prevent disease in those to whom or to which it is administered.

(All Destinations)

7-14. Software:

None.

7-15. Technology:

1. The transfer of “technology” for the “development” or “production” of AG controlled biological agents or AG controlled dual use biological equipment items found in Category 7-11. to 7-14.
2. Controls do not apply to that “technology” which is the minimum necessary for the installation, operation, maintenance, and repair of those products for which the export has been authorized.
3. Controls do not apply to information “in the public domain” or to “basic scientific research”, or the minimum necessary information for patent application.

Group 7 Definitions

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

"Development"
Development is related to all phases before "production" such as: design, design research, design analysis, design concepts, assembly of prototypes, pilot production schemes, design data, process or transforming design data into a product, configuration design, integration design, and layouts.

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

"Lighter than air vehicles"
Balloons and airships that rely on hot air or on lighter-than-air gases such as helium or hydrogen for their lift.

"Production"
Means all production phases such as: construction, production engineering, manufacture, integration, assembly (mounting), inspection, testing, and quality assurance.

"Technical assistance"
May take forms, such as: instruction, skills, training, working knowledge, consulting services.

N.B.:
"Technical assistance" may involve transfer of "technical data".

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

"Technology"
Specific information necessary for the "development", "production" or "use" of a product. The information takes the form of "technical data" or "technical assistance".

"UAVs"
Unmanned Aerial Vehicles.

"Use"
Operation, installation (including on-site installation), maintenance (checking), repair, overhaul or refurbishing.

"VMD"
Volume Median Diameter.

Note:
For water-based systems, VMD equates to MMD - the Mass Median Diameter.

Index

This non-exhaustive index is provided as a guide only.