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GOVERNMENT NOTICE

DEPARTMENT OF DEFENCE

No. R. 634

28 May 2004

NATIONAL CONVENTIONAL ARMS CONTROL REGULATIONS

The Minister of Defence has, in terms of section 27 of the National Conventional Arms Control Act, 2002 (Act No. 41 of 2002), and with the concurrence of the National Conventional Arms Control Committee, made the regulations in the Schedule.

Government Notice No. R. 1171 of 2 August 1996 is hereby withdrawn.

SCHEDULE

Definitions

1. In these Regulations any expression to which a meaning has been assigned in the Act, shall bear such meaning, and, unless inconsistent with the context-

“apostille stamp” means the validation stamp that is only recognised in countries that are State Parties to The Hague Convention of 1961 and is a special seal applied by the State Parties’ authorities to authenticate a document.

“dual-use goods” means the list of conventional arms contained in the Annexure to these regulations.

“munitions list” means the list of conventional arms contained in the Annexure to these regulations.

“the Act” means the National Conventional Arms Control Act, 2002 (Act No. 41 of 2002).

Application for permit

2. (1) A person registered in terms of section 13 of the Act as a trader in conventional arms may apply for-

(a) an armaments development and manufacturing permit;

- (b) a marketing permit;
 - (c) a contracting permit;
 - (d) an export permit;
 - (e) an import permit;
 - (f) a conveyance permit.
- (2) Conventional arms, incorporating both dual-use goods and munitions, for which a permit must be obtained are listed in the Annexure to these Regulations. All services as defined in the Act also require a permit.

Purposes for which permits may be issued

3. (1) An armaments development and manufacturing permit is required by registered trader to-

- (a) develop and manufacture conventional arms;
- (b) own or operate conventional arms; and
- (c) render brokering services or services related to conventional arms.

(2) A marketing permit is required by a holder of an armaments development and manufacturing permit to-

- (a) identify the specific conventional arms listed in the munitions list in which it may trade;
- (b) identify services relating to conventional arms in which it may trade; and
- (c) enable it to market the conventional arms contemplated in paragraph (a) and the services contemplated in paragraph (b) on the international market.

(3) A contracting permit is required to enable the holder of an armaments development and manufacturing permit to enter into an agreement with a person resident in a foreign country -

- (a) to trade in specified conventional arms; and
- (b) to render specified brokering services or services relating to conventional arms.

(4)(a) An export permit is required by the holder of an armaments development and manufacturing permit for-

- (i) each consignment of conventional arms which is exported from the Republic for the purpose of transferring ownership of the said arms;

- (ii) each consignment of conventional arms which is exported for the purpose of integration, repair, demonstration or evaluation without transfer of ownership; and
 - (iii) services which are exported relating to conventional arms.
- (b) Notwithstanding the stipulations contained in 3(4)(a) under special circumstances a single export permit may be issued to cover several consignments.
- (5)(a) An import permit is required by the holder of an armaments development and manufacturing permit for-
- (i) each consignment of conventional arms as listed in the munitions list which is imported into the Republic for the purpose of transferring ownership of the said arms; and
 - (ii) each consignment of conventional arms as listed in the munitions list which is imported for the purpose of integration, repair, demonstration or evaluation without transfer of ownership.
- (b) Notwithstanding the stipulations contained in 3(5)(a) under special circumstances a single import permit may be issued to cover several consignments.
- (6) A conveyance permit is required to enable the holder of an armaments development and manufacturing permit to convey conventional arms owned by a person resident in a foreign country through or over the territory of the Republic of South Africa. Such an application must include a diplomatic note from the government of the country who owns the conventional arms that are to be conveyed through the Republic requesting authorisation for such conveyance.

Conditions for issuing of permits

4. (1) A permit may, subject to the Act, be issued if the conventional arms concerned are not prohibited under international agreements dealing with conventional arms including the-

- (a) Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons which may be deemed to be Excessively Injurious or to have Indiscriminate Effects and its annexed Protocols; or
- (b) Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction;

- (2) An export permit may not be issued for any conventional arms of a calibre of 12.7mm (.50 inch) or smaller, including the ammunition for such arms, that is surplus to State or parastatal stock and have been designated by the Committee for destruction.

Keeping of records

5. A person trading in conventional arms must keep full records and permits of all trade activities relating to his conventional arms trade.

Matters contained in end-user certificate

6. (1) An end-user certificate must contain a certificate by the Department of Foreign Affairs that the end-user certificate is a legal and valid document that has been properly sealed and signed.
- (2) An end-user certificate containing an apostille stamp does not require a certificate contemplated in sub-regulation (1).

Applications in terms of Fire Arms Control Act

7. Any application for the export of firearms and ammunition submitted in terms of the Firearms Control Act, 2000 (Act No. 60 of 2000) where the quantity of the firearms exceeds 10 per type and the quantity of ammunition per calibre exceeds 20 000 must be submitted to the Committee by the National Commissioner of the South African Police Service.

WA-LIST (03) 1
12-12-03

LIST OF DUAL-USE GOODS, TECHNOLOGIES AND MUNITIONS

(The Wassenaar Arrangement on Export Controls for Conventional Arms and
Dual-Use Goods and Technologies)

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These Lists reflect the agreements recorded in Appendix 5 to the Initial Elements, dated 19 December 1995, and all amendments, including those approved by the Plenary Meeting (10 to 12 December 2003).

DUAL-USE LIST

Note Terms in "quotations" are defined terms. Refer to 'Definitions of Terms used in these Lists' annexed to this List.

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.E.2.e. & 1.E.2.f. and 8.E.2.a. & 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".

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. A. SYSTEMS, EQUIPMENT AND COMPONENTS**1. A. 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.C.9.b. or 1.C.9.c.;
- b. Piezoelectric polymers and copolymers made from vinylidene fluoride materials controlled by 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 vinyl ether group as a constitutional unit, specially designed for "aircraft", aerospace or missile use.

1. A. 2. "Composite" structures or laminates, having any of the following:

- a. An organic "matrix" and made from materials controlled by 1.C.10.c., 1.C.10.d. or 1.C.10.e.; or

Note 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. A metal or carbon "matrix" and made from:

1. Carbon "fibrous or filamentary materials" with:
 - a. A specific modulus exceeding $10.15 \times 10^6 \text{ m}$; and
 - b. A specific tensile strength exceeding $17.7 \times 10^4 \text{ m}$; or
2. Materials controlled by 1.C.10.c.

Note 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.

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. A. 2. b. 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 $(296 \pm 2) K$ ($(23 \pm 2)^\circ C$) and a relative humidity of $(50 \pm 5)\%$.*
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 $(296 \pm 2) K$ ($(23 \pm 2)^\circ C$) and a relative humidity of $(50 \pm 5)\%$.*

Note 1.A.2. does not control composite structures or laminates made from epoxy resin impregnated carbon "fibrous or filamentary materials" for the repair of aircraft structures or laminates, provided the size does not exceed $1 m^2$.

1. A. 3. Manufactures of non-fluorinated polymeric substances controlled by 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.A.3. does not control manufactures when coated or laminated with copper and designed for the production of electronic printed circuit boards.

1. A. 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.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.

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. A. 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.C.10.

Note 1 1.A.5. does not control body armour or protective garments when accompanying their user for the user's own personal protection.

Note 2 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. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1. B. 1. Equipment for the production of fibres, preregs, preforms or "composites" controlled by 1.A.2. or 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.B.1.c. the technique of interlacing includes knitting.

Note 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;

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. B. 1. e. Equipment for producing prepregs controlled by 1.C.10.e. by the hot melt method;
- f. Non-destructive inspection equipment capable of inspecting defects three dimensionally, using ultrasonic or X-ray tomography and specially designed for "composite" materials.
1. B. 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.C.2.c.2.
1. B. 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. 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, bricks, 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.

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 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.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 $\pm 15\%$ 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 $\pm 15\%$ 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.C.1.a. Note 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 7×10^6 N/m²; and
3. Compressive strength less than 14×10^6 N/m²;
- d. Planar absorbers made of sintered ferrite, having:
 1. A specific gravity exceeding 4.4; and
 2. A maximum operating temperature of 540 K (275°C).

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

1. C. 1. b. Materials for absorbing frequencies exceeding 1.5×10^{14} Hz but less than 3.7×10^{14} Hz and not transparent to visible light;

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 1. 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.

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

Note *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.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.*

1. C. 2. 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.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;

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 2. b. 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;
1. C. 2. 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 10⁹ 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.C.2.a. or 1.C.2.b.;
1. C. 2. d. Alloyed materials, having all of the following characteristics:
1. Made from any of the composition systems specified in 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;

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

c. "Melt extraction";

1. C. 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 5×10^{-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 2×10^{-4} ohm cm or more.

Technical Note

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

1. C. 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%.

1. C. 5. "Superconductive" "composite" conductors in lengths exceeding 100 m or with a mass exceeding 100 g, as follows:

- a. Multifilamentary "superconductive" "composite" conductors containing one or more niobium-titanium filaments:
 1. Embedded in a "matrix" other than a copper or copper-based mixed "matrix"; or
 2. Having a cross-section area less than $0.28 \times 10^{-4} \text{ mm}^2$ ($6 \mu\text{m}$ in diameter for circular filaments);

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 5. 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) but less than 24 K (-249.16°C);
 2. A cross-section area less than $0.28 \times 10^{-4} \text{ mm}^2$; and
 3. Remaining in the "superconductive" state at a temperature of 4.2 K (-268.96°C) when exposed to a magnetic field corresponding to a magnetic induction of 12 T.
1. C. 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.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.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;

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 6. 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 I.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 ($371 \pm 6^\circ\text{C}$) 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.

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 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.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 $12.7 \times 10^3 \text{m}$;
- 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.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.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.*

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 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) determined using the dry method described in ASTM D 3418;
- Note 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 ASTM D-648, method A, or national equivalents, with a load of 1.82 N/mm² 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. Polyarylene ether ketones, as follows:
 1. Polyether ether ketone (PEEK);
 2. Polyether ketone ketone (PEKK);
 3. Polyether ketone (PEK);
 4. Polyether ketone ether ketone ketone (PEKEKK);
 - d. Polyarylene ketones;
 - e. Polyarylene sulphides, where the arylene group is biphenylene, triphenylene or combinations thereof;
 - f. Polybiphenylenethersulphone.

Technical Note

The glass transition temperature (T_g) for 1.C.8. materials is determined using the method described in ASTM D 3418 using the dry method.

1. C. 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.

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 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 12.7×10^6 m; and
2. A specific tensile strength exceeding 23.5×10^4 m;

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

- b. Carbon "fibrous or filamentary materials", having all of the following:

1. A specific modulus exceeding 12.7×10^6 m; and
2. A specific tensile strength exceeding 23.5×10^4 m;

Technical Note

Properties for materials described in 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.C.10.b. does not control fabric made from "fibrous or filamentary materials" for the repair of aircraft structures or laminates, in which the size of individual sheets does not exceed 50 cm x 90 cm.

- c. Inorganic "fibrous or filamentary materials", having all of the following:

1. A specific modulus exceeding 2.54×10^6 m; and
2. A melting, softening, decomposition or sublimation point exceeding 1,922 K (1,649°C) in an inert environment;

Note 1.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 10×10^6 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.C.8.a; or
 - b. Materials controlled by 1.C.8.b. to 1.C.8.f.; or
2. Composed of materials controlled by 1.C.10.d.1.a. or 1.C.10.d.1.b. and "commingled" with other fibres controlled by 1.C.10.a., 1.C.10.b. or 1.C.10.c.;

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 10. 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.C.10.a., 1.C.10.b. or 1.C.10.c.;
 2. Made from organic or carbon "fibrous or filamentary materials":
 - a. With a specific tensile strength exceeding 17.7×10^4 m;
 - b. With a specific modulus exceeding 10.15×10^6 m;
 - c. Not controlled by 1.C.10.a. or 1.C.10.b.; and
 - d. When impregnated with materials controlled by 1.C.8. or 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.C.10.e. does not control:

1. Epoxy resin "matrix" impregnated carbon "fibrous or filamentary materials" (prepregs) for the repair of aircraft structures or laminates, in which the size of individual sheets of prepreg does not exceed 50 cm x 90 cm;
2. Prepregs when impregnated with phenolic or epoxy resins having a glass transition temperature (T_g) less than 433 K (160°C) and a cure temperature lower than the glass transition temperature.

Technical Note

The glass transition temperature (T_g) for 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 $((23 \pm 2)^\circ\text{C})$ and a relative humidity of $(50 \pm 5)\%$.
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 $((23 \pm 2)^\circ\text{C})$ and a relative humidity of $(50 \pm 5)\%$.

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

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. C. 11. 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.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).

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

1. D. SOFTWARE

1. D. 1. "Software" specially designed or modified for the "development", "production" or "use" of equipment controlled by 1.B.
1. D. 2. "Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites".

1. E. TECHNOLOGY

1. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials controlled by 1.A.1.b., 1.A.1.c., 1.A.2. to 1.A.5., 1.B. or 1.C.
1. E. 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 vinyl ether monomer;

DUAL-USE LIST - CATEGORY 1 - ADVANCED MATERIALS

1. E. 2. 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.E.2.c.1.;

Note 1.E.2.c.2. does not control technology for the design or production of abrasives.
1. E. 2. d. "Technology" for the "production" of aromatic polyamide fibres;
- e. "Technology" for the installation, maintenance or repair of materials controlled by 1.C.1.;
- f. "Technology" for the repair of "composite" structures, laminates or materials controlled by 1.A.2., 1.C.7.c. or 1.C.7.d.

Note 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.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

2. A. SYSTEMS, EQUIPMENT AND COMPONENTS

*N.B. For quiet running bearings, see Item 9 on the Munitions List.**

2. A. 1. Anti-friction bearings and bearing systems, as follows, and components thereof:
- Note 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 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 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.

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 2.B, the number of axes which can be co-ordinated simultaneously for "contouring control" is the number of axes which affect relative movement between any one workpiece and a tool, cutting head or grinding wheel which is cutting or removing material from the workpiece. This does not include any additional axes which affect other relative movement within the machine. Such axes include:*
 - 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.*

* France, the Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

Technical Notes contd.

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 \bar{A} becomes the stated value of each axis for the model ($\bar{A}_x \bar{A}_y \dots$);*
- 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 2.B.1.a. to 2.B.1.c. has a stated accuracy \bar{A} 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.*

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

Note 2 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 faceted 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 2.B.1.a., b. or c.

2. B. 1. a. Machine tools for turning, having all of the following characteristics:

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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 2.B.1.a. does not control turning machines specially designed for the production of contact lenses.

2. B. 1. 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"; or
 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;
 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.
2. B. 1. 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 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 having any of the following characteristics:

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- a. The c-axis is used to maintain the grinding wheel normal to the work surface; or
 - b. The a-axis is configured to grind barrel cams.
 - 3. Surface grinders.
 - 2. B. 1. 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";
 - 2. B. 1. 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. B. 2. Numerically controlled machine tools using a magnetorheological finishing (MRF) process.

Technical Note

For the purposes of 2.B.2., 'MRF' is a material removal process using an abrasive magnetic fluid whose viscosity is controlled by a magnetic field.

- 2. B. 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).
- 2. B. 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

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

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.B.3., 9.B.9. and ML18. of the Munitions List.**

2. B. 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 2.E.3.f., and specially designed automated handling, positioning, manipulation and control components therefor:
 - a. "Stored programme controlled" 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. "Stored programme controlled" ion implantation production equipment having beam currents of 5 mA or more;
 - c. "Stored programme controlled" 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 photoluminescence of the ionised atoms in the evaporant stream to control the deposition rate of a coating containing two or more elements;
 - d. "Stored programme controlled" 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;

* France, the Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

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- e. "Stored programme controlled" sputter deposition production equipment capable of current densities of 0.1 mA/mm^2 or higher at a deposition rate of $15 \text{ } \mu\text{m/h}$ or more;
- f. "Stored programme controlled" cathodic arc deposition production equipment incorporating a grid of electromagnets for steering control of the arc spot on the cathode;
- 2. B. 5. g. "Stored programme controlled" 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 2.B.5.a., 2.B.5.b., 2.B.5.e., 2.B.5.f. and 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.

- 2. B. 6. Dimensional inspection or measuring systems and equipment, as follows:
 - a. Computer controlled, "numerically controlled" or "stored programme controlled" co-ordinate measuring machines (CMM), having a three dimensional (volumetric) maximum permissible error of indication (MPE_E) at any point within the operating range of the machine (i.e., within the length of axes) equal to or less (better) than $1.7 + L/1,000 \text{ } \mu\text{m}$ (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 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 $0.2 \text{ } \mu\text{m}$ 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 $\pm 1 \text{ K}$; 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 $\pm 1 \text{ K}$ around a standard temperature and at a standard pressure, all of the following:
 - a. A "resolution" over their full scale of $0.1 \text{ } \mu\text{m}$ or less (better); and

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- b. A "measurement uncertainty" equal to or less (better) than $(0.2 + L/2,000) \mu\text{m}$ (L is the measured length in mm);

Note 2.B.6.b.1. 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.

2. B. 6. b. 2. Angular displacement measuring instruments having an "angular position deviation" equal to or less (better) than 0.00025° ;

Note 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.

2. B. 6. 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.

2. B. 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 $5 \times 10^3 \text{ Gy (Si)}$ without operational degradation; or
- d. Specially designed to operate at altitudes exceeding 30,000 m.

2. B. 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 $(800 + (600 \times L \times 10^{-3})) \text{ nm}$ (L equals the effective length in mm);

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

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

- 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 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 2.B.

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 2.B.9. regarded as flow-forming machines.

2. C. MATERIALS - None

2. D. SOFTWARE

1. "Software", other than that controlled by 2.D.2., specially designed or modified for the "development", "production" or "use" of equipment controlled by 2.A. or 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 2.D.2. does not control "software" specially designed or modified for the operation of machine tools not controlled by Category 2.

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

2. E. TECHNOLOGY

2. E. 1. "Technology" according to the General Technology Note for the "development" of equipment or "software" controlled by 2.A., 2.B. or 2.D.

2. E. 2. "Technology" according to the General Technology Note for the "production" of equipment controlled by 2.A. or 2.B.

2. E. 3. Other "technology", as follows:

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DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

- 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. E. 3. b. 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;
2. E. 3. 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.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

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)'.*

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. <u>Coating Process (1)*</u>	2. <u>Substrate</u>	3. <u>Resultant Coating</u>
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)

* The numbers in parenthesis refer to the Notes following this Table.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. <u>Coating Process (1)</u>	2. <u>Substrate</u>	3. <u>Resultant Coating</u>
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
	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

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. <u>Coating Process (1)</u>	2. <u>Substrate</u>	3. <u>Resultant Coating</u>
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

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. <u>Coating Process</u> (1)	2. <u>Substrate</u>	3. <u>Resultant Coating</u>
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)
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 Alloyed aluminides (2)
	Refractory metals and alloys (8)	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)
	Aluminium alloys (6)	MCrAlX (5) Modified zirconia (12) Silicides Mixtures thereof (4)
	Refractory metals and alloys (8)	Aluminides Silicides Carbides

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. <u>Coating Process</u> (1)	2. <u>Substrate</u>	3. <u>Resultant Coating</u>
D. (continued)	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)
	Ceramics and Low-expansion glasses (14)	Silicides Platinum Mixtures thereof (4) Dielectric layers (15) Diamond-like carbon (17)

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. <u>Coating Process</u> (1)	2. <u>Substrate</u>	3. <u>Resultant Coating</u>
F. (continued)	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

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES

1. <u>Coating Process (1)</u>	2. <u>Substrate</u>	3. <u>Resultant Coating</u>
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

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

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.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - NOTES

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 $1 \times 10^{-7} \text{ K}^{-1}$ 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.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

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;

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table - continued:

- b. 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.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table - continued:

- 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.

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

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;

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

3.
 - 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;

DUAL-USE LIST - CATEGORY 2 - MATERIALS PROCESSING

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

5. 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.

DUAL-USE LIST - CATEGORY 3 - ELECTRONICS

3. A. SYSTEMS, EQUIPMENT AND COMPONENTS

Note 1 *The control status of equipment and components described in 3.A., other than those described in 3.A.1.a.3. to 3.A.1.a.10. or 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 3.A.1.a.3. to 3.A.1.a.9. or 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 3.A.1.a.3. to 3.A.1.a.9. and 3.A.1.a.12. If the integrated circuit is a silicon-based "microcomputer microcircuit" or microcontroller microcircuit described in 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 3.A.1.a.3.*

3. A. 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 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".

3. A. 1. a. 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/cm² or higher on silicon, or its equivalent for other materials;

Note *3.A.1.a.1.c. does not apply to Metal Insulator Semiconductors (MIS).*

DUAL-USE LIST - CATEGORY 3 - ELECTRONICS

3. A. 1. a. 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 3.A.1.a.2. does not apply to integrated circuits for civil automobile or railway train applications.

3. A. 1. a. 3. "Microprocessor microcircuits", "micro-computer microcircuits" and microcontroller microcircuits, having any of the following characteristics:

Note 3.A.1.a.3. includes digital signal processors, digital array processors and digital coprocessors.

- a. Deleted
- b. Manufactured from a compound semiconductor and operating at a clock frequency exceeding 40 MHz; or
- c. More than one data or instruction bus or serial communication port that provides a direct external interconnection between parallel "microprocessor microcircuits" with a transfer rate exceeding 150 Mbyte/s;

3. A. 1. a. 4. Storage integrated circuits manufactured from a compound semiconductor;

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3. A. 1. a. 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 12 bit, with a total conversion time of less than 5 ns;
 2. A resolution of 12 bit with a total conversion time of less than 20 ns;
 3. A resolution of more than 12 bit but equal to or less than 14 bit with a total conversion time of less than 200 ns; or
 4. A resolution of more than 14 bit with a total conversion time of less than 1 microsecond;

- b. Digital-to-analogue converters with a resolution of 12 bit or more, and a "settling time" of less than 10 ns;

Technical Note

1. A resolution of n bit corresponds to a quantisation of 2^n levels.
2. Total conversion time is the inverse of the sample rate.

3. A. 1. a. 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;

3. A. 1. a. 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 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.

3. A. 1. a. 8. Deleted

3. A. 1. a. 9. Neural network integrated circuits;

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3. A. 1. a. 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:
- More than 1,000 terminals;
 - A typical "basic gate propagation delay time" of less than 0.1 ns;
or
 - An operating frequency exceeding 3 GHz;
3. A. 1. a. 11. Digital integrated circuits, other than those described in 3.A.1.a.3 to 3.A.1.a.10. and 3.A.1.a.12., based upon any compound semiconductor and having any of the following:
- An equivalent gate count of more than 3000 (2 input gates); or
 - A toggle frequency exceeding 1.2 GHz;
3. A. 1. a. 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 3.A.1.a.12. gives an execution time of 500 μ s.
3. A. 1. b. Microwave or millimetre wave components, as follows:
- Electronic vacuum tubes and cathodes, as follows:

Note 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:

 - Does not exceed 31.8 GHz; and
 - Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

Note 2 3.A.1.b.1. does not control non-"space-qualified" tubes which meet all of the following characteristics:

 - An average output power equal to or less than 50 W;
and
 - Designed or rated for operation in any frequency band which meets all of the following characteristics:
 - Exceeds 31.8 GHz but does not exceed 43.5 GHz;
and
 - Is "allocated by the ITU" for radio-communications services, but not for radio-determination;
 - Travelling wave tubes, pulsed or continuous wave, as follows:
 - Operating at frequencies exceeding 31.8 GHz;
 - Having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;
 - Coupled cavity tubes, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW;

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3. A. 1. b. 1. a. 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/cm²;
3. A. 1. b. 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 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 operating frequency spans more than one frequency range, as defined by 3.A.1.b.2., is determined by the lowest average output power control threshold.

Note 3 Notes 1 and 2 in the chapeau to Category 3 mean that 3.A.1.b.2. does not control MMICs if they are specially designed for other applications, e.g., telecommunications, radar, automobiles.

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3. A. 1. b. 3. 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 an item whose operating frequency spans more than one frequency range, as defined by 3.A.1.b.3, is determined by the lowest average output power control threshold.

3. A. 1. b. 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 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 [$P > 150 \text{ W} \cdot \text{GHz}^2 / f_{\text{GHz}}^2$];
 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 [$d \leq 15 \text{ cm} \cdot \text{GHz} / f_{\text{GHz}}$].

N.B. MMIC power amplifiers should be evaluated against the criteria in 3.A.1.b.2.

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Note 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 operating frequency spans more than one frequency range, as defined by 3.A.1.b.4, is determined by the lowest average output power control threshold.

3. A. 1. b. 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 μ s 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

3. A. 1. b. 7. Mixers and converters designed to extend the frequency range of equipment described in 3.A.2.c., 3.A.2.e. or 3.A.2.f. beyond the limits stated therein;
8. Microwave power amplifiers containing tubes controlled by 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 cm³;

Note 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.

3. A. 1. 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 μ s and bandwidth in MHz) of more than 100;
 - 3. A bandwidth greater than 250 MHz; or
 - 4. A dispersive delay of more than 10 μ s; or
 - c. A carrier frequency of 1 GHz or less, having any of the following:

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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;
3. A. 1. c. 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;
3. A. 1. 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;
3. A. 1. e. High energy devices, as follows:
1. Batteries and photovoltaic arrays, as follows:

Note 3.A.1.e.1. does not control batteries with volumes equal to or less than 27 cm^3 (e.g., standard C-cells or R14 batteries).

 - a. Primary cells and batteries having an energy density exceeding 480 Wh/kg and rated for operation in the temperature range from below 243 K (-30°C) to above 343 K (70°C);
 - b. Rechargeable cells and batteries having an energy density exceeding 150 Wh/kg after 75 charge/discharge cycles at a discharge current equal to C/5 hours (C being the nominal capacity in ampere hours) when operating in the temperature range from below 253 K (-20°C) to above 333 K (60°C);

Technical Note
Energy density is obtained by multiplying the average power in watts (average voltage in volts times average current in amperes) by the duration of the discharge in hours to 75% of the open circuit voltage divided by the total mass of the cell (or battery) in kg.

 - c. "Space qualified" and radiation hardened photovoltaic arrays with a specific power exceeding 160 W/m^2 at an operating temperature of 301 K (28°C) under a tungsten illumination of 1 kW/m^2 at 2,800 K ($2,527^\circ\text{C}$);

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3. A. 1. e. 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;
 3. A. 1. e. 2. 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. A. 1. e. 3. "Superconductive" electromagnets and solenoids specially designed to be fully charged or discharged in less than one second, having all of the following:

Note 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/mm²;
 3. A. 1. 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.
 3. A. 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 μ s;

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

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

Note 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.

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3. A. 2. a. 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 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;

3. A. 2. b. "Frequency synthesiser" "electronic assemblies" having a "frequency switching time" from one selected frequency to another of less than 1 ms;

- c. Radio frequency "signal analysers", as follows:
 - 1. "Signal analysers" capable of analysing any frequencies exceeding 31.8 GHz but less than 37.5 GHz or exceeding 43.5 GHz;
 - 2. "Dynamic signal analysers" having a "real-time bandwidth" exceeding 500 kHz;

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

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3. A. 2. 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 frequency, 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 of less than 1 ms; 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;

Technical Note

For the purposes of 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.

Note 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.

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

3. A. 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.

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3. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

3. B. 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 any of the following:
 - a. A silicon layer with a thickness uniform to less than $\pm 2.5\%$ across a distance of 200 mm or more; or
 - b. A layer of any material other than silicon with a thickness uniform to less than $\pm 2.5\%$ 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 3.C.3 or 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 0.3 μm or less with $\pm 5\%$ 3 sigma precision; or
 - b. Designed for generating less than 0.04 particles/cm² with a measurable particle size greater than 0.1 μm in diameter;
 2. Equipment specially designed for equipment controlled by 3.B.1.e. and having any of the following:
 - a. Designed or optimised to produce critical dimensions of 0.3 μm or less with $\pm 5\%$ 3 sigma precision; or
 - b. Designed for generating less than 0.04 particles/cm² 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;

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3. B. 1. d. 2. Equipment specially designed for equipment controlled by 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;

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

3. B. 1. 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 350 nm; or
- b. Capable of producing a pattern with a minimum resolvable feature size of 0.35 μm or less;

Technical Note

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

$$\text{MRF} = \frac{(\text{an exposure light source wavelength in } \mu\text{m}) \times (K\text{factor})}{\text{numerical aperture}}$$

where the K factor = 0.7.

MRF = minimum resolvable feature size.

2. 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 $\pm 0.20 \mu\text{m}$ (3 sigma);

3. B. 1. g. Masks and reticles designed for integrated circuits controlled by 3.A.1.;

- h. Multi-layer masks with a phase shift layer.

Note 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 3.A.1.

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3. B. 2. "Stored programme controlled" test equipment, specially designed for testing finished or unfinished semiconductor devices, as follows, and specially designed components and accessories therefor:
3. B. 2. a. For testing S-parameters of transistor devices at frequencies exceeding 31.8 GHz;

- b. For testing integrated circuits capable of performing functional (truth table) testing at a pattern rate of more than 667 MHz;

Note 3.B.2.b. does not control test equipment specially designed for testing:

1. "Electronic assemblies" or a class of "electronic assemblies" for home or entertainment applications;
2. Uncontrolled electronic components, "electronic assemblies" or integrated circuits;
3. Memories.

Technical Note

For the purpose of this entry, pattern rate is defined as the maximum frequency of digital operation of a tester. It is therefore equivalent to the highest data rate that a tester can provide in non-multiplexed mode. It is also referred to as test speed, maximum digital frequency or maximum digital speed.

3. B. 2. c. For testing microwave integrated circuits controlled by 3.A.1.b.2.;

3. C. MATERIALS

3. C. 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 Mendeleev's periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).

3. C. 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 350 nm ;
 - b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 $\mu\text{Coulomb}/\text{mm}^2$ 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.

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Technical Note

Silylation techniques are defined as processes incorporating oxidation of the resist surface to enhance performance for both wet and dry developing.

3. C. 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 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.

3. C. 4. Hydrides of phosphorus, arsenic or antimony, having a purity better than 99.999%, even diluted in inert gases or hydrogen.

Note 3.C.4. does not control hydrides containing 20% molar or more of inert gases or hydrogen.

3. D. **SOFTWARE**

3. D. 1. "Software" specially designed for the "development" or "production" of equipment controlled by 3.A.1.b. to 3.A.2.g. or 3.B.

3. D. 2. "Software" specially designed for the "use" of any of the following:
- a. Equipment controlled by 3.B.1.a. to f.; or
 - b. Equipment controlled by 3.B.2.

3. D. 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 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".

3. D. 4. "Software" specially designed for the "development" of the equipment controlled by 3.A.3.

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3. E. TECHNOLOGY

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

Note 3.E.1. does not control "technology" for the "production" of equipment or components controlled by 3.A.3.

2. "Technology" according to the General Technology Note other than that controlled in 3.E.1. for the "development" or "production" of "microprocessor microcircuits", "micro-computer microcircuits" and microcontroller microcircuits having a "composite theoretical performance" ("CTP") of 530 million theoretical operations per second (Mtops) or more and an arithmetic logic unit with an access width of 32 bits or more.

Note 3.E.1. and 3.E.2. do not control "technology" for the "development" or "production" of integrated circuits controlled by 3.A.1.a.3. to 3.A.1.a.12., having all of the following:

1. Using "technology" of 0.5 μm or more; and
2. Not incorporating multi-layer structures.

Technical Note

The term multi-layer structures in Note b.2. above does not include devices incorporating a maximum of three metal layers and three polysilicon layers.

3. E. 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 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.

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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 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").

4. A. SYSTEMS, EQUIPMENT AND COMPONENTS

4. A. 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 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 4.A.1.b. does not control electronic computers and related equipment when accompanying their user for the user's personal use.

4. A. 2. Deleted

4. A. 3. "Digital computers", "electronic assemblies", and related equipment therefor, as follows, and specially designed components therefor:

Note 1 4.A.3. includes the following:

- a. Vector processors;
- b. Array processors;
- c. Digital signal processors;
- d. Logic processors;

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- 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 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 I (Telecommunications).*

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

- 4. A. 3. a. *Designed or modified for "fault tolerance";*

Note *For the purposes of 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.*

- 4. A. 3. b. *"Digital computers" having a "composite theoretical performance" ("CTP") exceeding 190,000 Mtops;*

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4. A. 3. c. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.A.3.b.;

Note 1 4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit in 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 4.A.3.d., or 4.A.3.e.

Note 2 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 4.A.3.b.

d. Deleted

- e. Equipment performing analogue-to-digital conversions exceeding the limits in 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 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. A. 4. Computers, as follows, and specially designed related equipment, "electronic assemblies" and components therefor:

- a. "Systolic array computers";
- b. "Neural computers";
- c. "Optical computers".

4. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT - None

4. C. MATERIALS - None

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.

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- 4. D. 1. a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" controlled by 4.A. or 4.D.
- b. "Software", other than that controlled by 4.D.1.a., specially designed or modified for the "development" or "production" of:
 - 1. "Digital computers" having a "composite theoretical performance" ("CTP") exceeding 28,000 Mtops; or
 - 2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.D.1.b.1.
- 2. "Software" specially designed or modified to support "technology" controlled by 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 4.D.3.c. does not control "software" when accompanying its user for the user's personal use.
 - d. Deleted

4. E. TECHNOLOGY

- 4. E. 1. a. "Technology" according to the General Technology Note, for the "development", "production" or "use" of equipment or "software" controlled by 4.A. or 4.D.
- b. "Technology", other than that controlled by 4.E.1.a., specially designed or modified for the "development" or "production" of:
 - 1. "Digital computers" having a "composite theoretical performance" ("CTP") exceeding 28,000 Mtops; or
 - 2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of "computing elements" ("CEs") so that the "CTP" of the aggregation exceeds the limit in 4.E.1.b.1.

DUAL-USE LIST - CATEGORY 4 - COMPUTERS

TECHNICAL NOTE ON "COMPOSITE THEORETICAL PERFORMANCE" ("CTP")**Abbreviations used in this Technical Note**

"CE"	"computing element" (typically an arithmetic logical unit)
FP	floating point
XP	fixed point
t	execution time
XOR	exclusive OR
CPU	central processing unit
TP	theoretical performance (of a single "CE")
"CTP"	"composite theoretical performance" (multiple "CEs")
R	effective calculating rate
WL	word length
L	word length adjustment
*	multiply

Execution time 't' is expressed in microseconds, TP and "CTP" are expressed in millions of theoretical operations per second (Mtops) and WL is expressed in bits.

Outline of "CTP" calculation method

"CTP" is a measure of computational performance given in Mtops. In calculating the "CTP" of an aggregation of "CEs" the following three steps are required:

1. Calculate the effective calculating rate R for each "CE";
2. Apply the word length adjustment (L) to the effective calculating rate (R), resulting in a Theoretical Performance (TP) for each "CE";
3. If there is more than one "CE", combine the TPs, resulting in a "CTP" for the aggregation.

Details for these steps are given in the following sections.

Note 1 For aggregations of multiple "CEs" which have both shared and unshared memory subsystems, the calculation of "CTP" is completed hierarchically, in two steps: first, aggregate the groups of "CEs" sharing memory; second, calculate the "CTP" of the groups using the calculation method for multiple "CEs" not sharing memory.

Note 2 "CEs" that are limited to input/output and peripheral functions (e.g., disk drive, communication and video display controllers) are not aggregated into the "CTP" calculation.

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TECHNICAL NOTE ON "CTP"

The following table shows the method of calculating the Effective Calculating Rate R for each "CE":

Step 1: The effective calculating rate R

For "CEs" Implementing: <u>Note</u> Every "CE" must be evaluated independently.	Effective calculating Rate, R
XP only (R _{xp})	$\frac{1}{3 * (t_{xp \text{ add}})}$ <p>if no add is implemented use:</p> $\frac{1}{(t_{xp \text{ mult}})}$ <p>If neither add nor multiply is implemented use the fastest available arithmetic operation as follows:</p> $\frac{1}{3 * t_{xp}}$ <p>See Notes X & Z</p>
FP only (R _{fp})	$\max \frac{1}{t_{fp \text{ add}}}, \frac{1}{t_{fp \text{ mult}}}$ <p>See Notes X & Y</p>
Both FP and XP (R)	Calculate both R _{xp} , R _{fp}
For simple logic processors not implementing any of the specified arithmetic operations.	$\frac{1}{3 * t_{\log}}$ <p>Where t_{log} is the execute time of the XOR, or for logic hardware not implementing the XOR, the fastest simple logic operation. See Notes X & Z</p>
For special logic processors not using any of the specified arithmetic or logic operations.	$R = R' * WL/64$ <p>Where R' is the number of results per second, WL is the number of <u>bits</u> upon which the logic operation occurs, and 64 is a factor to normalize to a 64 bit operation.</p>

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TECHNICAL NOTE ON "CTP"

Note W For a pipelined "CE" capable of executing up to one arithmetic or logic operation every clock cycle after the pipeline is full, a pipelined rate can be established. The effective calculating rate (R) for such a "CE" is the faster of the pipelined rate or non-pipelined execution rate.

Note X For a "CE" which performs multiple operations of a specific type in a single cycle (e.g., two additions per cycle or two identical logic operations per cycle), the execution time t is given by:

$$t = \frac{\text{cycle time}}{\text{the number of identical operations per machine cycle}}$$

"CEs" which perform different types of arithmetic or logic operations in a single machine cycle are to be treated as multiple separate "CEs" performing simultaneously (e.g., a "CE" performing an addition and a multiplication in one cycle is to be treated as two "CEs", the first performing an addition in one cycle and the second performing a multiplication in one cycle).

If a single "CE" has both scalar function and vector function, use the shorter execution time value.

Note Y For the "CE" that does not implement FP add or FP multiply, but that performs FP divide:

$$R_{fp} = \frac{1}{t_{fpdivide}}$$

If the "CE" implements FP reciprocal but not FP add, FP multiply or FP divide, then

$$R_{fp} = \frac{1}{t_{fpreciprocal}}$$

If none of the specified instructions is implemented, the effective FP rate is 0.

Note Z In simple logic operations, a single instruction performs a single logic manipulation of no more than two operands of given lengths.
In complex logic operations, a single instruction performs multiple logic manipulations to produce one or more results from two or more operands.

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TECHNICAL NOTE ON "CTP"
Note Z

Rates should be calculated for all supported operand lengths considering both pipelined operations (if supported), and non-pipelined operations using the fastest executing instruction for each operand length based on:

1. Pipelined or register-to-register operations. Exclude extraordinarily short execution times generated for operations on a predetermined operand or operands (for example, multiplication by 0 or 1). If no register-to-register operations are implemented, continue with (2).
2. The faster of register-to-memory or memory-to-register operations; if these also do not exist, then continue with (3).
3. Memory-to-memory.

In each case above, use the shortest execution time certified by the manufacturer.

Step 2: TP for each supported operand length WL

Adjust the effective rate R (or R') by the word length adjustment L as follows:

$$TP = R * L,$$

where $L = (1/3 + WL/96)$

Note The word length WL used in these calculations is the operand length in bits. (If an operation uses operands of different lengths, select the largest word length.)

The combination of a mantissa ALU and an exponent ALU of a floating point processor or unit is considered to be one "CE" with a Word Length (WL) equal to the number of bits in the data representation (typically 32 or 64) for purposes of the "CTP" calculation.

This adjustment is not applied to specialized logic processors which do not use XOR instructions. In this case $TP = R$.

Select the maximum resulting value of TP for:

- Each XP-only "CE" (R_{xp});
- Each FP-only "CE" (R_{fp});
- Each combined FP and XP "CE" (R);
- Each simple logic processor not implementing any of the specified arithmetic operations; and
- Each special logic processor not using any of the specified arithmetic or logic operations.

DUAL-USE LIST - CATEGORY 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

Step 3: "CTP" for aggregations of "CEs", including CPUs.

For a CPU with a single "CE",

$$\text{"CTP"} = \text{TP}$$

(for "CEs" performing both fixed and floating point operations

$$\text{TP} = \max(\text{TP}_{\text{fp}}, \text{TP}_{\text{xp}})$$

"CTP" for aggregations of multiple "CEs" operating simultaneously is calculated as follows:

Note 1 For aggregations that do not allow all of the "CEs" to run simultaneously, the possible combination of "CEs" that provides the largest "CTP" should be used. The TP of each contributing "CE" is to be calculated at its maximum value theoretically possible before the "CTP" of the combination is derived.

N.B. To determine the possible combinations of simultaneously operating "CEs", generate an instruction sequence that initiates operations in multiple "CEs", beginning with the slowest "CE" (the one needing the largest number of cycles to complete its operation) and ending with the fastest "CE". At each cycle of the sequence, the combination of "CEs" that are in operation during that cycle is a possible combination. The instruction sequence must take into account all hardware and/or architectural constraints on overlapping operations.

Note 2 A single integrated circuit chip or board assembly may contain multiple "CEs".

Note 3 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 "CTP" values are not to be aggregated for "CE" 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.

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TECHNICAL NOTE ON "CTP"

Note 5 "CTP" values must be aggregated for multiple "CEs" specially designed to enhance performance by aggregation, operating simultaneously and sharing memory,- or multiple memory/"CE"- combinations operating simultaneously utilising specially designed hardware.
This aggregation does not apply to "electronic assemblies" described in 4.A.3.c.

$$\text{"CTP"} = TP_1 + C_2 * TP_2 + \dots + C_n * TP_n,$$

where the TPs are ordered by value, with TP₁ being the highest, TP₂ being the second highest, ..., and TP_n being the lowest. C_i is a coefficient determined by the strength of the interconnection between "CEs", as follows:

For multiple "CEs" operating simultaneously and sharing memory:

$$C_2 = C_3 = C_4 = \dots = C_n = 0.75$$

Note 1 When the "CTP" calculated by the above method does not exceed 194 Mtops, the following formula may be used to calculate C_i:

$$C_i = \frac{0.75}{\sqrt{m}} \quad (i = 2, \dots, n)$$

where m = the number of "CEs" or groups of "CEs" sharing access.

provided:

1. The TP_i of each "CE" or group of "CEs" does not exceed 30 Mtops;
2. The "CEs" or groups of "CEs" share access to main memory (excluding cache memory) over a single channel; and
3. Only one "CE" or group of "CEs" can have use of the channel at any given time.

N.B. This does not apply to items controlled under Category 3.

Note 2 "CEs" share memory if they access a common segment of solid state memory. This memory may include cache memory, main memory or other internal memory. Peripheral memory devices such as disk drives, tape drives or RAM disks are not included.

DUAL-USE LIST - CATEGORY 4 - COMPUTERS

TECHNICAL NOTE ON "CTP"

For Multiple "CEs" or groups of "CEs" not sharing memory, interconnected by one or more data channels:

$$\begin{aligned}
 C_i &= 0.75 * k_i & (i = 2, \dots, 32) \text{ (see Note below)} \\
 &= 0.60 * k_i & (i = 33, \dots, 64) \\
 &= 0.45 * k_i & (i = 65, \dots, 256) \\
 &= 0.30 * k_i & (i > 256)
 \end{aligned}$$

The value of C_i is based on the number of "CEs", not the number of nodes.

where $k_i = \min(S_i/K_r, 1)$, and
 $K_r =$ normalizing factor of 20 MByte/s.
 $S_i =$ sum of the maximum data rates (in units of MByte/s) for all data channels connected to the i^{th} "CE" or group of "CEs" sharing memory.

When calculating a C_i for a group of "CEs", the number of the first "CE" in a group determines the proper limit for C_i . For example, in an aggregation of groups consisting of 3 "CEs" each, the 22nd group will contain "CE"64, "CE"65 and "CE"66. The proper limit for C_i for this group is 0.60.

Aggregation (of "CEs" or groups of "CEs") should be from the fastest-to-slowest; i.e.:

$$TP_1 \geq TP_2 \geq \dots \geq TP_n, \text{ and}$$

in the case of $TP_i = TP_{i+1}$, from the largest to smallest; i.e.:

$$C_i \geq C_{i+1}$$

Note The k_i factor is not to be applied to "CEs" 2 to 12 if the TP_i of the "CE" or group of "CEs" is more than 50 Mtops; i.e., C_i for "CEs" 2 to 12 is 0.75.

DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

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.*

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 5.A.1.a.3. applies only to electronic equipment.

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

5. A. 1. b. Telecommunication transmission equipment and systems, 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;

DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

5. A. 1. b. 2. Being radio equipment operating in the 1.5 MHz to 87.5 MHz band and having any of the following characteristics:
- a. Incorporating adaptive techniques providing more than 15 dB suppression of an interfering signal; or
 - b. Having all of the following:
 - 1. Automatically predicting and selecting frequencies and "total digital transfer rates" per channel to optimise the transmission; and
 - 2. 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;
5. A. 1. b. 3. Being radio equipment employing "spread spectrum" techniques, including "frequency hopping" techniques, 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* 5.A.1.b.3.b. does not control radio equipment specially designed for use with civil cellular radio-communications systems.
- Note* 5.A.1.b.3. does not control equipment designed to operate at an output power of 1.0 Watt or less.
5. A. 1. b. 4. Being radio equipment employing "time-modulated ultra-wideband" techniques, having user programmable channelizing or scrambling codes;
5. A. 1. b. 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* 5.A.1.b.5. does not control radio equipment specially designed for use with civil cellular radio-communications systems.

DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

5. A. 1. b. 6. Employing functions of digital "signal processing" to provide voice coding output at rates of less than 2,400 bit/s.

Technical Note

For variable rate voice coding, 5.A.1.b.6. applies to the voice coding output of continuous speech.

5. A. 1. 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/m² 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 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 8.A.2.a.3.

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

5. A. 1. d. "Electronically steerable phased array antennae" operating above 31 GHz.

Note 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).

5. B. 1. TEST, INSPECTION AND PRODUCTION EQUIPMENT

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

5. B. 1. 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.

DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

5. B. 1. b. 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 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.

5. C. 1. MATERIALS - None

5. D. 1. SOFTWARE

5. D. 1. 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 5.E.1.
- c. Specific "software" as follows:
- 1. "Software" specially designed or modified to provide characteristics, functions or features of equipment controlled by 5.A.1. or 5.B.1.;
 - 2. Deleted
 - 3. "Software", other than in machine-executable form, specially designed for "dynamic adaptive routing".

DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

5. D. 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 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.

5. E. 1. TECHNOLOGY

5. E. 1. 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

DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

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

DUAL-USE LIST - CATEGORY 5 - PART 1 - TELECOMMUNICATIONS

5. E. 1. c. 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 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 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.*
5. Equipment employing "common channel signalling" operating in non-associated mode of operation.

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

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**

5.A.2. and 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.

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 7.A.5.

5. A. 2. a. 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:

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

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 5.A.2.a.1. includes equipment designed or modified to use "cryptography" employing analogue principles when implemented with digital techniques.

5. A. 2. a. 1. 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 $\mathbb{Z}/p\mathbb{Z}$); or
 3. Discrete logarithms in a group other than mentioned in 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, including the hopping code for "frequency hopping" systems;
6. Designed or modified to use cryptographic techniques to generate channelizing or scrambling codes for "time-modulated ultra-wideband" systems;
7. Deleted
8. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion.

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

Note 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; or
 3. Copying control of copyright protected audio/video data.
- d. Cryptographic equipment specially designed and limited for banking use or money transactions.

Technical Note

'Money transactions' in 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 base station) is less than 400 metres according to the manufacturer's specifications.

DUAL-USE LIST - CATEGORY 5 - PART 2 - "INFORMATION SECURITY"

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 5.A.2. or 5.D.2.

5. C. 2. MATERIALS - None**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 5.E.2.;
- c. Specific "software", as follows:
 - 1. "Software" having the characteristics, or performing or simulating the functions of the equipment controlled by 5.A.2. or 5.B.2.;
 - 2. "Software" to certify "software" controlled by 5.D.2.c.1.

Note 5.D.2. does not control:

- a. "Software" required for the "use" of equipment excluded from control under the Note to 5.A.2.;
- b. "Software" providing any of the functions of equipment excluded from control under the Note to 5.A.2.

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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. SYSTEMS, EQUIPMENT AND COMPONENTS

6. A. 1. ACOUSTICS

6. A. 1. a. Marine acoustic systems, equipment and specially designed components therefor, as follows:

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

Note 6.A.1.a.1. does not control:

- a. *Depth sounders operating vertically below the apparatus, not including a scanning function exceeding $\pm 20^\circ$, 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.*

6. A. 1. a. 1. 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;

6. A. 1. a. 1. 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 $1 \mu\text{Pa}$ 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 $1 \mu\text{Pa}$ 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;

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6. A. 1. a. 1. c. Acoustic projectors, including transducers, incorporating piezoelectric, magnetostrictive, electrostrictive, electrodynamic 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 *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.*

6. A. 1. a. 1. c. 1. An instantaneous radiated acoustic power density exceeding $0.01 \text{ mW/mm}^2/\text{Hz}$ for devices operating at frequencies below 10 kHz;
2. A continuously radiated acoustic power density exceeding $0.001 \text{ mW/mm}^2/\text{Hz}$ 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;

6. A. 1. a. 1. 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 *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.*

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 1. a. 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 sensors or assemblies of discrete sensor elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;
2. Having any of the following sensing elements:
 - a. Optical fibres; or
 - b. Flexible piezoelectric ceramic materials;
3. A hydrophone sensitivity better than -180 dB at any depth with no acceleration compensation;
4. When designed to operate at depths exceeding 35 m with acceleration compensation; or
5. Designed for operation at depths exceeding 1,000 m;

Technical Note

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 μ Pa. For example, a hydrophone of -160 dB (reference 1 V per μ Pa) 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.

6. A. 1. a. 2. 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 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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 1. a. 2. b. 3. Heading sensors controlled by 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 6.A.1.a.2.a.;
6. A. 1. a. 2. 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;
6. A. 1. a. 2. d. Heading sensors having all of the following:
1. An accuracy of better than $\pm 0.5^\circ$; 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;
6. A. 1. a. 2. e. Bottom or bay cable systems having any of the following:
1. Incorporating hydrophones specified in 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;
6. A. 1. 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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 2. OPTICAL SENSORS**a. Optical detectors, as follows:**

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

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;**6. A. 2. a. 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 μ m or less; and

3. Any of the following photocathodes:

- a. S-20, S-25 or multialkali photocathodes with a luminous sensitivity exceeding 350 μ A/lm;
- b. GaAs or GaInAs photocathodes; or
- c. Other III-V compound semiconductor photocathodes;

Note 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 μ m or less;
2. GaAs or GaInAs photocathodes;
3. Other III-V compound semiconductor photocathodes;

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

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 2. a. 3. Non-"space-qualified" "focal plane arrays", as follows:
Technical Notes

1. *Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays";*
2. *For the purposes of 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 6.A.2.a.3. includes photoconductive arrays and photovoltaic arrays.

Note 2 6.A.2.a.3. does not control:

- a. *Silicon "focal plane arrays";*
- b. *Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;*
- c. *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.*

6. A. 2. a. 3. 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;
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 2,500 nm; and*

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 2. a. 3. d. 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);
6. A. 2. a. 3. e. Non-"space-qualified" linear (1-dimensional) "focal plane arrays", having individual elements with a peak response in the wavelength range exceeding 2,500 nm but not exceeding 30,000 nm.
6. A. 2 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 μ rad (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).
6. A. 2 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 6.A.2.a.2.a.; or
 2. "Focal plane arrays" having the characteristics listed in 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

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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 2. 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.

6. A. 3. **CAMERAS**

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

6. A. 3. a. Instrumentation cameras and specially designed components therefor, as follows:

Note Instrumentation cameras, controlled by 6.A.3.a.3. to 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 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.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 3. a. 6. Plug-ins, having all of the following characteristics:
- Specially designed for instrumentation cameras which have modular structures and which are controlled by 6.A.3.a.; and
 - Enabling these cameras to meet the characteristics specified in 6.A.3.a.3., 6.A.3.a.4. or 6.A.3.a.5., according to the manufacturer's specifications.

6. A. 3. b. Imaging cameras, as follows:

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

- 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:

- Having any of the following:

- More than 4×10^6 "active pixels" per solid state array for monochrome (black and white) cameras;
- More than 4×10^6 "active pixels" per solid state array for colour cameras incorporating three solid state arrays; or
- More than 12×10^6 "active pixels" for solid state array colour cameras incorporating one solid state array;

and

- Having any of the following:

- Optical mirrors controlled by 6.A.4.a.;
- Optical control equipment controlled by 6.A.4.d.; or
- The capability for annotating internally generated camera tracking data.

Technical Notes

- For the purpose of this entry, digital video cameras should be evaluated by the maximum number of "active pixels" used for capturing moving images.
- 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.

6. A. 3. b. 2. Scanning cameras and scanning camera systems, having all of the following:
- A peak response in the wavelength range exceeding 10 nm, but not exceeding 30,000 nm;
 - Linear detector arrays with more than 8,192 elements per array; and
 - Mechanical scanning in one direction;
6. A. 3. b. 3. Imaging cameras incorporating image intensifier tubes having the characteristics listed in 6.A.2.a.2.a.;

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 3. b. 4. Imaging cameras incorporating "focal plane arrays" having the characteristics listed in 6.A.2.a.3.

Note 6.A.3.b.4 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.

6. A. 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/m² and a total mass exceeding 10 kg;
3. Lightweight "composite" or foam mirror structures having an average "equivalent density" of less than 30 kg/m² 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 (λ is equal to 633 nm) having a control bandwidth exceeding 100 Hz.

6. A. 4. 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 cm³ in volume; or
2. Exceeding 80 mm in diameter or length of major axis and 20 mm in thickness (depth).

6. A. 4. 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 5×10^{-6} in any coordinate direction.

DUAL-USE LIST - CATEGORY 6 - SENSORS AND "LASERS"

6. A. 4. d. Optical control equipment, as follows:
1. Specially designed to maintain the surface figure or orientation of the "space-qualified" components controlled by 6.A.4.c.1. or 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 μ rad (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 μ rad (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)/s²; or
 2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 rad (radians)/s²;
 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.
6. A. 4. 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 $3 \times 10^{-6}/K$ 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 6.A.4.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the control parameter.

Note

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;

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- d. *Being fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than $2.5 \times 10^{-6} / K$ 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 3.B.1.*

LASERS

6. A. 5. "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 *Pulse-excited "lasers" include those that run in a continuously excited mode with pulse excitation superimposed.*

Note 3 *The control status of Raman "lasers" is determined by the parameters of the pumping source "lasers". The pumping source "lasers" can be any of the "lasers" described below.*

6. A. 5. a. Gas "lasers", as follows:

1. 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 3.B.1.*

6. A. 5. a. 2. Metal vapour "lasers", as follows:

- a. Copper (Cu) "lasers" having an average output power exceeding 20 W;
- b. Gold (Au) "lasers" having an average output power exceeding 5 W;
- c. Sodium (Na) "lasers" having an output power exceeding 5 W;
- d. Barium (Ba) "lasers" having an average output power exceeding 2 W;

6. A. 5. a. 3. Carbon monoxide (CO) "lasers" having any of the following:

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- a. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 5 kW; or
- b. An average or CW output power exceeding 5 kW;

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6. A. 5. a. 4. Carbon dioxide (CO₂) "lasers" having any of the following:
- A CW output power exceeding 15 kW;
 - A pulsed output having a "pulse duration" exceeding 10 μ s and having any of the following:
 - An average output power exceeding 10 kW; or
 - A pulsed "peak power" exceeding 100 kW; or
 - A pulsed output having a "pulse duration" equal to or less than 10 μ s; and having any of the following:
 - A pulse energy exceeding 5 J per pulse; or
 - An average output power exceeding 2.5 kW;
6. A. 5. a. 5. "Chemical lasers", as follows:
- Hydrogen Fluoride (HF) "lasers";
 - Deuterium Fluoride (DF) "lasers";
 - "Transfer lasers", as follows:
 - Oxygen Iodine (O₂-I) "lasers";
 - Deuterium Fluoride-Carbon dioxide (DF-CO₂) "lasers";
6. A. 5. a. 6. Krypton ion or argon ion "lasers" having any of the following:
- An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 50 W; or
 - An average or CW output power exceeding 50 W;
6. A. 5. a. 7. Other gas "lasers", having any of the following:
- Note 6.A.5.a.7. does not control nitrogen "lasers".
- An output wavelength not exceeding 150 nm and having any of the following:
 - An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
 - An average or CW output power exceeding 1 W;
 - An output wavelength exceeding 150 nm but not exceeding 800 nm and having any of the following:
 - An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or
 - An average or CW output power exceeding 30 W;
 - An output wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:
 - An output energy exceeding 0.25 J per pulse and a pulsed "peak power" exceeding 10 W; or
 - An average or CW output power exceeding 10 W; or
 - An output wavelength exceeding 1,400 nm and an average or CW output power exceeding 1 W.

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6. A. 5. b. Semiconductor "lasers", as follows:

Note 1 6.A.5.b. 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.

1. Individual single-transverse mode semiconductor "lasers", having any of the following:
 - a. A wavelength equal to or less than 1510 nm, and having an average or CW output power exceeding 1.5 W; or
 - b. A wavelength greater than 1510 nm, and having an average or CW output power exceeding 500 mW;
2. Individual, multiple-transverse mode semiconductor "lasers", having any of the following:
 - a. A wavelength of less than 1400 nm, and having an average or CW output power exceeding 10W;
 - b. A wavelength equal to or greater than 1400 nm and less than 1900 nm, and having an average or CW output power exceeding 2.5 W; or
 - c. A wavelength equal to or greater than 1900 nm and having an average or CW output power exceeding 1 W.
6. A. 5. b. 3. Individual semiconductor "laser" arrays, having any of the following:
 - a. A wavelength of less than 1400 nm, and having an average or CW output power exceeding 80 W;
 - b. A wavelength equal to or greater than 1400 nm and less than 1900 nm, and having an average or CW output power exceeding 25 W; or
 - c. A wavelength equal to or greater than 1900 nm, and having an average or CW output power exceeding 10 W.
6. A. 5. b. 4. Array stacks of semiconductor "lasers" containing at least one array that is controlled under 6.A.5.b.3.

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.

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6. A. 5. c. Solid state "lasers", as follows:

1. "Tunable" "lasers" having any of the following:

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

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

6. A. 5. c. 2. Non-"tunable" "lasers", as follows:

Note 6.A.5.c.2. includes atomic transition solid state "lasers".

- a. Neodymium glass "lasers", as follows:
 1. "Q-switched lasers" having any of the following:
 - a. An output energy exceeding 20 J but not exceeding 50 J per pulse and an average output power exceeding 10 W; or
 - b. An output energy exceeding 50 J per pulse;
 2. Non-"Q-switched lasers" having any of the following:
 - a. An output energy exceeding 50 J but not exceeding 100 J per pulse and an average output power exceeding 20 W; or
 - b. An output energy exceeding 100 J per pulse;

6. A. 5. c. 2. b. Neodymium-doped (other than glass) "lasers", having an output wavelength exceeding 1,000 nm but not exceeding 1,100 nm, as follows:

N.B. For neodymium-doped (other than glass) "lasers" having an output wavelength not exceeding 1,000 nm or exceeding 1,100 nm, see 6.A.5.c.2.c.

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6. A. 5. c. 2. b. 1. Pulse-excited, mode-locked, "Q-switched lasers" having a "pulse duration" of less than 1 ns and having any of the following:
- a. A "peak power" exceeding 5 GW;
 - b. An average output power exceeding 10 W; or
 - c. A pulsed energy exceeding 0.1 J;
2. Pulse-excited, "Q-switched lasers" having a pulse duration equal to or more than 1 ns, and having any of the following:
- a. A single-transverse mode output having:
 - 1. A "peak power" exceeding 100 MW;
 - 2. An average output power exceeding 20 W; or
 - 3. A pulsed energy exceeding 2 J; or
 - b. A multiple-transverse mode output having:
 - 1. A "peak power" exceeding 400 MW;
 - 2. An average output power exceeding 2 kW; or
 - 3. A pulsed energy exceeding 2 J;
3. Pulse-excited, non-"Q-switched lasers", having:
- a. A single-transverse mode output having:
 - 1. A "peak power" exceeding 500 kW; or
 - 2. An average output power exceeding 150 W; or
 - b. A multiple-transverse mode output having:
 - 1. A "peak power" exceeding 1 MW; or
 - 2. An average power exceeding 2 kW;
4. Continuously excited "lasers" having:
- a. A single-transverse mode output having:
 - 1. A "peak power" exceeding 500 kW; or
 - 2. An average or CW output power exceeding 150 W; or
 - b. A multiple-transverse mode output having:
 - 1. A "peak power" exceeding 1 MW; or
 - 2. An average or CW output power exceeding 2 kW;
6. A. 5. c. 2. c. Other non-"tunable" "lasers", having any of the following:
- 1. A wavelength less than 150 nm and having any of the following:
 - a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
 - b. An average or CW output power exceeding 1 W;
 - 2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:
 - a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or
 - b. An average or CW output power exceeding 30 W;

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6. A. 5. c. 2. c. 3. A wavelength exceeding 800 nm but not exceeding 1,400 nm, as follows:
- a. "Q-switched lasers" having:
 1. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 50 W; or
 2. An average output power exceeding:
 - a. 10 W for single-transverse mode "lasers";
 - b. 30 W for multiple-transverse mode "lasers";
 - b. Non-"Q-switched lasers" having:
 1. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 50 W; or
 2. An average or CW output power exceeding 50 W; or
4. A wavelength exceeding 1,400 nm and having any of the following:
- a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
 - b. An average or CW output power exceeding 1 W;
6. A. 5. d. Dye and other liquid "lasers", having any of the following:
1. A wavelength less than 150 nm and:
 - a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
 - b. An average or CW output power exceeding 1 W;
 2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:
 - a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 20 W;
 - b. An average or CW output power exceeding 20 W; or
 - c. A pulsed single longitudinal mode oscillator having an average output power exceeding 1 W and a repetition rate exceeding 1 kHz if the "pulse duration" is less than 100 ns;
6. A. 5. d. 3. A wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:
- a. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 10 W; or
 - b. An average or CW output power exceeding 10 W; or
4. A wavelength exceeding 1,400 nm and having any of the following:
- a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
 - b. An average or CW output power exceeding 1 W;

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6. A. 5. 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";

6. A. 5. f. Optical equipment, as follows:

N.B. For shared aperture optical elements, capable of operating in "Super-High Power Laser" ("SHPL") applications, see Item 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 μ rad;
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 μ m, whichever is the smaller;
4. Projection telescopes specially designed for use with "SHPL" systems.

MAGNETOMETERS

6. A. 6. "Magnetometers", "magnetic gradiometers", "intrinsic magnetic gradiometers" and compensation systems, and specially designed components therefor, as follows:

Note 6.A.6. does not control instruments specially designed for biomagnetic measurements for medical diagnostics.

- a. "Magnetometers" using "superconductive", optically pumped, nuclear precession (proton/Overhauser) or triaxial fluxgate "technology" having a "noise level" (sensitivity) lower (better) than 0.05 nT rms per square root Hz;

* France, the Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

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6. A. 6. b. Induction coil "magnetometers" having a "noise level" (sensitivity) lower (better) than any of the following:
1. 0.05 nT rms/square root Hz at frequencies of less than 1 Hz;
 2. 1×10^{-3} nT rms/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; or
 3. 1×10^{-4} nT rms/square root Hz at frequencies exceeding 10 Hz;
- c. Fibre optic "magnetometers" having a "noise level" (sensitivity) lower (better) than 1 nT rms per square root Hz;
- d. "Magnetic gradiometers" using multiple "magnetometers" controlled by 6.A.6.a., 6.A.6.b. or 6.A.6.c.;
- e. 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;
- f. "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;
- g. Magnetic compensation systems for magnetic sensors designed for operation on mobile platforms;
6. A. 6. h. "Superconductive" electromagnetic sensors, containing components manufactured from "superconductive" materials and having all of the following:
1. Being designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents (including Josephson effect devices or "superconductive" quantum interference devices (SQUIDS));
 2. Being designed for sensing electromagnetic field variations at frequencies of 1 kHz or less; and
 3. Having any of the following characteristics:
 - a. Incorporating thin-film SQUIDS with a minimum feature size of less than $2 \mu\text{m}$ and with associated input and output coupling circuits;
 - b. Designed to operate with a magnetic field slew rate exceeding 1×10^6 magnetic flux quanta per second;
 - c. Designed to function without magnetic shielding in the earth's ambient magnetic field; or
 - d. Having a temperature coefficient less (smaller) than 0.1 magnetic flux quantum/K.

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GRAVIMETERS

6. A. 7. 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 μ gal;
Note 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.

RADAR

6. A. 8. Radar systems, equipment and assemblies having any of the following characteristics, and specially designed components therefor:

Note 6.A.8. does not control:

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

6. A. 8. a. Operating at frequencies from 40 GHz to 230 GHz and having an average output power exceeding 100 mW;
- b. Having a tunable bandwidth exceeding $\pm 6.25\%$ 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 6.A.8.f. does not control precision approach radar (PAR) equipment conforming to ICAO standards.

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6. A. 8. 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 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.
6. A. 8. 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 μ rad (microradians);
- Note 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 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;

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3. Processing for automatic pattern recognition (feature extraction) and comparison with target characteristic data bases (waveforms or imagery) to identify or classify targets; or
6. A. 8. 1. 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 6.A.8.1.4. does not control systems, equipment and assemblies used for marine traffic control.

6. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

6. B. 1. ACOUSTICS - None
6. B. 2. OPTICAL SENSORS - None
6. B. 3. CAMERAS - None

OPTICS

6. B. 4. Optical equipment, as follows:
- a. Equipment for measuring absolute reflectance to an accuracy of $\pm 0.1\%$ 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 6.B.4. does not control microscopes.

6. B. 5. LASERS - None
6. B. 6. MAGNETOMETERS - None

GRAVIMETERS

6. B. 7. Equipment to produce, align and calibrate land-based gravity meters with a static accuracy of better than 0.1 mgal.

RADAR

6. B. 8. Pulse radar cross-section measurement systems having transmit pulse widths of 100 ns or less and specially designed components therefor.

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6. C. MATERIALS**6. C. 1. ACOUSTICS - None****OPTICAL SENSORS****6. C. 2. 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 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.

6. C. 3. CAMERAS - None**OPTICS****6. C. 4. 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 cm³; 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 (AgGaSe₂);
 3. Thallium arsenic selenide (Tl₃AsSe₃, also known as TAS);
- c. Non-linear optical materials, having all of the following:
 1. Third order susceptibility (χ^3) of 10⁻⁶ m²/V² 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;

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6. C. 4. e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride (ZrF₄) and hafnium fluoride (HfF₄), 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 5×10^{-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.

LASERS

6. C. 5. Synthetic crystalline "laser" host material in unfinished form, as follows:
- a. Titanium doped sapphire;
 - b. Alexandrite.
6. C. 6. MAGNETOMETERS - None
6. C. 7. GRAVIMETERS - None
6. C. 8. RADAR - None.
6. D. SOFTWARE
1. "Software" specially designed for the "development" or "production" of equipment controlled by 6.A.4, 6.A.5., 6.A.8 or 6.B.8.
 2. "Software" specially designed for the "use" of equipment controlled by 6.A.2.b., 6.A.8 or 6.B.8.
 3. Other "software", as follows:

ACOUSTICS

6. D. 3. a. "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;
6. D. 3. b. OPTICAL SENSORS - None

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6. D. 3. c. CAMERAS - None
d. OPTICS - None
e. LASERS - None

MAGNETOMETERS

- f. "Software", as follows:
1. "Software" specially designed for magnetic compensation systems for magnetic sensors designed to operate on mobile platforms;
 2. "Software" specially designed for magnetic anomaly detection on mobile platforms;

GRAVIMETERS

6. D. 3. g. "Software" specially designed to correct motional influences of gravity meters or gravity gradiometers;

RADAR

6. D. 3. h. "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 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 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.

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6. E. TECHNOLOGY

6. E. 1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" controlled by 6.A., 6.B., 6.C. or 6.D.
6. E. 2. "Technology" according to the General Technology Note for the "production" of equipment or materials controlled by 6.A., 6.B. or 6.C.
6. E. 3. Other "technology", as follows:
- a. ACOUSTICS - None
 - b. OPTICAL SENSORS - None
 - c. CAMERAS - None

OPTICS

6. E. 3. d. "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 5×10^{-3} ;
N.B. See also 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 m²;

LASERS

6. E. 3. e. "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;

MAGNETOMETERS

6. E. 3. f. "Technology" "required" for the "development" or "production" of non-triaxial fluxgate "magnetometers" or non-triaxial fluxgate "magnetometer" systems, having any of the following:
- 1. A "noise level" of less than 0.05 nT rms per square root Hz at frequencies of less than 1 Hz; or
 - 2. A "noise level" of less than 1×10^{-3} nT rms per square root Hz at frequencies of 1 Hz or more.

6. E. 3. g. GRAVIMETERS - None

6. E. 3. h. RADAR - None

DUAL-USE LIST - CATEGORY 7 - NAVIGATION AND AVIONICS

7. A. SYSTEMS, EQUIPMENT AND COMPONENTS

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

7. A. 1. Linear accelerometers designed for use in inertial navigation or guidance systems and having any of the following characteristics, and specially designed components therefor:

- a. A "bias" "stability" of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year;
- b. A "scale factor" "stability" of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year; or
- c. Specified to function at linear acceleration levels exceeding 100 g.

N.B. For angular or rotational accelerometers, see 7.A.2.

7. A. 2. Gyros, and angular or rotational accelerometers, having any of the following characteristics, and specially designed components therefor:

- a. A "drift rate" "stability", when measured in a 1 g environment over a period of three months and with respect to a fixed calibration value, of:
 1. Less (better) than 0.1° per hour when specified to function at linear acceleration levels below 10 g; or
 2. Less (better) than 0.5° per hour when specified to function at linear acceleration levels from 10 g to 100 g inclusive; or
- b. Specified to function at linear acceleration levels exceeding 100 g.

7. A. 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.

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Note 1 *The parameters of 7.A.3.a. and 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 g²/Hz over a frequency interval of 15 to 1,000 Hz; and*
 - b. *The PSD attenuates with frequency from 0.04 g²/Hz to 0.01 g²/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 *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 *7.A.3.c.1 does not control theodolite systems incorporating inertial equipment specially designed for civil surveying purposes.*

Technical Notes

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.*
7. A. 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.
 7. A. 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.
 7. A. 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. A. 7. Direction finding equipment operating at frequencies above 30 MHz and having all of the following characteristics, and specially designed components therefor:
 - a. "Instantaneous bandwidth" of 1 MHz or more;
 - b. Parallel processing of more than 100 frequency channels; and

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- c. Processing rate of more than 1,000 direction finding results per second and per frequency channel.

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7. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

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

Note 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.

7. B. 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).

7. B. 3. Equipment specially designed for the "production" of equipment controlled by 7.A.

Note 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.

7. C. MATERIALS - None

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7. D. SOFTWARE

7. D. 1. "Software" specially designed or modified for the "development" or "production" of equipment controlled by 7.A. or 7.B.

2. "Source code" for the "use" of any inertial navigation equipment, including inertial equipment not controlled by 7.A.3. or 7.A.4., or Attitude and Heading Reference Systems (AHRS).

Note 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 7.A.3. or 7.A.4.;
- b. "Source code" for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified in 7.A.3. by continuously combining inertial data with any of the following:
 1. Doppler radar 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 7.E.4.b., 7.E.4.c.1. or 7.E.4.c.2.

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7. E. TECHNOLOGY

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

Note 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 7.B.1.

7. E. 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 7.A.1. or 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. E. 4. 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 7.E.4.b.3. does not control "technology" for the design of physical redundancy.

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7. E. 4. b. 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 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 9.E.3.a.9.
7. E. 4. 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.

DUAL-USE LIST - CATEGORY 8 - MARINE

8. A. SYSTEMS, EQUIPMENT AND COMPONENTS**8. A. 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 8.A. for underwater equipment.*

8. A. 1. a. Manned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m;**8. A. 1. 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 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 8.A.1.b., range means half the maximum distance a submersible vehicle can cover.*

8. A. 1. 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 8.A.2.a.2.; or
2. Having a fibre optic data link;

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8. A. 1. 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;
8. A. 1. 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;
8. A. 1. 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;
8. A. 1. 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;
8. A. 1. 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;
8. A. 1. 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}.

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8. A. 2. Systems and equipment, as follows:
- N.B. For underwater communications systems, see Category 5, Part 1 - Telecommunications.
8. A. 2. a. Systems and equipment, 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;
8. A. 2. b. Systems specially designed or modified for the automated control of the motion of submersible vehicles controlled by 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;
8. A. 2. c. Fibre optic hull penetrators or connectors;
8. A. 2. 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 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.
8. A. 2. d. 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;

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8. A. 2. c. 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;
8. A. 2. f. Electronic imaging systems, specially designed or modified for underwater use, capable of storing digitally more than 50 exposed images;
8. A. 2. 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;
8. A. 2. h. "Robots" specially designed for underwater use, controlled by using a dedicated "stored programme controlled" 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;
8. A. 2. 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 "stored programme controlled" 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 "stored programme controlled" computer are counted when determining the number of degrees of freedom of movement.

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8. A. 2. 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;

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8. A. 2. j. 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;
8. A. 2. 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 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 8.A.1.g.;
8. A. 2. l. Lift fans rated at more than 400 kW specially designed for surface effect vehicles controlled by 8.A.1.f. or 8.A.1.g.;
8. A. 2. m. Fully submerged subcavitating or supercavitating hydrofoils specially designed for vessels controlled by 8.A.1.h.;
8. A. 2. n. Active systems specially designed or modified to control automatically the sea-induced motion of vehicles or vessels controlled by 8.A.1.f., 8.A.1.g., 8.A.1.h. or 8.A.1.i.;
8. A. 2. 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 8.A.1.f., 8.A.1.g., 8.A.1.h. or 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;

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8. A. 2. o. 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;
8. A. 2. o. 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;
8. A. 2. 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;
8. A. 2. q. Self-contained, closed or semi-closed circuit (rebreathing) diving and underwater swimming apparatus.
- Note* 8.A.2.q. does not control an individual apparatus for personal use when accompanying its user.

8. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

8. B. 1. Water tunnels, having a background noise of less than 100 dB (reference 1 μ Pa, 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.

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8. C. MATERIALS

8. C. 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.

8. D. SOFTWARE

8. D. 1. "Software" specially designed or modified for the "development", "production" or "use" of equipment or materials controlled by 8.A., 8.B. or 8.C.
8. D. 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.

8. E. TECHNOLOGY

8. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials controlled by 8.A., 8.B. or 8.C.
8. E. 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 8.A.1., 8.A.2.b., 8.A.2.j., 8.A.2.o. or 8.A.2.p.

DUAL-USE LIST - CATEGORY 9 - PROPULSION

9. A. SYSTEMS, EQUIPMENT AND COMPONENTS

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

9. A. 1. Aero gas turbine engines incorporating any of the "technologies" controlled by 9.E.3.a., as follows:
 - a. Not certified for the specific "civil aircraft" for which they are intended;
Note For the purpose of the "civil aircraft" certification process, a number of up to 16 civil certified engines, assemblies or components including spares, is considered appropriate.
 - b. Not certified for civil use by the aviation authorities in a participating state;
 - c. Designed to cruise at speeds exceeding Mach 1.2 for more than thirty minutes.
9. A. 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.
9. A. 3. Specially designed assemblies and components, incorporating any of the "technologies" controlled by 9.E.3.a., for the following gas turbine engine propulsion systems:
 - a. Controlled by 9.A.1.;
 - b. Whose design or production origins are either non-participating states or unknown to the manufacturer.
9. A. 4. Space launch vehicles and "spacecraft".
Note 9.A.4. does not control payloads.
N.B. For the control status of products contained in "spacecraft" payloads, see the appropriate Categories.
9. A. 5. Liquid rocket propulsion systems containing any of the systems or components controlled by 9.A.6.
9. A. 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;

* France, the Russian Federation and Ukraine view this list as reference drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

DUAL-USE LIST - CATEGORY 9 - PROPULSION

9. A. 6. 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 $1.14 \times 10^{-3} \text{ cm}^2$ 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.

9. A. 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 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 9.A.7.e., a strong mechanical bond means bond strength equal to or more than propellant strength.

9. A. 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 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 $\pm 5^\circ$;
 2. Angular vector rotations of $20^\circ/\text{s}$ or more; or
 3. Angular vector accelerations of $40^\circ/\text{s}^2$ or more.

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9. A. 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.
9. A. 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 I.C.7. or I.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 9.A.5 to 9.A.9. manufactured using metal matrix, composite, organic composite, ceramic matrix or intermetallic reinforced materials controlled by I.C.7. or I.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.
9. A. 11. Ramjet, scramjet or combined cycle engines and specially designed components therefor.
9. A. 12. Unmanned aerial vehicles having any of the following:
- a. An autonomous flight control and navigation capability (e.g., an autopilot with an Inertial Navigation System); or
 - b. Capability of controlled-flight out of the direct vision range involving a human operator (e.g., televisual remote control).
- Note 9.A.12. does not control model aircraft.*

9. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

9. B. 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.
9. B. 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 9.E.3.a.
9. B. 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.

DUAL-USE LIST - CATEGORY 9 - PROPULSION

9. B. 4. Tools, dies or fixtures for the solid state joining of "superalloy", titanium or intermetallic airfoil-to-disk combinations described in 9.E.3.a.3. or 9.E.3.a.6. for gas turbines.
9. B. 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 25×10^6 .
9. B. 6. Acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 μ Pa) 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.
9. B. 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.
9. B. 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. B. 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.
9. C. MATERIALS - None
9. D. SOFTWARE
9. D. 1. "Software" specially designed or modified for the "development" of equipment or "technology" controlled by 9.A., 9.B. or 9.E.3.
9. D. 2. "Software" specially designed or modified for the "production" of equipment controlled by 9.A. or 9.B.

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9. D. 3. "Software" specially designed or modified for the "use" of full authority digital electronic engine controls (FADEC) for propulsion systems controlled by 9.A. or equipment controlled by 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.

9. D. 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 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.

9. E. TECHNOLOGY

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

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

Note "Development" or "production" "technology" controlled by 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.

9. E. 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

DUAL-USE LIST - CATEGORY 9 - PROPULSION

- (1,000°C) at a stress of 200 MPa, based on the average property values;
9. E. 3. a. 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.C.7.; or
 - c. "Composite" material controlled by 1.C.10. and manufactured with resins controlled by 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 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 2.E.3.b.;
 8. Damage tolerant gas turbine engine rotating components using powder metallurgy materials controlled by 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 9.E.3.a.10. do not include inlet guide vanes, variable pitch fans, variable stators or bleed valves for compressors.

Note 2 9.E.3.a.10. does not control "development" or "production" "technology" for adjustable flow path geometry for reverse thrust.
 11. Wide chord hollow fan blades without part-span support;

DUAL-USE LIST - CATEGORY 9 - PROPULSION

9. E. 3. 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;

9. E. 3. 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 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.

9. E. 3. d. "Technology" "required" for the "development" or "production" of helicopter power transfer systems or tilt rotor or tilt wing "aircraft" power transfer systems;
9. E. 3. 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 m³ 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/m³ 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.*

DUAL-USE LIST - CATEGORY 9 - PROPULSION

9. E. 3. 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 I.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 mm³ 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;
9. E. 3. 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.

Sensitive List

THE SENSITIVE LIST OF DUAL-USE GOODS AND TECHNOLOGIES

N.B. Where abbreviated entries are used, see the List of Dual-Use Goods and Technologies for full details. Text that differs from that in the List of Dual-Use Goods and Technologies is shaded.

Category 1

- 1.A.2. "Composite" structures or laminates...
- 1.C.1. Materials specially designed for use as absorbers of electromagnetic waves...
- 1.C.7.c. & 1.C.7.d. Ceramic-ceramic "composite" materials...
- 1.C.10.c. & 1.C.10.d. Fibrous or filamentary materials...
- 1.C.12. Materials as follows...
- 1.D. 2 "Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites" listed on this List.
- 1.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment and materials in 1.A.2. or 1.C. of this List.
- 1.E. 2.e. & 1.E.2.f. Other "technology"...

Category 2

- 2.B.1.a. Deleted
- 2.B.1.b. Deleted
- 2.B.1.d. Deleted
- 2.B.1.f. Deleted
- 2.B.3. Deleted
- 2.D.1. "Software", other than that controlled by 2.D.2., specially designed for the "development" or "production" of the following equipment:
- a. Machine tools for turning, having all of the following characteristics:
1. Positioning accuracy with "all compensations available" equal to or less (better) than 3.6 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".

Sensitive List

Category 2 contd.

- 2.D.1. b. Machine tools for milling, having any of the following characteristics:
- 1.a. Positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ 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" and have a positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ according to ISO 230/2 (1997) or national equivalents along any linear axis; or
 3. A positioning accuracy for jig boring machines, with "all compensations available", equal to or less (better) than $3\text{ }\mu\text{m}$ according to ISO 230/2 (1997) or national equivalents along any linear axis;
- c. Electrical discharge machines (EDM)....
- d. Deep-hole-drilling machines....
- e. "Numerically controlled" or manual machine tools...

2.E.1.

"Technology" according to the General Technology Note for the "development" of "software" in 2.D. of this List or for the "development" of the following equipment:

- a. Machine tools for turning, having all of the following characteristics:
1. Positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ 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".

Sensitive List

Category 2 contd.

2.E.1.

- b. Machine tools for milling, having any of the following characteristics:
 - 1.a. Positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ 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" and have a positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ according to ISO 230/2 (1997) or national equivalents along any linear axis; or
 - 3. A positioning accuracy for jig boring machines, with "all compensations available", equal to or less (better) than $3\text{ }\mu\text{m}$ according to ISO 230/2 (1997) or national equivalents along any linear axis;
- c. Electrical discharge machines (EDM)....
- d. Deep-hole-drilling machines....
- e. "Numerically controlled" or manual machine tools...

2.E.2.

"Technology" according to the General Technology Note for the "production" of the following equipment:

- a. Machine tools for turning, having all of the following characteristics:
 - 1. Positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ 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".

Sensitive List

Category 2 contd.

- 2.E.2.
- b. Machine tools for milling, having any of the following characteristics:
 - 1.a. Positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ 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"; or
 - 2. Five or more axes which can be coordinated simultaneously for "contouring control" and have a positioning accuracy with "all compensations available" equal to or less (better) than $3.6\text{ }\mu\text{m}$ according to ISO 230/2 (1997) or national equivalents along any linear axis; or
 - 3. A positioning accuracy for jig boring machines, with "all compensations available", equal to or less (better) than $3\text{ }\mu\text{m}$ according to ISO 230/2 (1997) or national equivalents along any linear axis;
 - c. Electrical discharge machines (EDM)....
 - d. Deep-hole-drilling machines....
 - e. "Numerically controlled" or manual machine tools...

Category 3

- 3.A.2.g.2. Atomic frequency standards....
- 3.B.1.a.2. Metal organic chemical vapour deposition reactors....
- 3.D.1. "Software" specially designed for the "development" or "production" of equipment in 3.A.2.g. or 3.B. of this List.
- 3.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment in 3.A. or 3.B. of this List.

Sensitive List

Category 4

- 4.A.1.a.2. Electronic computers.....radiation hardened;
 4.A.3.b. Deleted
 4.A.3.c. Deleted
- 4.D.1. "Software" specially designed for the "development" or "production" of equipment in 4.A. of this List or for the "development" or "production" of "digital computers" having a "composite theoretical performance" ("CTP") exceeding 75,000 Mtops.
- 4.E.1. "Technology" according to the General Technology Note for the "development" or "production" of the following equipment or "software":
 - Equipment in 4.A. of this List;
 - "Digital computers" having a "composite theoretical performance" ("CTP") exceeding 75,000 Mtops; or
 - "Software" in 4.D. of this List.

Category 5 - Part 1

- 5.A.1.b.3. Being radio equipment
- 5.A.1.b.5. Being digitally controlled radio receivers...
- 5.B.1.a. Equipment and specially designed components or accessories therefor, specially designed for the "development", "production" or "use" of equipment, functions or features in Category 5 - Part 1 of this List.
- 5.D.1.a. "Software" specially designed for the "development" or "production" of equipment, functions or features in Category 5 - Part 1 of this List.
- 5.D.1.b. "Software" specially designed or modified to support "technology" listed under 5.E.1. of this List.
- 5.E.1.a. "Technology" according to the General Technology Note for the "development" or "production" of equipment, functions, features or "software" in Category 5 - Part 1 of this List.

Category 5 - Part 2

- None

 Sensitive List

Category 6

- 6.A.1.a.1.b. Object detection or location systems having any of the following:
1. A transmitting frequency below 5 kHz or a sound pressure level exceeding 224 dB (reference 1 μ Pa at 1 m) for equipment with an operating frequency in the band from 5 kHz to 10 kHz inclusive;
 2. Sound pressure level exceeding 224 dB (reference 1 μ Pa at 1 m) for equipment with an operating frequency in the band from 10 kHz to 24 kHz inclusive;
 3. Sound pressure level...;
 4. Forming beams of ...;
 5. Designed to operate...;
 6. Designed to withstand...;
- 6.A.1.a.2.a.1. Hydrophones...Incorporating...
- 6.A.1.a.2.a.2. Hydrophones...Having any...
- 6.A.1.a.2.a.4. Hydrophones...When designed...
- 6.A.1.a.2.a.5. Hydrophones...Designed for...
- 6.A.1.a.2.b. Towed acoustic hydrophone arrays...
- 6.A.1.a.2.c. Processing equipment, specially designed for real time application with 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;
- 6.A.1.a.2.d. Heading sensors....
- 6.A.1.a.2.e. Bottom or bay cable systems having any of the following:
1. Incorporating hydrophones... or
 2. Incorporating multiplexed hydrophone group signal modules...;
- 6.A.1.a.2.f. Processing equipment, specially designed for real time application with 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;
- 6.A.2.a.1.a., b., and c. "Space-qualified" solid-state detectors...

Sensitive List

Category 6 contd.

6.A.2.a.2.a.

Image intensifier tubes ...

1. A peak response...
2. A microchannel plate...
3. Photocathodes, as follows:
 - a. S-20, S-25 or multialkali photocathodes with a luminous sensitivity exceeding 700 $\mu\text{A}/\text{lm}$;
 - b. GaAs or GaInAs photocathodes;
 - c. Other III-V compound semiconductor photocathodes.

6.A.2.a.3.

Non-space qualified "focal plane arrays" ...;

Note 3

In 6.A.2.a.3. the following "focal plane arrays" are not included in this List:

- a. Platinum Silicide (PtSi) "focal plane arrays" having less than 10,000 elements;
- b. Iridium Silicide (IrSi) "focal plane arrays".

Note 4

In 6.A.2.a.3. the following "focal plane arrays" are not included in this List:

- a. Indium Antimonide (InSb) or Lead Selenide (PbSe) "focal plane arrays" having less than 256 elements;
- b. Indium Arsenide (InAs) "focal plane arrays";
- c. Lead Sulphide (PbS) "focal plane arrays";
- d. Indium Gallium Arsenide (InGaAs) "focal plane arrays".

Note 5

In 6.A.2.a.3. Mercury Cadmium Telluride (HgCdTe) "focal plane arrays" as follows are not included in this List:

1. Scanning Arrays having any of the following:
 - a. 30 elements or less; or
 - b. incorporating time delay-and-integration within the element and having 2 elements or less;
2. Staring Arrays having less than 256 elements.

Technical Notes

'Scanning Arrays' are defined as "focal plane arrays" designed for use with a scanning optical system that images a scene in a sequential manner to produce an image;

'Staring Arrays' are defined as "focal plane arrays" designed for use with a non-scanning optical system that images a scene.

Sensitive List

Category 6 contd.

6.A.2.a.3.

Note 6

In 6.A.2.a.3. the following "focal plane arrays" are not included in this List:

- a. Gallium Arsenide (GaAs) or Gallium Aluminum Arsenide (GaAlAs) quantum well "focal plane arrays" having less than 256 elements;*
- b. Pyroelectric or Ferroelectric (including barium-strontium titanate, lead zirconate titanate or lead scandium titanate) "focal plane arrays" having less than 8,000 elements;*
- c. Vanadium Oxide-Silicon nitride microbolometer "focal plane arrays" having less than 8,000 elements.*

6.A.2.b.

"Monospectral imaging sensors" and "multispectral imaging sensors"....

6.A.2.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 6.A.2.a.2.a. of this List; or
- 2. "Focal plane arrays" having the characteristics listed in 6.A.2.a.3. of this List;

6.A.2.e.

"Space-qualified" "focal plane arrays"....

6.A.3.b.3

Imaging cameras incorporating image intensifier tubes having the characteristics listed in 6.A.2.a.2.a. of this List;

6.A.3.b.4

Imaging cameras incorporating "focal plane arrays" having the characteristics listed in 6.A.2.a.3. of this List;

6.A.4.c.

"Space-qualified" components for optical systems....

6.A.4.d.

Optical control equipment.....

6.A.6.g.

Magnetic compensation systems...

Note In 6.A.6.g. those compensators which provide only absolute values of the earth's magnetic field as output, (i.e., the frequency bandwidth of the output extends from DC to at least 0.8 Hz) are not included in this List.

6.A.6.h.

"Superconductive" electromagnetic sensors.....

6.A.8.d.

Radar systems.....Capable of...

6.A.8.h.

Radar systems...Employing processing

6.A.8.k.

Radar systems...Having "signal processing"...

6.A.8.l.3.

Radar systems...Having data processing... Processing for...

6.B.8.

Pulse radar cross-section...

Sensitive List

Category 6 contd.

- 6.D.1. "Software" specially designed for the "development" or "production" of equipment in 6.A.4., 6.A.8. or 6.B.8. of this List.
- 6.D.3.a. "Software", as follows:...
- 6.E.1. "Technology" according to...
- 6.E.2. "Technology" according to the General Technology Note for the "production" of equipment in 6.A. or 6.B. of this List.

Category 7

- 7.D.2. "Source code" for the "use"...
- 7.D.3.a. "Software" specially designed or modified to...
- 7.D.3.b. "Source code" for...
- 7.D.3.c. "Source code" for...
- 7.D.3.d.1. to 4. & 7. "Source code" for the "development" of...
- 7.E.1. & 7.E.2. "Technology" according to the General Technology Note...

Category 8

- 8.A.1.b. Manned, untethered submersible vehicles...
- 8.A.1.c. Unmanned, tethered submersible vehicles.....
- 8.A.1.d. Unmanned, untethered submersible vehicles...
- 8.A.2.b. Systems specially designed or modified for the automated control of the motion of submersible vehicles in 8.A.1. of this List using navigation data and having closed loop servo-controls:
 1. Enabling...;
 2. Maintaining...; or
 3. Maintaining...;
- 8.A.2.h. "Robots" specially designed for underwater use.....
- 8.A.2.j. Air independent power systems.....
- 8.A.2.o.3. Noise reduction systems for use on vessels...
- 8.A.2.p. Pumpjet propulsion systems....
- 8.D.1. "Software" specially designed for the "development" or "production" of equipment in 8.A. of this List.
- 8.D.2. Specific "software" ...
- 8.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment in 8.A. of this List.
- 8.E.2.a. Other "technology".....

Sensitive List

Category 9

- | | |
|--|--|
| 9.A.11. | Ramjet, scramjet or combined cycle engines... |
| 9.B.1.b. | Ceramic cores or shells |
| 9.D.1. | "Software" specially designed or modified for the "development" of equipment or "technology" in 9.A., 9.B. or 9.E.3. of this List. |
| 9.D.2. | "Software" specially designed or modified for the "production" of equipment in 9.A. or 9.B. of this List. |
| 9.D.4.a. | Other "software"...2D or 3D... |
| 9.D.4.c. | Other "software"... "Software" specially... |
| 9.E.1. | "Technology" according to the General Technology Note..... |
| 9.E.2. | "Technology" according to the General Technology Note... |
| 9.E.3.a.1. | Other "technology"...Gas turbine blades... |
| 9.E.3.a.2. to 5. &
9.E.3.a.8., 9.E.3.a.9. | Other "technology"... |

Very Sensitive List

VERY SENSITIVE LIST OF THE LIST OF DUAL-USE GOODS AND TECHNOLOGIES

N.B. Where abbreviated entries are used, see List of Dual-Use Goods and Technologies for full details. Text that differs from that in the List of Dual-Use Goods and Technologies is shaded.

Category 1

- | | |
|----------|---|
| 1.A.2.a. | "Composite" structures or laminates having an organic "matrix" and made from materials listed under 1.C.10.c. or 1.C.10.d. |
| 1.C.1. | Materials specially designed for use as absorbers of electromagnetic waves... |
| 1.C.12. | Materials as follows... |
| 1.E.1. | "Technology" according to the General Technology Note for the "development" or "production" of equipment and materials in 1.A.2 or 1.C. of this List. |

Category 2

None

Category 3

None

Category 4

- | | |
|----------|--|
| 4.A.3.b. | Deleted |
| 4.A.3.c. | Deleted |
| 4.D.1. | "Software" specially designed for the "development" or "production" of "digital computers" having a "composite theoretical performance" ("CTP") exceeding 150,000 Mtops. |
| 4.E.1. | "Technology" according to the General Technology Note for the "development" or "production" of "software" in 4.D. of this List or for the "development" or "production" of "digital computers" having a "composite theoretical performance" ("CTP") exceeding 150,000 Mtops. |

Category 5 - Part 1

- | | |
|------------|---|
| 5.A.1.b.5. | Digitally controlled radio receivers... |
| 5.D.1.a. | "Software" specially designed for the "development" or "production" of equipment, functions or features in Category 5, Part 1 of this List. |

Very Sensitive List

5.E.1.a.

"Technology" according to the General Technology Note for the "development" or "production" of equipment, functions, features or "software" in Category 5, Part 1 of this List.

Very Sensitive List

Category 5 - Part 2

None

Category 6

- 6.A.1.a.1.b.1. Object detection or location systems having a sound pressure level exceeding 210 dB (reference 1 μ Pa at 1 m) and an operating frequency in the band from 30 Hz to 2 kHz.
- 6.A.1.a.2.a.1. Hydrophones...Incorporating...
- 6.A.1.a.2.a.2. Hydrophones...Having any...
- 6.A.1.a.2.a.4. Hydrophones...When designed...
- 6.A.1.a.2.a.5. Hydrophones...Designed for...
- 6.A.1.a.2.b. Towed acoustic hydrophone arrays...
- 6.A.1.a.2.c. Processing equipment, specially designed for real time application with 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;
- 6.A.1.a.2.e. Bottom or bay cable systems having any of the following:
 1. Incorporating hydrophones... or
 2. Incorporating multiplexed hydrophone group signal modules ...;
- 6.A.1.a.2.f. Processing equipment, specially designed for real time application with 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;
- 6.A.2.a.1.c. "Space-qualified" solid-state detectors...
- 6.A.8.1.3. Radar systems...Having data processing... Processing for...
- 6.B.8. Pulse radar cross-section...
- 6.D.1. "Software" specially designed for the "development" or "production" of equipment in 6.A.8., or 6.B.8. of this List.
- 6.D.3.a. "Software", as follows:...
- 6.E.1. "Technology" according to the General Technology Note for the "development" of equipment or "software" in 6.A., 6.B., or 6.D. of this List.
- 6.E.2. "Technology" according to the General Technology Note for the "production" of equipment in 6.A. or 6.B. of this List.

Very Sensitive List

Category 7

- 7.D.3.a. "Software" specially designed or modified to...
7.D.3.b. "Source code" for...

Category 8

- 8.A.1.b. Manned, untethered submersible vehicles...
8.A.1.d. Unmanned, untethered submersible vehicles...
8.A.2.o.3.b. Active noise reduction or cancellation systems...
8.D.1. "Software" specially designed for the "development" or "production" of equipment in 8.A. of this List.
8.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment in 8.A. of this List.

Category 9

- 9.A.11. Ramjet, scramjet or combined cycle engines...
9.D.1. "Software" specially designed or modified for the "development" of equipment or "technology" in 9.A. or 9.E.3. of this List.
9.D.2. "Software" specially designed or modified for the "production" of equipment in 9.A. of this List.
9.E.1. "Technology" according to the General Technology Note for the "development" of equipment or "software" in 9.A.11. or 9.D. of this List.
9.E.2. "Technology" according to the General Technology Note for the "production" of equipment in 9.A.11. of this List.
9.E.3.a.1. Other "technology"...Gas turbine blades...
9.E.3.a.3.a. "Technology" "required" for ...
Components manufactured from...
Organic "composite" materials designed to operate above 588 K (315°C).

MUNITIONS LIST*

Note 1 Terms in "quotations" are defined terms. Refer to 'Definitions of Terms used in these Lists' annexed to this List.

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.

GENERAL TECHNOLOGY NOTE

The export of "technology" which is "required" for the "development", "production" or "use" of items controlled in the Munitions List is controlled according to the provisions in the Munitions List entries. 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.

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

* France, the Russian Federation and Ukraine view this list as a reference list drawn up to help in the selection of dual-use goods which could contribute to the indigenous development, production or enhancement of conventional munitions capabilities.

MUNITIONS LIST

ML1. 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:

a. Rifles, carbines, revolvers, pistols, machine pistols and machine guns:

Note *ML1.a. does not control the following:*

1. *Muskets, rifles and carbines manufactured earlier than 1938;*
2. *Reproductions of muskets, rifles and carbines the originals of which were manufactured earlier than 1890;*
3. *Revolvers, pistols and machine guns manufactured earlier than 1890, and their reproductions;*

b. Smooth-bore weapons, as follows:

1. Smooth-bore weapons specially designed for military use;
2. Other smooth-bore weapons, as follows:
 - a. Of the fully automatic type;
 - b. Of the semi-automatic or pump-action type;

c. Weapons using caseless ammunition;

d. Silencers, special gun-mountings, clips, weapons sights and flash suppressers for arms controlled by sub-items ML1.a., ML1.b. or ML1.c.

Note 1 *ML1. does not control smooth-bore weapons used for hunting or sporting purposes. These weapons must not be specially designed for military use or of the fully automatic firing type.*

Note 2 *ML1. does not control firearms specially designed for dummy ammunition and which are incapable of firing any controlled ammunition.*

Note 3 *ML1. does not control weapons using non-centre fire cased ammunition and which are not of the fully automatic firing type.*

MUNITIONS LIST

ML2. 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, recoilless rifles and signature reduction devices therefor;

Note ML2.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 ML2.a.

- b. Military smoke, gas and pyrotechnic projectors or generators.

Note ML2.b. does not control signal pistols.

- c. Weapons sights.

ML3. Ammunition and fuze setting devices, as follows, and specially designed components therefor:

- a. Ammunition for the weapons controlled by ML1., ML2. or ML12.;

- b. Fuze setting devices specially designed for ammunition controlled by ML3.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 ML3.a. does not control ammunition crimped without a projectile (blank star) and dummy ammunition with a pierced powder chamber.

Note 3 ML3.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.

MUNITIONS LIST

ML4. 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 ML11, Note g.

- 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);

Note ML4.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 ML4.a.

Note ML4.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 ML4.a.

ML5. 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 ML5.a. or ML5.b.
- d. Field test or alignment equipment, specially designed for items controlled by ML5.a. or ML5.b.

MUNITIONS LIST

ML6. Ground vehicles and components, as follows:

N.B. For guidance and navigation equipment, see ML11, Note g.

- a. Ground vehicles and components therefor, specially designed or modified for military use;

Technical Note

For the purposes of ML6.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 ML13.a.

Note 1 ML6.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 ML4;
- 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 ML6.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 ML6. does not control civil automobiles, or trucks designed or modified for transporting money or valuables, having armoured or ballistic protection.

MUNITIONS LIST

ML7. Chemical or biological toxic agents, "tear gases", radioactive materials, related equipment, components, materials and "technology", 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, and chemical warfare (CW) agents;

Note ML7.a. includes the following:

1. CW nerve agents:

- a. O-Alkyl (equal to or less than C₁₀, 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 C₁₀, 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 C₁₀, 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:
2-Chloroethylchloromethylsulphide (CAS 2625-76-5);
Bis(2-chloroethyl) sulphide (CAS 505-60-2);
Bis(2-chloroethylthio) methane (CAS 63869-13-6);
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);
Bis (2-chloroethylthioethyl) ether (CAS 63918-89-8);
- b. Lewisites, such as:
2-chlorovinylchloroarsine (CAS 541-25-3);
Tris (2-chlorovinyl) arsine (CAS 40334-70-1);
Bis (2-chlorovinyl) chloroarsine (CAS 40334-69-8);
- c. Nitrogen mustards, such as:
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);

MUNITIONS LIST

ML 7.a. Note Contd.

3. *CW incapacitating agents, such as:*
3-Quinuclidinyl benzilate (BZ) (CAS 6581-06-2);
 4. *CW defoliants, such as:*
Butyl 2-chloro-4-fluorophenoxyacetate (LNF);
2,4,5-trichlorophenoxyacetic acid mixed with
2,4-dichlorophenoxyacetic acid (Agent Orange).
- b. 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 C₁₀, 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);
- c. "Tear gases" and "riot control agents" including:
1. Bromobenzyl cyanide (CA) (CAS 5798-79-8);
 2. o-Chlorobenzylidenemalononitrile (o-Chlorobenzalmalononitrile) (CS) (CAS 2698-41-1);
 3. Phenylacetyl chloride (ω-chloroacetophenone) (CN) (CAS 532-27-4);
 4. Dibenz-(b,f)-1,4-oxazepine (CR) (CAS 257-07-8);
- Note ML7.c. does not control tear gases or riot control agents individually packaged for personal self defence purposes.*
- d. 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 ML7.a. or c.; or
 2. CW made up of precursors controlled by ML7.b.