# A Guide To Canada's Export Control List

**December 2018**

Canada

# INTRODUCTION

The issuance of export permits under the *Export and Import Permits Act (EIPA)* is administered by the Trade and Export Controls Bureau of Global Affairs Canada. To assist exporters, the Trade and Export Controls Bureau publishes on its website (www.exportcontrols.gc.ca) important information, such as the Export Controls Handbook, Export Controls Online (EXCOL), Notices to Exporters, Frequently Asked Questions (FAQs), Commodity Codes, and the contact information for the divisions in the Trade and Export Controls Bureau administering export controls for specific items.

**For information on how to apply for an export permit and additional information on export controls, please refer to our website:** www.exportcontrols.gc.ca.

**For detailed information on export controls, please refer to the Export Controls Handbook:** The main reference tool to assist exporters with questions about the administration of Canada's export controls (except export of logs). The handbook includes how to obtain the necessary permits for the export or transfer of controlled items and how to comply with the requirements of the *Export and Import Permits Act* and its related regulations.

**To enquire on the status of an export permit application:**
Recognized EXCOL users can check the status of an export permit application on-line.
Non-recognized users can obtain, from our website (www.exportcontrols.gc.ca), the contact information for the appropriate division responsible for administering the specific control and request a status by providing their export permit application identification (ref ID) number.

***Export Control List***
The Regulation establishing Canada's *Export Control List (ECL)* can be found at the Department of Justice website at www.laws.justice.gc.ca/eng/regulations.

Regulatory amendments to the *ECL* that occur after the publication date of this Guide are published in the Canada Gazette (http://www.gazette.gc.ca/gazette/home-accueil-eng.php), are available on our website (www.exportcontrols.gc.ca) and, upon coming into force, are available on the Department of Justice website (www.laws.justice.gc.ca/eng/regulations/). It is the individual's responsibility to conduct the due diligence required to confirm whether any intervening regulatory changes are applicable to their export or transfer.

This Guide, at time of publication, encompasses the list of items enumerated on the *ECL* that are controlled for export in accordance with section 3 of the *EIPA*. The *EIPA* can be found at the Department of Justice website at www.laws.justice.gc.ca/eng/acts/.

The Guide includes military, dual-use, and strategic goods and technology and all United States-origin goods and technology that are controlled pursuant to Canada's commitments made in multilateral export control regimes, bilateral agreements, as well as certain unilateral controls.

The Guide also includes forest products (logs, softwood lumber) agricultural and food products (peanut butter, sugar and sugar-containing products, processed foods, dog and cat food) apparel goods and vehicles that are controlled for economic reasons or further to Canada's international trade agreements.

Unless otherwise specified, the export controls for military, dual-use and strategic items contained in this Guide apply to all destinations except the United States.

The most recent versions of each multilateral export control regime's control lists included in the *ECL* are:

| **Export Control Regimes** | **Latest Controls Incorporated into *ECL*** |
|---|---|
| Wassenaar Arrangement | December 2018 |
| Nuclear Suppliers Group | June 2018 |
| Missile Technology Control Regime | December 2018 |
| Australia Group | June 2018 |

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# GROUP 1 – DUAL-USE LIST

***Note 1:***

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

***Note 2:***

*In some instances chemicals are listed by name and CAS number. The list applies to chemicals of the same structural formula (including hydrates) regardless of name or CAS number. CAS numbers are shown to assist in identifying a particular chemical or mixture, 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 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) or repair of those items which are not controlled or whose export has been authorised.*

***Note:***

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

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

***GENERAL SOFTWARE NOTE:***

*The Lists do not control "software" which is any of the following:*

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;*

   ***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";* ***or***
3. *The minimum necessary "object code" for the installation, operation, maintenance (checking) or repair of those items whose export has been authorised.*

   ***Note:***

   *Entry 3 of the General Software Note does not release "software" controlled by Category 5 - Part 2 ("Information Security").*

***GENERAL "INFORMATION SECURITY" NOTE***

*"Information security" items or functions should be considered against the provisions in Category 5 - Part 2, even if they are components, "software" or functions of other items.*

# CATEGORY 1: SPECIAL MATERIALS AND RELATED EQUIPMENT

## 1-1.A. SYSTEMS, EQUIPMENT AND COMPONENTS

1-1.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 specified by 1-1.C.9.b. or 1-1.C.9.c.;

b. Not used since 2015

c. Not used since 2015

1-1.A.2. "Composite" structures or laminates, as follows:

a. Made from any of the following:

1. An organic "matrix" and "fibrous or filamentary materials" specified by 1-1.C.10.c. or 1-1.C.10.d.; **or**

2. Prepregs or preforms specified by 1-1.C.10.e.;

b. Made from a metal or carbon "matrix", and any of the following:

1. Carbon "fibrous or filamentary materials" having all of the following:

a. A "specific modulus" exceeding 10.15 x $10^6$ m; **and**

b. A "specific tensile strength" exceeding 17.7 x $10^4$ m; **or**

2. Materials specified by 1-1.C.10.c.

***Note 1:***

*1-1.A.2. does not apply to "composite" structures or laminates, made from epoxy resin impregnated carbon "fibrous or filamentary materials", for the repair of "civil aircraft" structures or laminates, having all of the following:*

*a. An area not exceeding 1 $m^2$;*

*b. A length not exceeding 2.5 m;* ***and***

*c. A width exceeding 15 mm.*

***Note 2:***

*1-1.A.2. does not apply to semi-finished items, specially designed for purely civilian applications as follows:*

*a. Sporting goods;*

*b. Automotive industry;*

*c. Machine tool industry;*

*d. Medical applications.*

***Note 3:***

*1-1.A.2.b.1. does not apply to semi-finished items containing a maximum of two dimensions of interwoven filaments and specially designed for applications as follows:*

*a. Metal heat-treatment furnaces for tempering metals;*

*b. Silicon boule production equipment.*

***Note 4:***

*1-1.A.2. does not apply to finished items specially designed for a specific application.*

1-1.A.3. Manufactures of non-"fusible" aromatic polyimides in film, sheet, tape or ribbon form having any of the following:

a. A thickness exceeding 0.254 mm; **or**

b. Coated or laminated with carbon, graphite, metals or magnetic substances.

***Note:***

*1-1.A.3. does not apply to manufactures when coated or laminated with copper and designed for the production of electronic printed circuit boards.*

***N.B.:***

*For "fusible" aromatic polyimides in any form, see 1-1.C.8.a.3.*

1-1.A.4. Protective and detection equipment and components, not specially designed for military use, as follows:

a. Full face masks, filter canisters and decontamination equipment therefor, designed or modified for defence against any of the following, and specially designed components therefor:

***Note:***

*1-1.A.4.a. includes Powered Air Purifying Respirators (PAPR) that are designed or modified for defence against agents or materials, listed in 1-1.A.4.a.*

***Technical Notes:***

*For the purposes of 1-1.A.4.a.:*

*1. Full face masks are also known as gas masks.*

*2. Filter canisters include filter cartridges.*

1. "Biological agents";
2. 'Radioactive materials';
3. Chemical warfare (CW) agents; **or**
4. "Riot control agents", including:
   a. α-Bromobenzeneacetonitrile, (Bromobenzyl cyanide) (CA) (CAS 5798-79-8);
   b. [(2-chlorophenyl) methylene] propanedinitrile, (o-Chlorobenzylidenemalononitrile) (CS) (CAS 2698-41-1);
   c. 2-Chloro-1-phenylethanone, Phenylacyl chloride (ω-chloroacetophenone) (CN) (CAS 532-27-4);
   d. Dibenz-(b,f)-1,4-oxazephine, (CR) (CAS 257-07-8);
   e. 10-Chloro-5,10-dihydrophenarsazine, (Phenarsazine chloride), (Adamsite), (DM) (CAS 578-94-9);
   f. N-Nonanoylmorpholine, (MPA) (CAS 5299-64-9);

b. Protective suits, gloves and shoes, specially designed or modified for defence against any of the following:
   1. "Biological agents";
   2. 'Radioactive materials'; **or**
   3. Chemical warfare (CW) agents;

c. Detection systems, specially designed or modified for detection or identification of any of the following, and specially designed components therefor:
   1. "Biological agents";
   2. 'Radioactive materials'; **or**
   3. Chemical warfare (CW) agents.

d. Electronic equipment designed for automatically detecting or identifying the presence of "explosives" residues and utilising 'trace detection' techniques (e.g., surface acoustic wave, ion mobility spectrometry, differential mobility spectrometry, mass spectrometry).

***Technical Note:***

*'Trace detection' is defined as the capability to detect less than 1 ppm vapour, or 1 mg solid or liquid.*

***Note 1:***

*1-1.A.4.d. does not apply to equipment specially designed for laboratory use.*

***Note 2:***

*1-1.A.4.d. does not apply to non-contact walk-through security portals.*

***Note:***

*1-1.A.4. does not apply to:*

*a. Personal radiation monitoring dosimeters;*

*b. Occupational health or safety equipment limited by design or function to protect against hazards specific to residential safety or civil industries, including:*

*1. mining;*
*2. quarrying;*
*3. agriculture;*
*4. pharmaceutical;*
*5. medical;*
*6. veterinary;*
*7. environmental;*
*8. waste management;*
*9. food industry.*

***Technical Notes:***

*1. 1-1.A.4. includes equipment and components that have been identified, successfully tested to national standards or otherwise proven effective, for the detection of or defence against 'radioactive materials', "biological agents", chemical warfare agents, 'simulants' or "riot control agents", even if such equipment or components are used in civil industries such as mining, quarrying, agriculture, pharmaceuticals, medical, veterinary, environmental, waste management, or the food industry.*

*2. 'Simulant': A substance or material that is used in place of toxic agent (chemical or biological) in training, research, testing or evaluation.*

*3. For the purposes of 1-1.A.4., 'radioactive materials' are those selected or modified to increase their effectiveness in producing casualties in humans or animals, degrading equipment or damaging crops or the environment.*

1-1.A.5. Body armour and components therefor, as follows:

a. Soft body armour not manufactured to military standards or specifications, or to their equivalents, and specially designed components therefor;

b. Hard body armour plates providing ballistic protection equal to or less than level IIIA (NIJ 0101.06, July 2008) or national equivalents.

***N.B. 1:***

*For "fibrous or filamentary materials" used in the manufacture of body armour, see entry 1-1.C.10.*

***N.B. 2:***

*For body armour manufactured to military standards or specifications, see entry 2-13.d.*

***Note 1:***

*1-1.A.5. does not apply to body armour when accompanying its user for the user's own personal protection.*

***Note 2:***

*1-1.A.5. does not apply to body armour designed to provide frontal protection only from both fragment and blast from non-military explosive devices.*

***Note 3:***

*1-1.A.5. does not apply to body armour designed to provide protection only from knife, spike, needle or blunt trauma.*

1-1.A.6. Equipment, specially designed or modified for the disposal of improvised explosive devices, as follows, and specially designed components and accessories therefor:

a. Remotely operated vehicles;

b. 'Disruptors';

***Technical Note:***

*'Disruptors' – Devices specially designed for the purpose of preventing the operation of an explosive device by projecting a liquid, solid or frangible projectile.*

***N.B.:***

*For equipment specially designed for military use for the disposal of improvised explosive devices, see also 2-4.*

***Note:***

*1-1.A.6. does not apply to equipment when accompanying its operator .*

1-1.A.7. Equipment and devices, specially designed to initiate charges and devices containing "energetic materials", by electrical means, as follows:

a. Explosive detonator firing sets designed to drive explosive detonators specified by 1-1.A.7.b.

b. Electrically driven explosive detonators as follows:

1. Exploding bridge (EB);
2. Exploding bridge wire (EBW);
3. Slapper;
4. Exploding foil initiators (EFI).

***Technical Notes:***

*1. The word initiator or igniter is sometimes used in place of the word detonator.*

*2. For the purpose of 1-1.A.7.b. the detonators of concern all utilise a small electrical conductor (bridge, bridge wire, or foil) that explosively vaporises when a fast, high-current electrical pulse is passed through it. In non-slapper types, the exploding conductor starts a chemical detonation in a contacting high explosive material such as PETN (pentaerythritoltetranitrate). In slapper detonators, the explosive vaporisation of the electrical conductor drives a flyer or slapper across a gap, and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by magnetic force. The term exploding foil detonator may refer to either an EB or a slapper-type detonator.*

***N.B.:***

*For equipment and devices specially designed for military use see the Munitions List.*

1-1.A.8. Charges, devices and components, as follows:

a. 'Shaped charges' having all of the following:

1. Net Explosive Quantity (NEQ) greater than 90 g; **and**
2. Outer casing diameter equal to or greater than 75 mm;

b. Linear shaped cutting charges having all of the following, and specially designed components therefor:
1. An explosive load greater than 40 g/m; **and**
2. A width of 10 mm or more;

c. Detonating cord with explosive core load greater than 64 g/m;

d. Cutters, other than those specified by 1-1.A.8.b., and severing tools, having a NEQ greater than 3.5 kg.

***Note:***
*The only charges and devices specified in 1-1.A.8. are those containing "explosives" listed in the Annex to Category 1 and mixtures thereof.*

***Technical Note:***
*'Shaped charges' are explosive charges shaped to focus the effects of the explosive blast.*

## 1-1.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1-1.B.1. Equipment for the production or inspection of "composite" structures or laminates specified by 1-1.A.2. or "fibrous or filamentary materials" specified by 1-1.C.10., as follows, and specially designed components and accessories therefor:

a. Filament winding machines, of which the motions for positioning, wrapping and winding fibres are coordinated and programmed in three or more 'primary servo positioning' axes, specially designed for the manufacture of "composite" structures or laminates, from "fibrous or filamentary materials";

b. 'Tape-laying machines', of which the motions for positioning and laying tape are coordinated and programmed in five or more 'primary servo positioning' axes, specially designed for the manufacture of "composite" airframe or missile structures;

***Technical Note:***
*For the purposes of 1-1.B.1.b., 'tape-laying machines' have the ability to lay one or more 'filament bands' limited to widths greater than 25.4 mm and less than or equal to 304.8 mm, and to cut and restart individual 'filament band' courses during the laying process.*

c. Multidirectional, multidimensional weaving machines or interlacing machines, including adapters and modification kits, specially designed or modified for weaving, interlacing or braiding fibres for "composite" structures;

***Technical Note:***
*For the purposes of 1-1.B.1.c., the technique of interlacing includes knitting.*

d. Equipment specially designed or adapted for the production of reinforcement fibres, as follows:
1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, pitch or polycarbosilane) into carbon fibres or silicon carbide fibres, including special equipment to strain the fibre during heating;
2. Equipment for the chemical vapour deposition of elements or compounds, on heated filamentary substrates, to manufacture silicon carbide fibres;
3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);

4. Equipment for converting aluminium containing precursor fibres into alumina fibres by heat treatment;

e. Equipment for producing prepregs specified by 1-1.C.10.e. by the hot melt method;

f. Non-destructive inspection equipment specially designed for "composite" materials, as follows:

1. X-ray tomography systems for three dimensional defect inspection;
2. Numerically controlled ultrasonic testing machines of which the motions for positioning transmitters or receivers are simultaneously coordinated and programmed in four or more axes to follow the three dimensional contours of the component under inspection;

g. 'Tow-placement machines', of which the motions for positioning and laying tows are coordinated and programmed in two or more 'primary servo positioning' axes, specially designed for the manufacture of "composite" airframe or missile structures.

***Technical Note:***

*For the purposes of 1-1.B.1.g., 'tow-placement machines' have the ability to place one or more 'filament bands' having widths less than or equal to 25.4 mm, and to cut and restart individual 'filament band' courses during the placement process.*

***Technical Notes:***

1. *For the purposes of 1-1.B.1., 'primary servo positioning' axes control, under computer program direction, the position of the end effector (i.e., head) in space relative to the work piece at the correct orientation and direction to achieve the desired process.*
2. *For the purposes of 1-1.B.1., a 'filament band' is a single continuous width of fully or partially resin-impregnated tape, tow or fibre. Fully or partially resin-impregnated 'filament bands' include those coated with dry powder that tacks upon heating.*

1-1.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 by 1-1.C.2.c.2.

1-1.B.3. Tools, dies, moulds or fixtures, for "superplastic forming" or "diffusion bonding" titanium, aluminium or their alloys, specially designed for the manufacture of any of the following:

a. Airframe or aerospace structures;

b. "Aircraft" or aerospace engines; **or**

c. Specially designed components for structures specified by 1-1.B.3.a. or for engines specified by 1-1.B.3.b.

## 1-1.C. MATERIALS

***Technical Note:***

***Metals and alloys***

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

***Crude forms***

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

***Semi-fabricated forms (whether or not coated, plated, drilled or punched)***

*a. Wrought or worked materials fabricated by rolling, drawing, extruding, forging, impact extruding, pressing, graining, atomising, and grinding, i.e.: angles, channels, circles, discs, dust, flakes, foils and leaf, forging, plate, powder, pressings and stampings, ribbons, rings, rods (including bare welding rods, wire rods, and rolled wire), sections, shapes, sheets, strip, pipe and tubes (including tube rounds, squares, and hollows), drawn or extruded wire;*

*b. Cast material produced by casting in sand, die, metal, plaster or other types of moulds, including high pressure castings, sintered forms, and forms made by powder metallurgy.*

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

1-1.C.1. Materials specially designed for absorbing electromagnetic radiation, or intrinsically conductive polymers, as follows:

a. Materials for absorbing frequencies exceeding 2 x $10^8$ Hz but less than 3 x $10^{12}$ Hz;

***Note 1:***

*1-1.C.1.a. does not apply to:*

*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:*

*1. Made from any of the following:*

*a. Plastic foam materials (flexible or non-flexible) with carbon-loading, or organic materials, including binders, providing more than 5% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 450 K (177° C);* ***or***

*b. Ceramic materials providing more than 20% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 800 K (527° C);*

***Technical Note:***

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

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

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

*d. Planar absorbers made of sintered ferrite, having all of the following:*

*1. A specific gravity exceeding 4.4;* ***and***

*2. A maximum operating temperature of 548 K (275° C);*

*e. Planar absorbers having no magnetic loss and fabricated from 'open-cell foam' plastic material with a density of 0.15 grams/$cm^3$ or less.*

***Technical Note:***

*'Open-cell foams' are flexible and porous materials, having an inner structure open to the atmosphere. 'Open-cell foams' are also known as reticulated foams.*

***Note 2:***

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

b. Materials not transparent to visible light and specially designed for absorbing near-infrared radiation having a wavelength exceeding 810 nm but less than 2000 nm (frequencies exceeding 150 THz but less than 370 THz);

***Note:***

*1-1.C.1.b. does not apply to materials, specially designed or formulated for any of the following applications:*

*a. "Laser" marking of polymers;* ***or***

*b. "Laser" welding of polymers.*

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.*

***Note:***

*1-1.C.1.c. does not apply to materials in a liquid form.*

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

***Note:***

*1-1.C.2. does not apply to metal alloys, metal alloy powder and alloyed materials, specially formulated for coating purposes.*

***Technical Notes:***

*1. The metal alloys in 1-1.C.2. are those containing a higher percentage by weight of the stated metal than of any other element.*

*2. 'Stress-rupture life' should be measured in accordance with ASTM standard E-139 or national equivalents.*

*3. 'Low cycle fatigue life' should be measured in accordance with ASTM Standard E-606 'Recommended Practice for Constant-Amplitude Low-Cycle Fatigue Testing' or national equivalents. Testing should be axial with an average stress ratio equal to 1 and a stress-concentration factor ($K_t$) equal to 1. The average stress is defined as maximum stress minus minimum stress divided by maximum stress.*

a. Aluminides, as follows:

1. Nickel aluminides containing a minimum of 15% by weight aluminium, a maximum of 38% by weight aluminium and at least one additional alloying element;
2. Titanium aluminides containing 10% by weight or more aluminium and at least one additional alloying element;

b. Metal alloys, as follows, made from the powder or particulate material specified by 1-1.C.2.c.:

1. Nickel alloys having any of the following:
   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 having any of the following:
   a. A ‘stress-rupture life’ of 10,000 hours or longer at 1,073 K (800° C) at a stress of 400 MPa; **or**
   b. A ‘low cycle fatigue life’ of 10,000 cycles or more at 973 K (700° C) at a maximum stress of 700 MPa;
3. Titanium alloys having any of the following:
   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 having any of the following:
   a. A tensile strength of 240 MPa or more at 473 K (200° C); **or**
   b. A tensile strength of 415 MPa or more at 298 K (25° C);
5. Magnesium alloys having all of the following:
   a. A tensile strength of 345 MPa or more; **and**
   b. A corrosion rate of less than 1 mm/year in 3% sodium chloride aqueous solution measured in accordance with ASTM standard G-31 or national equivalents;

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

      ***Technical Note:***
      *X in the following equals one or more alloying elements.*
      a. Nickel alloys (Ni-Al-X, Ni-X-Al) qualified for turbine engine parts or components, i.e. with less than 3 non-metallic particles (introduced during the manufacturing process) larger than 100 µm in $10^9$ alloy particles;
      b. Niobium alloys (Nb-Al-X or Nb-X-Al, Nb-Si-X or Nb-X-Si, Nb-Ti-X or Nb-X-Ti);
      c. Titanium alloys (Ti-Al-X or Ti-X-Al);
      d. Aluminium alloys (Al-Mg-X or Al-X-Mg, Al-Zn-X or Al-X-Zn, Al-Fe-X or Al-X-Fe); **or**
      e. Magnesium alloys (Mg-Al-X or Mg-X-Al);
   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’;
      g. ‘Mechanical alloying’; **or**
      h. ‘Plasma atomisation’; **and**
   3. Capable of forming materials specified by 1-1.C.2.a. or 1-1.C.2.b.;

d. Alloyed materials having all of the following:
   1. Made from any of the composition systems specified by 1-1.C.2.c.1.;

2. In the form of uncomminuted flakes, ribbons or thin rods; **and**
3. Produced in a controlled environment by any of the following:
   a. 'Splat quenching';
   b. 'Melt spinning'; **or**
   c. 'Melt extraction';

***Technical Notes:***

1. *'Vacuum atomisation' is a process to reduce a molten stream of metal to droplets of a diameter of 500 μm or less by the rapid evolution of a dissolved gas upon exposure to a vacuum.*
2. *'Gas atomisation' is a process to reduce a molten stream of metal alloy to droplets of 500 μm diameter or less by a high pressure gas stream.*
3. *'Rotary atomisation' is a process to reduce a stream or pool of molten metal to droplets to a diameter of 500 μm or less by centrifugal force.*
4. *'Splat quenching' is a process to 'solidify rapidly' a molten metal stream impinging upon a chilled block, forming a flake-like product.*
5. *'Melt spinning' is a process to 'solidify rapidly' a molten metal stream impinging upon a rotating chilled block, forming a flake, ribbon or rod-like product.*
6. *'Comminution' is a process to reduce a material to particles by crushing or grinding.*
7. *'Melt extraction' is a process to 'solidify rapidly' and extract a ribbon-like alloy product by the insertion of a short segment of a rotating chilled block into a bath of a molten metal alloy.*
8. *'Mechanical alloying' is an alloying process resulting from the bonding, fracturing and rebonding of elemental and master alloy powders by mechanical impact. Non-metallic particles may be incorporated in the alloy by addition of the appropriate powders.*
9. *'Plasma atomisation' is a process to reduce a molten stream or solid metal to droplets of 500 μm diameter or less, using plasma torches in an inert gas environment.*
10. *'Solidify rapidly' is a process involving the solidification of molten material at cooling rates exceeding 1000 K/sec.*

1-1.C.3. Magnetic metals, of all types and of whatever form, having any of the following:

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

***Technical Note:***

*Measurement of initial relative permeability must be performed on fully annealed materials.*

b. Magnetostrictive alloys having any of the following:
   1. A saturation magnetostriction of more than $5 \times 10^{-4}$; **or**
   2. A magnetomechanical coupling factor (k) of more than 0.8; **or**
c. Amorphous or 'nanocrystalline' alloy strips, having all of the following:
   1. A composition having a minimum of 75% by weight 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 $2 \times 10^{-4}$ ohm cm or more.

***Technical Note:***

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

1-1.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%.

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

a. "Superconductive" "composite" conductors containing one or more niobium-titanium 'filaments', having all of the following:
   1. Embedded in a "matrix" other than a copper or copper-based mixed "matrix"; **and**
   2. Having a cross-section area less than 0.28 x 10$^{-4}$ mm$^2$ (6 µm in diameter for circular 'filaments');
b. "Superconductive" "composite" conductors consisting of one or more "superconductive" 'filaments' other than niobium-titanium, having all of the following:
   1. A "critical temperature" at zero magnetic induction exceeding 9.85 K (-263.31° C); **and**
   2. Remaining in the "superconductive" state at a temperature of 4.2 K (-268.96° C) when exposed to a magnetic field oriented in any direction perpendicular to the longitudinal axis of conductor and corresponding to a magnetic induction of 12 T with critical current density exceeding 1,750 A/mm$^2$ on overall cross-section of the conductor.
c. "Superconductive" "composite" conductors consisting of one or more "superconductive" 'filaments', which remain "superconductive" above 115 K (-158.16° C).

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

1-1.C.6. Fluids and lubricating materials, as follows:

a. Not used since 2015
b. Lubricating materials containing, as their principal ingredients, any of the following:
   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 having all of the following:
   1. Purity exceeding 99.8%;
   2. Containing less than 25 particles of 200 µm or larger in size per 100 ml; **and**
   3. Made from at least 85% of any of the following:
      a. Dibromotetrafluoroethane (CAS 25497-30-7, 124-73-2, 27336-23-8);
      b. Polychlorotrifluoroethylene (oily and waxy modifications only); **or**
      c. Polybromotrifluoroethylene;
d. Fluorocarbon electronic cooling fluids having all of the following:
   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.

***Note:***
*1-1.C.6.d. does not apply to materials specified and packaged as medical products.*

1-1.C.7. Ceramic powders, ceramic-"matrix" "composite" materials and 'precursor materials', as follows:

a. Ceramic powders of titanium diboride ($TiB_2$) (CAS 12045-63-5) 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. Not used since 2016
c. Ceramic-"matrix" "composite" materials as follows:
   1. Ceramic-ceramic "composite" materials with a glass or oxide-"matrix" and reinforced with any of the following:
      a. Continuous fibres made from any of the following materials:
         1. $Al_2O_3$ (CAS 1344-28-1); **or**
         2. Si-C-N; **or**

         ***Note:***
         *1-1.C.7.c.1.a. does not apply to "composites" containing fibres with a tensile strength of less than 700 MPa at 1,273 K (1,000° C) or tensile creep resistance of more than 1% creep strain at 100 MPa load and 1,273 K (1,000° C) for 100 hours.*
      b. Fibres being all of the following:
         1. Made from any of the following materials:
            a. Si-N;
            b. Si-C;
            c. Si-Al-O-N; **or**
            d. Si-O-N; **and**
         2. Having a "specific tensile strength" exceeding 12.7 x $10^3$ m;
   2. Ceramic-"matrix" "composite" materials with a "matrix" formed of carbides or nitrides of silicon, zirconium or boron;

      ***N.B.:***
      *For items previously specified by 1-1.C.7.c. see 1-1.C.7.c.1.b.*
d. Not used since 2016

   ***N.B.:***
   *For items previously specified by 1-1.C.7.d. see 1-1.C.7.c.2.*
e. 'Precursor materials' specially designed for the "production" of materials specified by 1-1.C.7.c., as follows:
   1. Polydiorganosilanes;
   2. Polysilazanes;
   3. Polycarbosilazanes;

***Technical Note:***

*For the purposes of 1-1.C.7., 'precursor materials' are special purpose polymeric or metallo-organic materials used for the "production" of silicon carbide, silicon nitride, or ceramics with silicon, carbon and nitrogen.*

f. Not used since 2016

***N.B.:***

*For items previously specified by 1-1.C.7.f. see 1-1.C.7.c.1.a.*

1-1.C.8. Non-fluorinated polymeric substances as follows:

a. Imides as follows:
   1. Bismaleimides;
   2. Aromatic polyamide-imides (PAI) having a 'glass transition temperature (Tg)' exceeding 563 K (290° C);
   3. Aromatic polyimides having a 'glass transition temperature (Tg)' exceeding 505 K (232° C);
   4. Aromatic polyetherimides having a 'glass transition temperature (Tg)' exceeding 563 K (290° C);

***Note:***

*1-1.C.8.a. applies to the substances in liquid or solid "fusible" form, including resin, powder, pellet, film, sheet, tape, or ribbon.*

***N.B.:***

*For non-"fusible" aromatic polyimides in film, sheet, tape, or ribbon form, see 1-1.A.3.*

b. Not used since 2014

c. Not used since 2006

d. Polyarylene ketones;

e. Polyarylene sulphides, where the arylene group is biphenylene, triphenylene or combinations thereof;

f. Polybiphenylenethersulphone having a 'glass transition temperature (Tg)' exceeding 563 K (290° C).

***Technical Notes:***

1. *The 'glass transition temperature (Tg)' for 1-1.C.8.a.2. thermoplastic materials, 1-1.C.8.a.4. materials and 1-1.C.8.f. materials is determined using the method described in ISO 11357-2 (1999) or national equivalents.*
2. *The 'glass transition temperature (Tg)' for 1-1.C.8.a.2. thermosetting materials and 1-1.C.8.a.3. materials is determined using the 3-point bend method described in ASTM D 7028-07 or equivalent national standard. The test is to be performed using a dry test specimen which has attained a minimum of 90% degree of cure as specified by ASTM E 2160-04 or equivalent national standard, and was cured using the combination of standard- and post-cure processes that yield the highest Tg.*

1-1.C.9. Unprocessed fluorinated compounds as follows:

a. Not used since 2015

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.

1-1.C.10. "Fibrous or filamentary materials" as follows:

***Technical Notes:***

1. *For the purpose of calculating "specific tensile strength", "specific modulus" or specific weight of "fibrous or filamentary materials" in 1-1.C.10.a., 1-1.C.10.b., 1-1.C.10.c. or 1-1.C.10.e.1.b., the tensile strength and modulus should be determined by using Method A described in ISO 10618 (2004) or national equivalents.*
2. *Assessing the "specific tensile strength", "specific modulus" or specific weight of non-unidirectional "fibrous or filamentary materials" (e.g., fabrics, random mats or braids) in 1-1.C.10. is to be based on the mechanical properties of the constituent unidirectional monofilaments (e.g., monofilaments, yarns, rovings or tows) prior to processing into the non-unidirectional "fibrous or filamentary materials".*

a. Organic "fibrous or filamentary materials", having all of the following:
   1. "Specific modulus" exceeding 12.7 x $10^6$ m; **and**
   2. "Specific tensile strength" exceeding 23.5 x $10^4$ m;

   ***Note:***

   *1-1.C.10.a. does not apply to polyethylene.*

b. Carbon "fibrous or filamentary materials", having all of the following:
   1. "Specific modulus" exceeding 14.65 x $10^6$ m; **and**
   2. "Specific tensile strength" exceeding 26.82 x $10^4$ m;

   ***Note:***

   *1-1.C.10.b. does not apply to:*

   *a. "Fibrous or filamentary materials", for the repair of "civil aircraft" structures or laminates, having all of the following:*
      *1. An area not exceeding 1 $m^2$;*
      *2. A length not exceeding 2.5 m; **and***
      *3. A width exceeding 15 mm.*

   *b. Mechanically chopped, milled or cut carbon "fibrous or filamentary materials" 25.0 mm or less in length.*

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

   ***Note:***

   *1-1.C.10.c. does not apply to:*

   *a. Discontinuous, multiphase, polycrystalline alumina fibres in chopped fibre or random mat form, containing 3% by weight or more silica, with a "specific modulus" of less than 10 x $10^6$ m;*

   *b. Molybdenum and molybdenum alloy fibres;*

   *c. Boron fibres;*

   *d. 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", having any of the following:
   1. Composed of any of the following:
      a. Polyetherimides specified by 1-1.C.8.a.; **or**
      b. Materials specified by 1-1.C.8.d. to 1-1.C.8.f.; **or**

2. Composed of materials specified by 1-1.C.10.d.1.a. or 1-1.C.10.d.1.b. and 'commingled' with other fibres specified by 1-1.C.10.a., 1-1.C.10.b. or 1-1.C.10.c.;

***Technical Note:***

*'Commingled' is filament to filament blending of thermoplastic fibres and reinforcement fibres in order to produce a fibre reinforcement "matrix" mix in total fibre form.*

e. Fully or partially resin-impregnated or pitch-impregnated "fibrous or filamentary materials" (prepregs), metal or carbon-coated "fibrous or filamentary materials" (preforms) or 'carbon fibre preforms', having all of the following:
   1. Having any of the following:
      a. Inorganic "fibrous or filamentary materials" specified by 1-1.C.10.c.; **or**
      b. Organic or carbon "fibrous or filamentary materials", having all of the following:
         1. "Specific modulus" exceeding 10.15 x $10^6$ m; **and**
         2. "Specific tensile strength" exceeding 17.7 x $10^4$ m; **and**
   2. Having any of the following:
      a. Resin or pitch, specified by 1-1.C.8. or 1-1.C.9.b.;
      b. 'Dynamic Mechanical Analysis glass transition temperature (DMA Tg)' equal to or exceeding 453 K (180° C) and having a phenolic resin; **or**
      c. 'Dynamic Mechanical Analysis glass transition temperature (DMA Tg)' equal to or exceeding 505 K (232° C) and having a resin or pitch, not specified by 1-1.C.8. or 1-1.C.9.b., and not being a phenolic resin;

***Note 1:***

*Metal or carbon-coated "fibrous or filamentary materials" (preforms) or 'carbon fibre preforms', not impregnated with resin or pitch, are specified by "fibrous or filamentary materials" in 1-1.C.10.a., 1-1.C.10.b. or 1-1.C.10.c.*

***Note 2:***

*1-1.C.10.e. does not apply to:*

*a. Epoxy resin "matrix" impregnated carbon "fibrous or filamentary materials" (prepregs) for the repair of "civil aircraft" structures or laminates, having all of the following;*
   *1. An area not exceeding 1 $m^2$;*
   *2. A length not exceeding 2.5 m;* ***and***
   *3. A width exceeding 15 mm;*

*b. Fully or partially resin-impregnated or pitch-impregnated mechanically chopped, milled or cut carbon "fibrous or filamentary materials" 25.0 mm or less in length when using a resin or pitch other than those specified by 1-1.C.8. or 1-1.C.9.b.*

***Technical Notes:***

*1. 'Carbon fibre preforms' are an ordered arrangement of uncoated or coated fibres intended to constitute a framework of a part before the "matrix" is introduced to form a "composite".*

*2. The 'Dynamic Mechanical Analysis glass transition temperature (DMA Tg)' for materials specified by 1-1.C.10.e. is determined using the method described in ASTM D 7028-07, or equivalent national standard, on a dry test specimen. In the case of thermoset materials, degree of cure of a dry test specimen shall be a minimum of 90% as defined by ASTM E 2160-04 or equivalent national standard.*

1-1.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 thereof;

***Note:***

*The metals or alloys specified by 1-1.C.11.a. also refer to metals or alloys encapsulated in aluminium, magnesium, zirconium or beryllium.*

***Technical Note:***

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

b. Boron or boron alloys, with a particle size of 60 µm or less, as follows:
   1. Boron with a purity of 85% by weight or more;
   2. Boron alloys with a boron content of 85% by weight or more;

***Note:***

*The metals or alloys specified by 1-1.C.11.b. also refer to metals or alloys encapsulated in aluminium, magnesium, zirconium or beryllium.*

c. Guanidine nitrate (CAS 506-93-4);

d. Nitroguanidine (NQ) (CAS 556-88-7).

***N.B.:***

*See 2-8.c.5.b. for metal powders mixed with other substances to form a mixture formulated for military purposes.*

1-1.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:***

*1-1.C.12.a. does not apply to:*

*a. Shipments with a plutonium content of 1 g or less;*

*b. Shipments of 3 'effective grams' or less when contained in a sensing component in instruments.*

***Technical Note:***

*'Effective grams' for plutonium isotope is defined as the isotope weight in grams.*

b. 'Previously separated' neptunium-237 in any form.

***Note:***

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

***Technical Note:***

*'Previously separated' is the application of any process intended to increase the concentration of the controlled isotope.*

## 1-1.D. SOFTWARE

1-1.D.1. "Software" specially designed or modified for the "development", "production" or "use" of equipment specified by 1-1.B.

1-1.D.2. "Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites".

1-1.D.3. "Software" specially designed or modified to enable equipment to perform the functions of equipment specified by 1-1.A.4.c. or 1-1.A.4.d.

## 1-1.E. TECHNOLOGY

1-1.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials specified by 1-1.A.2. to 1-1.A.5., 1-1.A.6.b., 1-1.A.7., 1-1.B. or 1-1.C.

1-1.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 vinylether monomer;

c. "Technology" for the design or "production" of the following ceramic powders or non-"composite" ceramic materials:

1. Ceramic powders having all of the following:

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. Any of the following total metallic impurities (excluding intentional additions):

1. Less than 1,000 ppm for single oxides or carbides; **or**
2. Less than 5,000 ppm for complex compounds or single nitrides; **and**

c. Being any of the following:

1. Zirconia (CAS 1314-23-4) with an average particle size equal to or less than 1 µm and no more than 10% of the particles larger than 5 µm; **or**
2. Other ceramic powders with an average particle size equal to or less than 5 µm and no more than 10% of the particles larger than 10 µm;

2. Non-"composite" ceramic materials composed of the materials specified by 1-1.E.2.c.1.;

***Note:***
*1-1.E.2.c.2. does not apply to "technology" for abrasives.*

d. Not used since 2014

e. "Technology" for the installation, maintenance or repair of materials specified by 1-1.C.1.;

f. "Technology" for the repair of "composite" structures, laminates or materials specified by 1-1.A.2. or 1-1.C.7.c.;

***Note:***
*1-1.E.2.f. does not apply to "technology" for the repair of "civil aircraft" structures using carbon "fibrous or filamentary materials" and epoxy resins, contained in "aircraft" manufacturers' manuals.*

g. "Libraries" specially designed or modified to enable equipment to perform the functions of equipment specified by 1-1.A.4.c. or 1-1.A.4.d.

LIST – "EXPLOSIVES"

1. ADNBF (aminodinitrobenzofuroxan or 7-amino-4,6-dinitrobenzofurazane-1-oxide) (CAS 97096-78-1);
2. BNCP (cis-bis (5-nitrotetrazolato) tetra amine-cobalt (III) perchlorate) (CAS 117412-28-9);
3. CL-14 (diamino dinitrobenzofuroxan or 5,7-diamino-4,6-dinitrobenzofurazane-1-oxide) (CAS 117907-74-1);
4. CL-20 (HNIW or Hexanitrohexaazaisowurtzitane) (CAS 135285-90-4); chlathrates of CL-20;
5. CP (2-(5-cyanotetrazolato) penta amine-cobalt (III) perchlorate) (CAS 70247-32-4);
6. DADE (1,1-diamino-2,2-dinitroethylene, FOX-7) (CAS 145250-81-3);
7. DATB (diaminotrinitrobenzene) (CAS 1630-08-6);
8. DDFP (1,4-dinitrodifurazanopiperazine);
9. DDPO (2,6-diamino-3,5-dinitropyrazine-1-oxide, PZO) (CAS 194486-77-6);
10. DIPAM (3,3′-diamino-2,2′,4,4′,6,6′-hexanitrobiphenyl or dipicramide) (CAS 17215-44-0);
11. DNGU (DINGU or dinitroglycoluril) (CAS 55510-04-8);
12. Furazans as follows:
    a. DAAOF (diaminoazoxyfurazan);
    b. DAAzF (diaminoazofurazan) (CAS 78644-90-3);
13. HMX and derivatives, as follows:
    a. HMX (Cyclotetramethylenetetranitramine, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazine, 1,3,5,7-tetranitro-1,3,5,7-tetraza-cyclooctane, octogen or octogene) (CAS 2691-41-0);
    b. difluoroaminated analogs of HMX;
    c. K-55 (2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo [3,3,0]-octanone-3, tetranitrosemiglycouril or keto-bicyclic HMX) (CAS 130256-72-3);
14. HNAD (hexanitroadamantane) (CAS 143850-71-9);
15. HNS (hexanitrostilbene) (CAS 20062-22-0);
16. Imidazoles as follows:
    a. BNNII (Octahydro-2,5-bis(nitroimino)imidazo [4,5-d]imidazole);
    b. DNI (2,4-dinitroimidazole) (CAS 5213-49-0);
    c. FDIA (1-fluoro-2,4-dinitroimidazole);
    d. NTDNIA (N-(2-nitrotriazolo)-2,4-dinitroimidazole);
    e. PTIA (1-picryl-2,4,5-trinitroimidazole);
17. NTNMH (1-(2-nitrotriazolo)-2-dinitromethylene hydrazine);
18. NTO (ONTA or 3-nitro-1,2,4-triazol-5-one) (CAS 932-64-9);
19. Polynitrocubanes with more than four nitro groups;
20. PYX (2,6-Bis(picrylamino)-3,5-dinitropyridine) (CAS 38082-89-2);
21. RDX and derivatives, as follows:
    a. RDX (cyclotrimethylenetrinitramine, cyclonite, T4, hexahydro-1,3,5-trinitro-1,3,5-triazine, 1,3,5-trinitro-1,3,5-triaza-cyclohexane, hexogen or hexogene) (CAS 121-82-4);
    b. Keto-RDX (K-6 or 2,4,6-trinitro-2,4,6-triazacyclohexanone) (CAS 115029-35-1);
22. TAGN (triaminoguanidinenitrate) (CAS 4000-16-2);
23. TATB (triaminotrinitrobenzene) (CAS 3058-38-6);
24. TEDDZ (3,3,7,7-tetrabis(difluoroamine) octahydro-1,5-dinitro-1,5-diazocine);

25. Tetrazoles as follows:
    a. NTAT (nitrotriazol aminotetrazole);
    b. NTNT (1-N-(2-nitrotriazolo)-4-nitrotetrazole);
26. Tetryl (trinitrophenylmethylnitramine) (CAS 479-45-8);
27. TNAD (1,4,5,8-tetranitro-1,4,5,8-tetraazadecalin) (CAS 135877-16-6);
28. TNAZ (1,3,3-trinitroazetidine) (CAS 97645-24-4);
29. TNGU (SORGUYL or tetranitroglycoluril) (CAS 55510-03-7);
30. TNP (1,4,5,8-tetranitro-pyridazino[4,5-d]pyridazine) (CAS 229176-04-9);
31. Triazines as follows:
    a. DNAM (2-oxy-4,6-dinitroamino-s-triazine) (CAS 19899-80-0);
    b. NNHT (2-nitroimino-5-nitro-hexahydro-1,3,5-triazine) (CAS 130400-13-4);
32. Triazoles as follows:
    a. 5-azido-2-nitrotriazole;
    b. ADHTDN (4-amino-3,5-dihydrazino-1,2,4-triazole dinitramide) (CAS 1614-08-0);
    c. ADNT (1-amino-3,5-dinitro-1,2,4-triazole);
    d. BDNTA ((bis-dinitrotriazole)amine);
    e. DBT (3,3′-dinitro-5,5-bi-1,2,4-triazole) (CAS 30003-46-4);
    f. DNBT (dinitrobistriazole) (CAS 70890-46-9);
    g. Not used since 2011
    h. NTDNT (1-N-(2-nitrotriazolo) 3,5-dinitrotriazole);
    i. PDNT (1-picryl-3,5-dinitrotriazole);
    j. TACOT (tetranitrobenzotriazolobenzotriazole) (CAS 25243-36-1);
33. “Explosives” not listed elsewhere in this list having a detonation velocity exceeding 8,700 m/s, at maximum density, or a detonation pressure exceeding 34 GPa (340 kbar);
34. Not used since 2013
35. Nitrocellulose (containing more than 12.5% nitrogen) (CAS 9004-70-0);
36. Nitroglycol (CAS 628-96-6);
37. Pentaerythritol tetranitrate (PETN) (CAS 78-11-5);
38. Picryl chloride (CAS 88-88-0);
39. 2,4,6-Trinitrotoluene (TNT) (CAS 118-96-7);
40. Nitroglycerine (NG) (CAS 55-63-0);
41. Triacetone Triperoxide (TATP) (CAS 17088-37-8);
42. Guanidine nitrate (CAS 506-93-4);
43. Nitroguanidine (NQ) (CAS 556-88-7);
44. DNAN (2,4-dinitroanisole) (CAS 119-27-7);
45. TEX (4,10-Dinitro-2,6,8,12-tetraoxa-4,10-diazaisowurtzitane);
46. GUDN (Guanylurea dinitramide) FOX-12 (CAS 217464-38-5);
47. Tetrazines as follows:
    a. BTAT (Bis(2,2,2-trinitroethyl)-3,6-diaminotetrazine);
    b. LAX-112 (3,6-diamino-1,2,4,5-tetrazine-1,4-dioxide);
48. Energetic ionic materials melting between 343 K (70° C) and 373 K (100° C) and with detonation velocity exceeding 6,800 m/s or detonation pressure exceeding 18 GPa (180 kbar);
49. BTNEN (Bis(2,2,2-trinitroethyl)-nitramine) (CAS 19836-28-3);
50. FTDO (5,6-(3’,4’-furazano)- 1,2,3,4-tetrazine-1,3-dioxide).

# CATEGORY 2: MATERIALS PROCESSING

## 1-2.A. SYSTEMS, EQUIPMENT AND COMPONENTS

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

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

***Note:***
*1-2.A.1. does not apply to balls with tolerances specified by the manufacturer in accordance with ISO 3290:2001 as grade G5 (or national equivalents) 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 Class 2 (or national equivalents), or better, and having both 'rings' and 'rolling elements', made from monel or beryllium;

***Note:***
*1-2.A.1.a. does not apply to tapered roller bearings.*

***Technical Notes:***
1. *'Ring' - annular part of a radial rolling bearing incorporating one or more raceways (ISO 5593:1997).*
2. *'Rolling element' - ball or roller which rolls between raceways (ISO 5593:1997).*

b. Not used since 2010

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

## 1-2.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

***Technical Notes:***
1. *Secondary parallel contouring axes, (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centre line of which is parallel to the primary rotary axis) are not counted in the total number of contouring axes. Rotary axes need not rotate over 360°. A rotary axis can be driven by a linear device (e.g., a screw or a rack-and-pinion).*
2. *For the purposes of 1-2.B., the number of axes which can be co-ordinated simultaneously for "contouring control" is the number of axes along or around which, during processing of the workpiece, simultaneous and interrelated motions are performed between the workpiece and a tool. This does not include any additional axes along or around which other relative motions within the machine are performed, such as:*
   a. *Wheel-dressing systems in grinding machines;*
   b. *Parallel rotary axes designed for mounting of separate workpieces;*
   c. *Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.*
3. *Axis nomenclature shall be in accordance with International Standard ISO 841:2001, Industrial automation systems and integration - Numerical control of machines - Coordinate system and motion nomenclature.*
4. *For the purposes of this Category a "tilting spindle" is counted as a rotary axis.*

5. *'Stated "unidirectional positioning repeatability"' may be used for each machine tool model as an alternative to individual machine tests, and is determined as follows:*
   a. *Select five machines of a model to be evaluated;*
   b. *Measure the linear axis repeatability (R↑ ,R↓ ) according to ISO 230-2:2014 and evaluate "unidirectional positioning repeatability" for each axis of each of the five machines;*
   c. *Determine the arithmetic mean value of the "unidirectional positioning repeatability" -values for each axis of all five machines together. These arithmetic mean values of "unidirectional positioning repeatability" ( $\overline{UPR}$) become the stated value of each axis for the model ($\overline{UPR}_x$, $\overline{UPR}_{y,\ldots}$)*
   d. *Since the Category 2 list refers to each linear axis there will be as many 'stated "unidirectional positioning repeatability"' -values as there are linear axes;*
   e. *If any axis of a machine model not specified by 1-2.B.1.a. to 1-2.B.1.c. has a 'stated "unidirectional positioning repeatability"' equal to or less than the specified "unidirectional positioning repeatability" of each machine tool model plus 0.7 µm, the builder should be required to reaffirm the accuracy level once every eighteen months.*
6. *For the purposes of 1-2.B., measurement uncertainty for the "unidirectional positioning repeatability" of machine tools, as defined in the International Standard ISO 230-2:2014 or national equivalents, shall not be considered.*
7. *For the purpose of 1-2.B., the measurement of axes shall be made according to test procedures in 5.3.2. of ISO 230-2:2014. Tests for axes longer than 2 meters shall be made over 2 m segments. Axes longer than 4 m require multiple tests (e.g., two tests for axes longer than 4 m and up to 8 m, three tests for axes longer than 8 m and up to 12 m), each over 2 m segments and distributed in equal intervals over the axis length. Test segments are equally spaced along the full axis length, with any excess length equally divided at the beginning, in between, and at the end of the test segments. The smallest "unidirectional positioning repeatability" -value of all test segments is to be reported.*

1-2.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", as follows:

***Note 1:***

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

***Note 2:***

*1-2.B.1. does not apply to special purpose machine tools limited to the manufacture of any of the following:*

a. *Crank shafts or cam shafts;*
b. *Tools or cutters;*
c. *Extruder worms;*
d. *Engraved or facetted jewellery parts;* ***or***
e. *Dental prostheses.*

***Note 3:***

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

***N.B.:***

*For optical finishing machines, see 1-2.B.2.*

a. Machine tools for turning having two or more axes which can be coordinated simultaneously for "contouring control" having any of the following:

1. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; **or**
2. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;

***Note 1:***

*1-2.B.1.a. does not apply to turning machines specially designed for producing contact lenses, having all of the following:*

*a. Machine controller limited to using ophthalmic based "software" for part programming data input;* ***and***

*b. No vacuum chucking.*

***Note 2:***

*1-2.B.1.a. does not apply to bar machines (Swissturn), limited to machining only bar feed thru, if maximum bar diameter is equal to or less than 42 mm and there is no capability of mounting chucks. Machines may have drilling or milling capabilities for machining parts with diameters less than 42 mm.*

b. Machine tools for milling having any of the following:
   1. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control" having any of the following:
      a. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m; **or**
      b. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis with a travel length equal to or greater than 1.0 m;
   2. Five or more axes which can be coordinated simultaneously for "contouring control" having any of the following:
      a. "Unidirectional positioning repeatability" equal to or less (better) than 0.9 µm along one or more linear axis with a travel length less than 1.0 m;
      b. "Unidirectional positioning repeatability" equal to or less (better) than 1.4 µm along one or more linear axis with a travel length equal to or greater than 1 m and less than 4 m; **or**
      c. "Unidirectional positioning repeatability" equal to or less (better) than 6.0 µm along one or more linear axis with a travel length equal to or greater than 4 m;
      d. Not used since 2016
   3. A "unidirectional positioning repeatability" for jig boring machines, equal to or less (better) than 1.1 µm along one or more linear axis; **or**
   4. Fly cutting machines having all of the following:
      a. Spindle "run-out" and "camming" less (better) than 0.0004 mm TIR; **and**
      b. Angular deviation of slide movement (yaw, pitch and roll) less (better) than 2 seconds of arc, TIR, over 300 mm of travel;

c. Machine tools for grinding having any of the following:
   1. Having all of the following:
      a. "Unidirectional positioning repeatability" equal to or less (better) than 1.1 µm along one or more linear axis; **and**
      b. Three or four axes which can be coordinated simultaneously for "contouring control"; **or**

2. Five or more axes which can be coordinated simultaneously for “contouring control” having any of the following:
   a. “Unidirectional positioning repeatability” equal to or less (better) than 1.1 µm along one or more linear axis with a travel length less than 1 m;
   b. “Unidirectional positioning repeatability” equal to or less (better) than 1.4 µm along one or more linear axis with a travel length equal to or greater than 1 m and less than 4 m; **or**
   c. “Unidirectional positioning repeatability” equal to or less (better) than 6.0 µm along one or more linear axis with a travel length equal to or greater than 4 m.

***Note:***

*1-2.B.1.c. does not apply to grinding machines as follows:*

*a. Cylindrical external, internal, and external-internal grinding machines, having all of the following:*
   *1. Limited to cylindrical grinding;* ***and***
   *2. Limited to a maximum workpiece capacity of 150 mm outside diameter or length.*

*b. Machines designed specifically as jig grinders that do not have a z-axis or a w-axis, with a “unidirectional positioning repeatability” less (better) than 1.1 µm.*

*c. Surface grinders.*

d. Electrical discharge machines (EDM) of the non-wire type which have two or more rotary axes which can be coordinated simultaneously for “contouring control”;

e. Machine tools for removing metals, ceramics or “composites”, having all of the following:
   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. At least two rotary axes having all of the following:
      a. Can be coordinated simultaneously for “contouring control”; **and**
      b. 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 m.

1-2.B.2. Numerically controlled optical finishing machine tools equipped for selective material removal to produce non-spherical optical surfaces having all of the following characteristics:

a. Finishing the form to less (better) than 1.0 µm;

b. Finishing to a roughness less (better) than 100 nm rms;

c. Four or more axes which can be coordinated simultaneously for “contouring control”; **and**

d. Using any of the following processes:
   1. ‘Magnetorheological finishing (MRF)’;
   2. ‘Electrorheological finishing (ERF)’;
   3. ‘Energetic particle beam finishing’;
   4. ‘Inflatable membrane tool finishing’; **or**
   5. ‘Fluid jet finishing’.

***Technical Notes:***

*For the purposes of 1-2.B.2.:*

1. *'MRF' is a material removal process using an abrasive magnetic fluid whose viscosity is controlled by a magnetic field.*
2. *'ERF' is a removal process using an abrasive fluid whose viscosity is controlled by an electric field.*
3. *'Energetic particle beam finishing' uses Reactive Atom Plasmas (RAP) or ion-beams to selectively remove material.*
4. *'Inflatable membrane tool finishing' is a process that uses a pressurized membrane that deforms to contact the workpiece over a small area.*
5. *'Fluid jet finishing' makes use of a fluid stream for material removal.*

1-2.B.3. "Numerically controlled" machine tools, specially designed for the shaving, finishing, grinding or honing of hardened ($R_c$ = 40 or more) spur, helical and double-helical gears having all of the following:

a. A pitch diameter exceeding 1,250 mm;
b. A face width of 15% of pitch diameter or larger; **and**
c. A finished quality of AGMA 14 or better (equivalent to ISO 1328 class 3).

1-2.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. Having any of the following:
   1. A maximum working pressure exceeding 207 MPa;
   2. A controlled thermal environment exceeding 1,773 K (1,500° C); **or**
   3. A facility for hydrocarbon impregnation and removal of resultant gaseous degradation products.

***Technical Note:***

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

***N.B.:***

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

1-2.B.5. Equipment specially designed for the deposition, processing and in-process control of inorganic overlays, coatings and surface modifications, as follows, for substrates specified in column 2, by processes shown in column 1 in the Table following 1-2.E.3.f., and specially designed automated handling, positioning, manipulation and control components therefor:

a. Chemical vapour deposition (CVD) production equipment having all of the following:
   1. A 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. Having any of the following:

a. Incorporating high vacuum (equal to or less than 0.01 Pa) rotating seals; **or**
b. Incorporating *in situ* coating thickness control;

b. Ion implantation production equipment having beam currents of 5 mA or more;

c. Electron beam physical vapour deposition (EB-PVD) production equipment incorporating power systems rated for over 80 kW and having any of the following:
1. A liquid pool level "laser" control system which regulates precisely the ingots feed rate; **or**
2. A computer controlled rate monitor operating on the principle of photo-luminescence of the ionised atoms in the evaporant stream to control the deposition rate of a coating containing two or more elements;

d. Plasma spraying production equipment having any of the following:
1. Operating at reduced pressure controlled atmosphere (equal to or less than 10 kPa measured above and within 300 mm of the gun nozzle exit) in a vacuum chamber capable of evacuation down to 0.01 Pa prior to the spraying process; **or**
2. Incorporating *in situ* coating thickness control;

e. Sputter deposition production equipment capable of current densities of 0.1 mA/mm$^2$ or higher at a deposition rate of 15 µm/h or more;

f. Cathodic arc deposition production equipment incorporating a grid of electromagnets for steering control of the arc spot on the cathode;

g. Ion plating production equipment capable of *in situ* measurement of any of the following:
1. Coating thickness on the substrate and rate control; **or**
2. Optical characteristics.

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

1-2.B.6. Dimensional inspection or measuring systems, equipment, position feedback units and "electronic assemblies", as follows:

a. Computer controlled or "numerical controlled" Coordinate Measuring Machines (CMM), having a three dimensional (volumetric) maximum permissible error of length measurement ($E_{0,MPE}$) at any point within the operating range of the machine (i.e., within the length of axes) equal to or less (better) than 1.7 + L/1,000 µm (L is the measured length in mm), according to ISO 10360-2 (2009);

***Technical Note:***
*The $E_{0,MPE}$ of the most accurate configuration of the CMM specified by the manufacturer (e.g., best of the following: probe, stylus length, motion parameters, environment) and with "all compensations available" shall be compared to the 1.7 + L/1,000 µm threshold.*

b. Linear displacement measuring instruments or systems, linear position feedback units, and "electronic assemblies", as follows:

***Note:***
*Interferometer and optical-encoder measuring systems containing a "laser" are only specified in 1-2.B.6.b.3.*

1. 'Non-contact type measuring systems' with a 'resolution' equal to or less (better) than 0.2 µm within 0 to 0.2 mm of the 'measuring range';

***Technical Notes:***

1. *For the purposes of 1-2.B.6.b.1., 'non-contact type measuring systems' are designed to measure the distance between the probe and measured object along a single vector, where the probe or measured object is in motion.*
2. *For the purposes of 1-2.B.6.b.1., 'measuring range' means the distance between the minimum and maximum working distance.*

2. Linear position feedback units specially designed for machine tools and having an overall "accuracy" less (better) than (800 + (600 x L/1,000)) nm (L equals effective length in mm);
3. Measuring systems having all of the following:
   a. Containing a "laser";
   b. A 'resolution' over their full scale of 0.200 nm or less (better); **and**
   c. Capable of achieving a "measurement uncertainty" equal to or less (better) than (1.6 + L/2,000) nm (L is the measured length in mm) at any point within a measuring range, when compensated for the refractive index of air and measured over a period of 30 seconds at a temperature of 20 ±0.01° C; **or**

***Technical Note:***

*For the purposes of 1-2.B.6.b., 'resolution' is the least increment of a measuring device; on digital instruments, the least significant bit.*

4. "Electronic assemblies" specially designed to provide feedback capability in systems specified by 1-2.B.6.b.3.;

c. Rotary position feedback units specially designed for machine tools or angular displacement measuring instruments, having an angular position "accuracy" equal to or less (better) than 0.9 second of arc;

***Note:***

*1-2.B.6.c. does not apply to optical instruments, such as autocollimators, using collimated light (e.g., "laser" light) to detect angular displacement of a mirror.*

d. Equipment for measuring surface roughness (including surface defects), by measuring optical scatter with a sensitivity of 0.5 nm or less (better).

***Note:***

*1-2.B.6. includes machine tools, other than those specified by 1-2.B.1., that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function.*

1-2.B.7. "Robots" having any of the following characteristics and specially designed controllers and "end-effectors" therefor:

a. Not used since 2017

b. Specially designed to comply with national safety standards applicable to potentially explosive munitions environments;

***Note:***

*1-2.B.7.b. does not apply to "robots" specially designed for paint-spraying booths.*

c. Specially designed or rated as radiation-hardened to withstand greater than $5 \times 10^3$ Gy (Si) without operational degradation; **or**

d. Specially designed to operate at altitudes exceeding 30,000 m.

1-2.B.8. ‘Compound rotary tables’ and “tilting spindles”, specially designed for machine tools, as follows:

a. Not used since 2017

b. Not used since 2017

c. ‘Compound rotary tables’ having all of the following:

1. Designed for machine tools for turning, milling or grinding; **and**
2. Two rotary axes designed to be coordinated simultaneously for “contouring control”;

***Technical Note:***

*A ‘compound rotary table’ is a table allowing the workpiece to rotate and tilt about two non-parallel axes.*

d. “Tilting spindles” having all of the following:

1. Designed for machine tools for turning, milling or grinding; **and**
2. Designed to be coordinated simultaneously for “contouring control”.

1-2.B.9. Spin-forming machines and flow-forming machines, which, according to the manufacturer’s technical specification, can be equipped with “numerical control” units or a computer control and having all of the following:

a. Three or more axes which can be coordinated simultaneously for “contouring control”; **and**

b. A roller force more than 60 kN.

***Technical Note:***

*For the purpose of 1-2.B.9., machines combining the function of spin-forming and flow-forming are regarded as flow-forming machines.*

## 1-2.C. MATERIALS

None

## 1-2.D. SOFTWARE

1-2.D.1. “Software”, other than that specified by 1-2.D.2., as follows:

a. “Software” specially designed or modified for the “development” or “production” of equipment specified by 1-2.A. or 1-2.B.;

b. “Software” specially designed or modified for the “use” of equipment specified by 1-2.A.1.c., 1-2.B.1., or 1-2.B.3. to 1-2.B.9.

***Note:***

*1-2.D.1. does not apply to part programming “software” that generates “numerical control” codes for machining various parts.*

1-2.D.2. “Software” for electronic devices, even when residing in an electronic device or system, enabling such devices or systems to function as a “numerical control” unit, capable of co-ordinating simultaneously more than 4 axes for “contouring control”.

***Note 1:***

*1-2.D.2. does not apply to “software” specially designed or modified for the operation of items not specified by Category 2.*

***Note 2:***

*1-2.D.2. does not apply to "software" for items specified by 1-2.B.2. See 1-2.D.1.and 1-2.D.3. for "software" for items specified by 1-2.B.2.*

***Note 3:***

*1-2.D.2. does not apply to "software" that is exported with, and the minimum necessary for the operation of, items not specified by Category 2.*

1-2.D.3. "Software", designed or modified for the operation of equipment specified by 1-2.B.2., that converts optical design, workpiece measurements and material removal functions into "numerical control" commands to achieve the desired workpiece form.

## 1-2.E. TECHNOLOGY

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

***Note:***

*1-2.E.1. includes "technology" for the integration of probe systems into coordinate measurement machines specified by 1-2.B.6.a.*

1-2.E.2. "Technology" according to the General Technology Note for the "production" of equipment specified by 1-2.A. or 1-2.B.

1-2.E.3. Other "technology", as follows:

a. Not used since 2017

b. "Technology" for metal-working manufacturing processes, as follows:

1. "Technology" for the design of tools, dies or fixtures specially designed for any of the following processes:

a. "Superplastic forming";

b. "Diffusion bonding"; **or**

c. 'Direct-acting hydraulic pressing';

2. Technical data consisting of process methods or parameters as listed below used to control:

a. "Superplastic forming" of aluminium alloys, titanium alloys or "superalloys":

1. Surface preparation;

2. Strain rate;

3. Temperature;

4. Pressure;

b. "Diffusion bonding" of "superalloys" or titanium alloys:

1. Surface preparation;

2. Temperature;

3. Pressure;

c. 'Direct-acting hydraulic pressing' of aluminium alloys or titanium alloys:

1. Pressure;

2. Cycle time;

d. 'Hot isostatic densification' of titanium alloys, aluminium alloys or "superalloys":

1. Temperature;

2. Pressure;
3. Cycle time;

***Technical Notes:***

1. *'Direct-acting hydraulic pressing' is a deformation process which uses a fluid-filled flexible bladder in direct contact with the workpiece.*
2. *'Hot isostatic densification' is a process of pressurising a casting at temperatures exceeding 375 K (102° C) in a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal force in all directions to reduce or eliminate internal voids in the casting.*

c. "Technology" for the "development" or "production" of hydraulic stretch-forming machines and dies therefor, for the manufacture of airframe structures;

d. Not used since 2017

e. "Technology" for the "development" of integration "software" for incorporation of expert systems for advanced decision support of shop floor operations into "numerical control" units;

f. "Technology" for the application of inorganic overlay coatings or inorganic surface modification coatings (specified in column 3 of the following table) to non-electronic substrates (specified in column 2 of the following table), by processes specified in column 1 of the following table and defined in the Technical Note.

***N.B.:***

*This Table should be read to specify the "technology" for 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 included for the application of 'silicides' to 'Carbon-carbon, Ceramic and Metal "matrix" "composites" substrates, but are not included for the application of 'silicides' to 'Cemented tungsten carbide (16), Silicon carbide (18)' substrates. In the second case, the resultant coating is not listed in the paragraph under column 3 directly across from the paragraph under column 2 listing 'Cemented tungsten carbide (16), Silicon carbide (18)'.*

TABLE - DEPOSITION TECHNIQUES

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

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

| Coating Process (1)* | Substrate | Resultant Coating |
|---|---|---|
| | | Modified zirconia (12)<br>Mixtures thereof (4) |
| B.1. (con't) | Carbon-carbon, Ceramic and Metal "matrix" "composites" | Silicides<br>Carbides<br>Refractory metals<br>Mixtures thereof (4)<br>Dielectric layers (15)<br>Boron nitride |
| | Cemented tungsten carbide (16)<br>Silicon carbide (18) | Carbides<br>Tungsten<br>Mixtures thereof (4)<br>Dielectric layers (15) |
| | Molybdenum and Molybdenum alloys | Dielectric layers (15) |
| | Beryllium and Beryllium alloys | Dielectric layers (15)<br>Borides<br>Beryllium |
| | Sensor window materials (9) | Dielectric layers (15) |
| | Titanium alloys (13) | Borides<br>Nitrides |
| B.2. Ion assisted resistive heating Physical Vapour Deposition (PVD) (Ion Plating) | Ceramics (19) and Low-expansion glasses (14) | Dielectric layers (15)<br>Diamond-like carbon (17) |
| | Carbon-carbon, Ceramic and Metal "matrix" "composites" | Dielectric layers (15) |
| | Cemented tungsten carbide (16)<br>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)<br>Diamond-like carbon (17) |
| B.3. Physical Vapour Deposition (PVD): "Laser" Vaporization | Ceramics (19) and Low-expansion glasses (14) | Silicides<br>Dielectric layers (15)<br>Diamond-like carbon (17) |
| | Carbon-carbon, Ceramic and Metal "matrix" "composites" | Dielectric layers (15) |
| | Cemented tungsten carbide (16)<br>Silicon carbide | Dielectric layers (15) |

| Coating Process (1)* | Substrate | Resultant Coating |
|---|---|---|
| | Molybdenum and Molybdenum alloys | Dielectric layers (15) |
| B.3. (con't) | Beryllium and Beryllium alloys | Dielectric layers (15) |
| | Sensor window materials (9) | Dielectric layers (15)<br>Diamond-like carbon (17) |
| B.4. Physical Vapour Deposition (PVD): Cathodic Arc Discharge | "Superalloys" | Alloyed silicides<br>Alloyed aluminides (2)<br>MCrAlX (5) |
| | Polymers (11) and Organic "matrix" "composites" | Borides<br>Carbides<br>Nitrides<br>Diamond-like carbon (17) |
| C. Pack cementation (see A above for out-of-pack cementation) (10) | Carbon-carbon, Ceramic and Metal "matrix" "composites" | Silicides<br>Carbides<br>Mixtures thereof (4) |
| | Titanium alloys (13) | Silicides<br>Aluminides<br>Alloyed aluminides (2) |
| | Refractory metals and alloys (8) | Silicides<br>Oxides |
| D. Plasma spraying | "Superalloys" | MCrAlX (5)<br>Modified zirconia (12)<br>Mixtures thereof (4)<br>Abradable Nickel-Graphite<br>Abradable materials containing Ni-Cr-Al<br>Abradable Al-Si-Polyester<br>Alloyed aluminides (2) |
| | Aluminium alloys (6) | MCrAlX (5)<br>Modified zirconia (12)<br>Silicides<br>Mixtures thereof (4) |
| | Refractory metals and alloys (8) | Aluminides<br>Silicides<br>Carbides |
| | Corrosion resistant steel (7) | MCrAlX (5)<br>Modified zirconia (12)<br>Mixtures thereof (4) |
| | Titanium alloys (13) | Carbides<br>Aluminides<br>Silicides |

| Coating Process (1)* | Substrate | Resultant Coating |
|---|---|---|
| | | Alloyed aluminides (2)<br>Abradable Nickel-Graphite<br>Abradable materials containing Ni-Cr-Al<br>Abradable Al-Si-Polyester |
| E. Slurry Deposition | Refractory metals and alloys (8) | Fused silicides<br>Fused aluminides except for resistance heating elements |
| | Carbon-carbon, Ceramic and Metal “matrix” “composites” | Silicides<br>Carbides<br>Mixtures thereof (4) |
| F. Sputter Deposition | “Superalloys” | Alloyed silicides<br>Alloyed aluminides (2)<br>Noble metal modified aluminides (3)<br>MCrAlX (5)<br>Modified zirconia (12)<br>Platinum<br>Mixtures thereof (4) |
| | Ceramics (19) and Low-expansion glasses (14) | Silicides<br>Platinum<br>Mixtures thereof (4)<br>Dielectic layers (15)<br>Diamond-like carbon (17) |
| | Titanium alloys (13) | Borides<br>Nitrides<br>Oxides<br>Silicides<br>Aluminides<br>Alloyed aluminides (2)<br>Carbides |
| | Carbon-carbon, Ceramic and Metal “matrix” “composites” | Silicides<br>Carbides<br>Refractory metals<br>Mixtures thereof (4)<br>Dielectric layers (15)<br>Boron nitride |
| | Cemented tungsten carbide (16)<br>Silicon carbide (18) | Carbides<br>Tungsten<br>Mixtures thereof (4)<br>Dielectric layers (15)<br>Boron nitride |
| | Molybdenum and Molybdenum alloys | Dielectric layers (15) |

| Coating Process (1)* | Substrate | Resultant Coating |
|---|---|---|
| | Beryllium and Beryllium alloys | Borides<br>Dielectric layers (15)<br>Beryllium |
| | Sensor window materials (9) | Dielectric layers (15)<br>Diamond-like carbon (17) |
| F. (con't) | Refractory metals and alloys (8) | Aluminides<br>Silicides<br>Oxides<br>Carbides |
| G. Ion Implantation | High temperature bearing steels | Additions of Chromium Tantalum or Niobium (Columbium) |
| | Titanium alloys (13) | Borides<br>Nitrides |
| | Beryllium and Beryllium alloys | Borides |
| | Cemented tungsten carbide (16) | Carbides<br>Nitrides |

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% by weight in various proportions and combinations, except:
   a. CoCrAlY coatings which contain less than 22% by weight of chromium, less than 7% by weight of aluminium and less than 2 weight percent of yttrium;
   b. CoCrAlY coatings which contain 22 to 24% by weight of chromium, 10 to 12% by weight of aluminium and 0.5 to 0.7% by weight of yttrium; **or**
   c. NiCrAlY coatings which contain 21 to 23% by weight of chromium, 10 to 12% by weight of aluminium and 0.9 to1.1% by weight 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. Category 2 does not include “technology” for single-step pack cementation of solid airfoils.
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 included.
13. ‘Titanium alloys’ refers only to aerospace alloys having an ultimate tensile strength of 900 MPa or more measured at 293 K (20° C).
14. ‘Low-expansion glasses’ refers to glasses which have a coefficient of thermal expansion of $1 \times 10^{-7}$ $K^{-1}$ or less measured at 293 K (20° C).
15. ‘Dielectric layers’ are coatings constructed of multi-layers of insulator materials in which the interference properties of a design composed of materials of various refractive indices are used to reflect, transmit or absorb various wavelength bands. Dielectric layers refers to more than four dielectric layers or dielectric/metal “composite” layers.
16. ‘Cemented tungsten carbide’ does not include cutting and forming tool materials consisting of tungsten carbide/(cobalt, nickel), titanium carbide/(cobalt, nickel), chromium carbide/nickel-chromium and chromium carbide/nickel.
17. “Technology” for depositing diamond-like carbon on any of the following is not included: magnetic disk drives and heads, equipment for the manufacture of disposables, valves for faucets, acoustic diaphragms for speakers, engine parts for automobiles, cutting tools, punching-pressing dies, office automation equipment, microphones, medical devices or moulds, for casting or moulding of plastics, manufactured from alloys containing less than 5% beryllium.
18. ‘Silicon carbide’ does not include cutting and forming tool materials.
19. Ceramic substrates, as used in this entry, does not include ceramic materials containing 5% by weight, or greater, clay or cement content, either as separate constituents or in combination.

TABLE - DEPOSITION TECHNIQUES - TECHNICAL 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;
4. Cathodic Arc Deposition employs a consumable cathode of the material which forms the coating and has an arc discharge established on the surface by a momentary contact of a ground trigger. Controlled motion of arcing erodes the cathode surface creating a highly ionized plasma. The anode can be either a cone attached to the periphery of the cathode, through an insulator, or the chamber. Substrate biasing is used for non line-of-sight deposition;

   ***N.B.:***

   *This definition does not include random cathodic arc deposition with non-biased substrates.*
5. Ion Plating is a special modification of a general TE-PVD process in which a plasma or an ion source is used to ionize the species to be deposited, and a negative bias is applied to the substrate in order to facilitate the extraction of the species from the plasma. The introduction of reactive species, evaporation of solids within the process chamber, and the use of monitors to provide in-process measurement of optical characteristics and thicknesses of coatings are ordinary modifications of the process.

C. Pack Cementation is a surface modification coating or overlay coating process wherein a substrate is immersed in a powder mixture (a pack), that consists of:

1. The metallic powders that are to be deposited (usually aluminium, chromium, silicon or combinations thereof);
2. An activator (normally a halide salt); and
3. An inert powder, most frequently alumina.

The substrate and powder mixture is contained within a retort which is heated to between 1,030 K (757° C) and 1,375 K (1,102° C) for sufficient time to deposit the coating.

D. Plasma Spraying is an overlay coating process wherein a gun (spray torch) which produces and controls a plasma accepts powder or wire coating materials, melts them and propels them

towards a substrate, whereon an integrally bonded coating is formed. Plasma spraying constitutes either low pressure plasma spraying or high velocity plasma spraying.

***N.B. 1:***

*Low pressure means less than ambient atmospheric pressure.*

***N.B. 2:***

*High velocity refers to nozzle-exit gas velocity exceeding 750 m/s calculated at 293 K (20° C) at 0.1 MPa.*

E. Slurry Deposition is a surface modification coating or overlay coating process wherein a metallic or ceramic powder with an organic binder is suspended in a liquid and is applied to a substrate by either spraying, dipping or painting, subsequent air or oven drying, and heat treatment to obtain the desired coating.

F. Sputter Deposition is an overlay coating process based on a momentum transfer phenomenon, wherein positive ions are accelerated by an electric field towards the surface of a target (coating material). The kinetic energy of the impacting ions is sufficient to cause target surface atoms to be released and deposited on an appropriately positioned substrate.

***N.B. 1:***

*The Table refers only to triode, magnetron or reactive sputter deposition which is used to increase adhesion of the coating and rate of deposition and to radio frequency (RF) augmented sputter deposition used to permit vaporisation of non-metallic coating materials.*

***N.B. 2:***

*Low-energy ion beams (less than 5 keV) can be used to activate the deposition.*

G. Ion Implantation is a surface modification coating process in which the element to be alloyed is ionized, accelerated through a potential gradient and implanted into the surface region of the substrate. This includes processes in which ion implantation is performed simultaneously with electron beam physical vapour deposition or sputter deposition.

<u>TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING</u>

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

1. Technical information 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. Technical information 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. Technical information for post deposition treatments of the coated substrates listed in the Table, as follows:
    a. Shot peening parameters, as follows:
        1. Shot composition;
        2. Shot size;
        3. Shot velocity;
    b. Post shot peening cleaning parameters;
    c. Heat treatment cycle parameters, as follows:
        1. Atmosphere parameters, as follows:
            a. Composition of the atmosphere;
            b. Pressure of the atmosphere;
        2. Time-temperature cycles;
    d. Post heat treatment visual and macroscopic criteria for acceptance of the coated substrates;
4. Technical information 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. Technical information and parameters related to specific coating and surface modification processes listed in the Table, as follows:
   a. For Chemical Vapour Deposition (CVD):
      1. Coating source composition and formulation;
      2. Carrier gas composition;
      3. Substrate temperature;
      4. Time-temperature-pressure cycles;
      5. Gas control and part manipulation;
   b. For Thermal Evaporation - Physical Vapour Deposition (PVD):
      1. Ingot or coating material source composition;
      2. Substrate temperature;
      3. Reactive gas composition;
      4. Ingot feed rate or material vaporisation rate;
      5. Time-temperature-pressure cycles;
      6. Beam and part manipulation;
      7. “Laser” parameters, as follows:
         a. Wave length;
         b. Power density;
         c. Pulse length;
         d. Repetition ratio;
         e. Source;
   c. For Pack Cementation:
      1. Pack composition and formulation;
      2. Carrier gas composition;
      3. Time-temperature-pressure cycles;
   d. For Plasma Spraying:
      1. Powder composition, preparation and size distributions;
      2. Feed gas composition and parameters;
      3. Substrate temperature;
      4. Gun power parameters;
      5. Spray distance;
      6. Spray angle;
      7. Cover gas composition, pressure and flow rates;
      8. Gun control and part manipulation;
   e. For Sputter Deposition:
      1. Target composition and fabrication;
      2. Geometrical positioning of part and target;
      3. Reactive gas composition;
      4. Electrical bias;
      5. Time-temperature-pressure cycles;
      6. Triode power;

7. Part manipulation;

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

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

# CATEGORY 3: ELECTRONICS

## 1-3.A. SYSTEMS, EQUIPMENT AND COMPONENTS

***Note 1:***

*The status of equipment and components described in 1-3.A., other than those described in 1-3.A.1.a.3. to 1-3.A.1.a.10., or 1-3.A.1.a.12. to 1-3.A.1.a.14., which are specially designed for or which have the same functional characteristics as other equipment is determined by the status of the other equipment.*

***Note 2:***

*The status of integrated circuits described in 1-3.A.1.a.3. to 1-3.A.1.a.9., or 1-3.A.1.a.12. to 1-3.A.1.a.14., which are unalterably programmed or designed for a specific function for another equipment is determined by the status of the other equipment.*

***N.B.:***

*When the manufacturer or applicant cannot determine the status of the other equipment, the status of the integrated circuits is determined in 1-3.A.1.a.3. to 1-3.A.1.a.9., and 1-3.A.1.a.12. to 1-3.A.1.a.14.*

***Note 3:***

*The status of wafers (finished or unfinished), in which the function has been determined, is to be evaluated against the parameters of 1-3.A.1.a., 1-3.A.1.b., 1-3.a.1.d., 1-3.A.1.e.4., 1-3.A.1.g., 1-3.A.1.h., or 1-3.A.1.i.*

1-3.A.1. Electronic items as follows:

1-3.A.1.a. General purpose integrated circuits, as follows:

***Note:***

*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";*

*-"Three dimensional integrated circuits";*

*-"Monolithic Microwave Integrated Circuits" ("MMICs").*

1-3.A.1.a.1. Integrated circuits designed or rated as radiation hardened to withstand any of the following:

a. A total dose of $5 \times 10^3$ Gy (Si) or higher;

b. A dose rate upset of $5 \times 10^6$ Gy (Si)/s or higher; **or**

c. A fluence (integrated flux) of neutrons (1 MeV equivalent) of $5 \times 10^{13}$ n/cm$^2$ or higher on silicon, or its equivalent for other materials;

***Note:***

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

2. "Microprocessor microcircuits", "microcomputer microcircuits", microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, integrated circuits that contain analogue-to-digital converters and store or process the digitized data, digital-to-analogue converters, electro-optical or "optical integrated circuits" designed for "signal processing", field programmable

logic devices, custom integrated circuits for which either the function is unknown or the status of the equipment in which the integrated circuit will be used is unknown, Fast Fourier Transform (FFT) processors, Static Random-Access Memories (SRAMs) or 'non-volatile memories', having any of the following:

***Technical Note:***

*'Non-volatile memories' are memories with data retention over a period of time after a power shutdown.*

a. Rated for operation at an ambient temperature above 398 K (+125° C);

b. Rated for operation at an ambient temperature below 218 K (-55° C); **or**

c. Rated for operation over the entire ambient temperature range from 218 K (-55° C) to 398 K (+125° C);

***Note:***

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

3. "Microprocessor microcircuits", "microcomputer microcircuits" and microcontroller microcircuits, manufactured from a compound semiconductor and operating at a clock frequency exceeding 40 MHz;

***Note:***

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

4. Not used since 2010

5. Analogue-to-Digital Converter (ADC) and Digital-to-Analogue Converter (DAC) integrated circuits, as follows:

a. ADCs having any of the following:

1. A resolution of 8 bit or more, but less than 10 bit, with a "sample rate" greater than 1.3 Giga Samples Per Second (GSPS);
2. A resolution of 10 bit or more, but less than 12 bit, with a "sample rate" greater than 600 Mega Samples Per Second (MSPS);
3. A resolution of 12 bit or more, but less than 14 bit, with a "sample rate" greater than 400 MSPS;
4. A resolution of 14 bit or more, but less than 16 bit, with a "sample rate" greater than 250 MSPS; **or**
5. A resolution of 16 bit or more with a "sample rate"greater than 65 MSPS;

***N.B.:***

*For integrated circuits that contain analogue-to-digital converters and store or process the digitized data, see 1-3.A.1.a.14.*

***Technical Notes:***

1. *A resolution of n bit corresponds to a quantisation of $2^n$ levels.*
2. *The resolution of the ADC is the number of bits of the digital output that represents the measured analogue input. Effective Number of Bits (ENOB) is not used to determine the resolution of the ADC.*
3. *For "multiple channel ADCs", the "sample rate"is not aggregated and the "sample rate"is the maximum rate of any single channel.*

4. *For "interleaved ADCs" or for "multiple channel ADCs" that are specified to have an interleaved mode of operation, the "sample rates"are aggregated and the "sample rate" is the maximum combined total rate of all of the interleaved channels.*

b. Digital-to-Analogue Converters (DAC) having any of the following:
   1. A resolution of 10 bit or more but less than 12 bit, with an 'adjusted update rate' exceeding 3,500 MSPS; **or**
   2. A resolution of 12 bit or more and having any of the following:
      a. An 'adjusted update rate' exceeding 1,250 MSPS but not exceeding 3,500 MSPS, and having any of the following:
         1. A settling time less than 9 ns to arrive at or within 0.024% of full scale from a full scale step; **or**
         2. A 'Spurious Free Dynamic Range' (SFDR) greater than 68 dBc (carrier) when synthesising a full scale analogue signal of 100 MHz or the highest full scale analogue signal frequency specified below 100 MHz; **or**
      b. An 'adjusted update rate' exceeding 3,500 MSPS;

***Technical Notes:***

1. *'Spurious Free Dynamic Range' (SFDR) is defined as the ratio of the RMS value of the carrier frequency (maximum signal component) at the input of the DAC to the RMS value of the next largest noise or harmonic distortion component at its output.*
2. *SFDR is determined directly from the specification table or from the characterisation plots of SFDR versus frequency.*
3. *A signal is defined to be full scale when its amplitude is greater than -3 dBfs (full scale).*
4. *'Adjusted update rate' for DACs:*
   a. *For conventional (non-interpolating) DACs, the 'adjusted update rate' is the rate at which the digital signal is converted to an analogue signal and the output analogue values are changed by the DAC. For DACs where the interpolation mode may be bypassed (interpolation factor of one), the DAC should be considered as a conventional (non-interpolating) DAC.*
   b. *For interpolating DACs (oversampling DACs), the 'adjusted update rate' is defined as the DAC update rate divided by the smallest interpolating factor. For interpolating DACs, the 'adjusted update rate' may be referred to by different terms including:*
      - *input data rate;*
      - *input word rate;*
      - *input sample rate;*
      - *maximum total input bus rate;*
      - *maximum DAC clock rate for DAC clock input.*

6. Electro-optical and "optical integrated circuits", designed for "signal processing" and having all of the following:
   a. One or more than one internal "laser" diode;
   b. One or more than one internal light detecting element; **and**
   c. Optical waveguides;

7. Field programmable logic devices having any of the following:
   a. A maximum number of single-ended digital input/outputs of greater than 700; **or**
   b. An ‘aggregate one-way peak serial transceiver data rate’ of 500 Gb/s or greater;

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

   ***N.B.:***
   *For integrated circuits having field programmable logic devices that are combined with an analogue-to-digital converter, see 1-3.A.1.a.14.*

   ***Technical Notes:***
   1. *Maximum number of digital input/outputs in 1-3.A.1.a.7.a. is also referred to as maximum user input/outputs or maximum available input/outputs, whether the integrated circuit is packaged or bare die.*
   2. *‘Aggregate one-way peak serial transceiver data rate’ is the product of the peak serial one-way transceiver data rate times the number of transceivers on the FPGA.*
8. Not used since 1999
9. Neural network integrated circuits;
10. Custom integrated circuits for which the function is unknown, or the status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:
    a. More than 1,500 terminals;
    b. A typical “basic gate propagation delay time” of less than 0.02 ns; **or**
    c. An operating frequency exceeding 3 GHz;
11. Digital integrated circuits, other than those described in 1-3.A.1.a.3. to 1-3.A.1.a.10. and 1-3.A.1.a.12., based upon any compound semiconductor and having any of the following:
    a. An equivalent gate count of more than 3,000 (2 input gates); **or**
    b. A toggle frequency exceeding 1.2 GHz;
12. Fast Fourier Transform (FFT) processors having a rated execution time for an N-point complex FFT of less than $(N \log_2 N)/20{,}480$ ms, where N is the number of points;

    ***Technical Note:***
    *When N is equal to 1,024 points, the formula in 1-3.A.1.a.12. gives an execution time of 500 µs.*
13. Direct Digital Synthesiser (DDS) integrated circuits having any of the following:
    a. A Digital-to-Analogue Converter (DAC) clock frequency of 3.5 GHz or more and a DAC resolution of 10 bit or more, but less than 12 bit; **or**
    b. A DAC clock frequency of 1.25 GHz or more and a DAC resolution of 12 bit or more;

***Technical Note:***

*The DAC clock frequency may be specified as the master clock frequency or the input clock frequency.*

14. Integrated circuits that perform or are programmable to perform all of the following:
    a. Analogue-to-digital conversions meeting any of the following:
        1. A resolution of 8 bit or more, but less than 10 bit, with a "sample rate" greater than 1.3 Giga Samples Per Second (GSPS);
        2. A resolution of 10 bit or more, but less than 12 bit, with a "sample rate" greater than 1.0 GSPS;
        3. A resolution of 12 bit or more, but less than 14 bit, with a "sample rate" greater than 1.0 GSPS;
        4. A resolution of 14 bit or more, but less than 16 bit, with a "sample rate" greater than 400 Mega Samples Per Second (MSPS); **or**
        5. A resolution of 16 bit or more with a "sample rate" greater than 180 MSPS; **and**
    b. Any of the following:
        1. Storage of digitized data; **or**
        2. Processing of digitized data.

***N.B. 1:***

*For analogue-to-digital converter integrated circuits see 1-3.A.1.a.5.a.*

***N.B. 2:***

*For field programmable logic devices see 1-3.A.1.a.7.*

***Technical Notes:***

1. *A resolution of n bit corresponds to a quantisation of $2^n$ levels.*
2. *The resolution of the ADC is the number of bits of the digital output of the ADC that represents the measured analogue input. Effective Number of Bits (ENOB) is not used to determine the resolution of the ADC.*
3. *For integrated circuits with non-interleaving "multiple channel ADCs", the "sample rate" is not aggregated and the "sample rate" is the maximum rate of any single channel.*
4. *For integrated circuits with "interleaved ADCs" or with "multiple channel ADCs" that are specified to have an interleaved mode of operation, the "sample rates" are aggregated and the "sample rate" is the maximum combined total rate of all of the interleaved channels.*

1-3.A.1.b. Microwave or millimetre wave items, as follows:

***Technical Note:***

*For purposes of 1-3.A.1.b., the parameter peak saturated power output may also be referred to on product data sheets as output power, saturated power output, maximum power output, peak power output, or peak envelope power output.*

1. "Vacuum electronic devices" and cathodes, as follows:

***Note 1:***

*1-3.A.1.b.1. does not apply to "vacuum electronic devices" designed or rated for operation in any frequency bands and having all of the following:*

*a. Does not exceed 31.8 GHz;* ***and***

*b. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

***Note 2:***

*1-3.A.1.b.1. does not apply to non-"space-qualified" "vacuum electronic devices" having all of the following:*

*a. An average output power equal to or less than 50 W;* ***and***

*b. Designed or rated for operation in any frequency band and having all of the following:*

*1. Exceeds 31.8 GHz but does not exceed 43.5 GHz;* ***and***

*2. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

a. Travelling-wave "vacuum electronic devices", pulsed or continuous wave, as follows:

1. Devices operating at frequencies exceeding 31.8 GHz;
2. Devices having a cathode heater with a turn on time to rated RF power of less than 3 seconds;
3. Coupled cavity devices, or derivatives thereof, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW;
4. Devices based on helix, folded waveguide, or serpentine waveguide circuits, or derivatives thereof, having any of the following:
   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;
   c. Being "space-qualified"; **or**
   d. Having a gridded electron gun;
5. Devices with a "fractional bandwidth" greater than or equal to 10%, with any of the following:
   a. An annular electron beam;
   b. A non-axisymmetric electron beam; **or**
   c. Multiple electron beams;

b. Crossed-field amplifier "vacuum electronic devices" with a gain of more than 17 dB;

c. Thermionic cathodes designed for "vacuum electronic devices" producing an emission current density at rated operating conditions exceeding 5 A/cm$^2$ or a pulsed (non-continuous) current density at rated operating conditions exceeding 10 A/cm$^2$;

d. "Vacuum electronic devices" with the capability to operate in a 'dual mode'.

***Technical Note:***

*'Dual mode' means the "vacuum electronic device" beam current can be intentionally changed between continuous-wave and pulsed mode operation by use of a grid and produces a peak pulse output power greater than the continuous-wave output power.*

2. "Monolithic Microwave Integrated Circuit" ("MMIC") amplifiers that are any of the following:

***N.B.:***

*For "MMIC" amplifiers that have an integrated phase shifter see 1-3.A.1.b.12.*

a. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz with a "fractional bandwidth" greater than 15%, and having any of the following:
   1. A peak saturated power output greater than 75 W (48.75 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
   2. A peak saturated power output greater than 55 W (47.4 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
   3. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; **or**
   4. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;

b. Rated for operation at frequencies exceeding 6.8 GHz up to and including 16 GHz with a "fractional bandwidth" greater than 10%, and having any of the following:
   1. A peak saturated power output greater than 10 W (40 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz; **or**
   2. A peak saturated power output greater than 5 W (37 dBm) at any frequency exceeding 8.5 GHz up to and including 16 GHz;

c. Rated for operation with a peak saturated power output greater than 3 W (34.77 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz, and with a "fractional bandwidth" of greater than 10%;

d. Rated for operation with a peak saturated power output greater than 0.1n W (-70 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;

e. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz, and with a "fractional bandwidth" of greater than 10%;

f. Rated for operation with a peak saturated power output greater than 31.62 mW (15 dBm) at any frequency exceeding 43.5 GHz up to and including 75 GHz, and with a "fractional bandwidth" of greater than 10%;

g. Rated for operation with a peak saturated power output greater than 10 mW (10 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a "fractional bandwidth" of greater than 5%; **or**

h. Rated for operation with a peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 90 GHz;

***Note 1:***

*Not used since 2010*

***Note 2:***

*The status of the "MMIC" whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 1-3.A.1.b.2.a. through 1-3.A.1.b.2.h., is determined by the lowest peak saturated power output threshold.*

***Note 3:***

*Notes 1 and 2 in 1-3.A. mean that 1-3.A.1.b.2. does not apply to "MMICs" if they are specially designed for other applications, e.g., telecommunications, radar, automobiles.*

3. Discrete microwave transistors that are any of the following:
   a. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz and having any of the following:
      1. A peak saturated power output greater than 400 W (56 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
      2. A peak saturated power output greater than 205 W (53.12 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
      3. A peak saturated power output greater than 115 W (50.61 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; **or**
      4. A peak saturated power output greater than 60 W (47.78 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;
   b. Rated for operation at frequencies exceeding 6.8 GHz up to and including 31.8 GHz and having any of the following:
      1. A peak saturated power output greater than 50 W (47 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz;
      2. A peak saturated power output greater than 15 W (41.76 dBm) at any frequency exceeding 8.5 GHz up to and including 12 GHz;
      3. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 12 GHz up to and including 16 GHz; **or**
      4. A peak saturated power output greater than 7 W (38.45 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz;
   c. Rated for operation with a peak saturated power output greater than 0.5 W (27 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;
   d. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz;
   e. Rated for operation with a peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 43.5 GHz; **or**
   f. Other than those specified by 1-3.A.1.b.3.a. to 1-3.A.1.b.3.e. and rated for operation with a peak saturated power output greater than 5 W (37.0 dBm) at all frequencies exceeding 8.5 GHz up to and including 31.8 GHz;

***Note 1:***

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

***Note 2:***

*1-3.A.1.b.3. includes bare dice, dice mounted on carriers, or dice mounted in packages. Some discrete transistors may also be referred to as power amplifiers, but the status of these discrete transistors is determined by 1-3.A.1.b.3.*

4. Microwave solid state amplifiers and microwave assemblies/modules containing microwave solid state amplifiers, that are any of the following:
   a. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz with a “fractional bandwidth” greater than 15%, and having any of the following:
      1. A peak saturated power output greater than 500 W (57 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
      2. A peak saturated power output greater than 270 W (54.3 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
      3. A peak saturated power output greater than 200 W (53 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; **or**
      4. A peak saturated power output greater than 90 W (49.54 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;
   b. Rated for operation at frequencies greater than 6.8 GHz up to and including 31.8 GHz with a “fractional bandwidth” greater than 10%, and having any of the following:
      1. A peak saturated power output greater than 70 W (48.54 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz;
      2. A peak saturated power output greater than 50 W (47 dBm) at any frequency exceeding 8.5 GHz up to and including 12 GHz;
      3. A peak saturated power output greater than 30 W (44.77 dBm) at any frequency exceeding 12 GHz up to and including 16 GHz; **or**
      4. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz;
   c. Rated for operation with a peak saturated power output greater than 0.5 W (27 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;
   d. Rated for operation with a peak saturated power output greater than 2 W (33 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz, and with a “fractional bandwidth” of greater than 10%;
   e. Rated for operation at frequencies exceeding 43.5 GHz and having any of the following:
      1. A peak saturated power output greater than 0.2 W (23 dBm) at any frequency exceeding 43.5 GHz up to and including 75 GHz, and with a “fractional bandwidth” of greater than 10%;
      2. A peak saturated power output greater than 20 mW (13 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a “fractional bandwidth” of greater than 5%; **or**
      3. A peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 90 GHz; **or**
   f. Not used since 2016

   ***N.B. 1:***
   *For “MMIC” amplifiers see 1-3.A.1.b.2.*

   ***N.B. 2:***
   *For ‘transmit/receive modules’ and ‘transmit modules’ see 1-3.A.1.b.12.*

***N.B. 3:***

*For converters and harmonic mixers, designed to extend the operating or frequency range of signal analysers, signal generators, network analysers or microwave test receivers, see 1-3.A.1.b.7.*

***Note 1:***

*Not used since 2010*

***Note 2:***

*The status of an item whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 1-3.A.1.b.4.a. through 1-3.A.1.b.4.e., is determined by the lowest peak saturated power output threshold.*

5. Electronically or magnetically tunable band-pass or band-stop filters, having more than 5 tunable resonators capable of tuning across a 1.5:1 frequency band ($f_{max}/f_{min}$) in less than 10 µs and 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. Not used since 2003
7. Converters and harmonic mixers, that are any of the following:
   a. Designed to extend the frequency range of "signal analysers" beyond 90 GHz;
   b. Designed to extend the operating range of signal generators as follows:
      1. Beyond 90 GHz;
      2. To an output power greater than 100 mW (20 dBm) anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
   c. Designed to extend the operating range of network analysers as follows:
      1. Beyond 110 GHz;
      2. To an output power greater than 31.62 mW (15 dBm) anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
      3. To an output power greater than 1 mW (0 dBm) anywhere within the frequency range exceeding 90 GHz but not exceeding 110 GHz; **or**
   d. Designed to extend the frequency range of microwave test receivers beyond 110 GHz.
8. Microwave power amplifiers containing "vacuum electronic devices" specified by 1-3.A.1.b.1. and having all of the following:
   a. Operating frequencies above 3 GHz;
   b. An average output power to mass ratio exceeding 80 W/kg; **and**
   c. A volume of less than 400 $cm^3$;

***Note:***

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

9. Microwave Power Modules (MPMs) consisting of, at least, a travelling-wave "vacuum electronic device", a "Monolithic Microwave Integrated

Circuit" ("MMIC") and an integrated electronic power conditioner and having all of the following:

a. A 'turn-on time' from off to fully operational in less than 10 seconds;

b. A volume less than the maximum rated power in Watts multiplied by 10 $cm^3/W$; **and**

c. An "instantaneous bandwidth" greater than 1 octave ($f_{max.} > 2f_{min.}$) and having any of the following:

   1. For frequencies equal to or less than 18 GHz, an RF output power greater than 100 W; **or**

   2. A frequency greater than 18 GHz;

***Technical Notes:***

*1. To calculate the volume in 1-3.A.1.b.9.b., the following example is provided: for a maximum rated power of 20 W, the volume would be: 20 W x 10 $cm^3/W$ = 200 $cm^3$.*

*2. The 'turn-on time' in 1-3.A.1.b.9.a. refers to the time from fully-off to fully operational, i.e., it includes the warm-up time of the MPM.*

10. Oscillators or oscillator assemblies, specified to operate with a single sideband (SSB) phase noise, in dBc/Hz, less (better) than $-(126+20 \log_{10}F-20 \log_{10}f)$ anywhere within the range of $10 \text{ Hz} \leq F \leq 10 \text{ kHz}$;

***Technical Note:***

*In 1-3.A.1.b.10., F is the offset from the operating frequency in Hz and f is the operating frequency in MHz.*

11. 'Frequency synthesiser' "electronic assemblies" having a "frequency switching time" as specified by any of the following:

a. Less than 143 ps;

b. Less than 100 µs for any frequency change exceeding 2.2 GHz within the synthesised frequency range exceeding 4.8 GHz but not exceeding 31.8 GHz;

c. Not used since 2016

d. Less than 500 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 31.8 GHz but not exceeding 37 GHz;

e. Less than 100 µs for any frequency change exceeding 2.2 GHz within the synthesised frequency range exceeding 37 GHz but not exceeding 90 GHz; **or**

f. Not used since 2016

g. Less than 1 ms within the synthesised frequency range exceeding 90 GHz;

***Technical Note:***

*A 'frequency synthesiser' is any kind of frequency source, regardless of the actual technique used, providing a multiplicity of simultaneous or alternative output frequencies, from one or more outputs, controlled by, derived from or disciplined by a lesser number of standard (or master) frequencies.*

***N.B.:***

*For general purpose "signal analysers", signal generators, network analysers and microwave test receivers, see 1-3.A.2.c., 1-3.A.2.d., 1-3.A.2.e. and 1-3.A.2.f., respectively.*

12. 'Transmit/receive modules', 'transmit/receive MMICs', 'transmit modules', and 'transmit MMICs', rated for operation at frequencies above 2.7 GHz and having all of the following:
    a. A peak saturated power output (in watts), $P_{sat}$, greater than 505.62 divided by the maximum operating frequency (in GHz) squared [$P_{sat}$>505.62 W*GHz$^2$/$f_{GHz}^2$] for any channel;
    b. A "fractional bandwidth" of 5% or greater for any channel;
    c. Any planar side with length d (in cm) equal to or less than 15 divided by the lowest operating frequency in GHz [$d \leq 15cm*GHz*N/f_{GHz}$] where N is the number of transmit or transmit/receive channels; **and**
    d. An electronically variable phase shifter per channel.

***Technical Notes***

*1. A 'transmit/receive module': is a multifunction "electronic assembly" that provides bi-directional amplitude and phase control for transmission and reception of signals.*

*2. A 'transmit module': is an "electronic assembly" that provides amplitude and phase control for transmission of signals.*

*3. A 'transmit/receive MMIC': is a multifunction "MMIC" that provides bi-directional amplitude and phase control for transmission and reception of signals.*

*4. A 'transmit MMIC': is a "MMIC" that provides amplitude and phase control for transmission of signals.*

*5. 2.7 GHz should be used as the lowest operating frequency ($f_{GHz}$) in the formula in 1-3.A.1.b.12.c. for transmit/receive or transmit modules that have a rated operation range extending downward to 2.7 GHz and below [$d \leq 15cm*GHz*N/2.7\ GHz$].*

*6. 1-3.A.1.b.12. applies to 'transmit/receive modules' or 'transmit modules' with or without a heat sink. The value of d in 1-3.A.1.b.12.c. does not include any portion of the 'transmit/receive module' or 'transmit module' that functions as a heat sink.*

*7. 'Transmit/receive modules', or 'transmit modules', or 'transmit/receive MMICs' or 'transmit MMICs' may or may not have N integrated radiating antenna elements where N is the number of transmit or transmit/receive channels.*

1-3.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, having any of the following:
    a. A carrier frequency exceeding 6 GHz;
    b. A carrier frequency exceeding 1 GHz, but not exceeding 6 GHz and having any of the following:
        1. A 'frequency side-lobe rejection' exceeding 65 dB;
        2. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
        3. A bandwidth greater than 250 MHz; **or**
        4. A dispersive delay of more than 10 µs; **or**

c. A carrier frequency of 1 GHz or less and having any of the following:
   1. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
   2. A dispersive delay of more than 10 µs; **or**
   3. A 'frequency side-lobe rejection' exceeding 65 dB and a bandwidth greater than 100 MHz;

***Technical Note:***

*'Frequency side-lobe rejection' is the maximum rejection value specified in data sheet.*

2. Bulk (volume) acoustic wave devices which permit the direct processing of signals at frequencies exceeding 6 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;

***Note:***

*1-3.A.1.c. does not apply to acoustic wave devices that are limited to a single band pass, low pass, high pass or notch filtering, or resonating function.*

1-3.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 and having 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;

1-3.A.1.e. High energy devices as follows:

1. 'Cells' as follows:
   a. 'Primary cells' having any of the following at 20° C:
      1. 'Energy density' exceeding 550 Wh/kg and a 'continuous power density' exceeding 50 W/kg; **or**
      2. 'Energy density' exceeding 50 Wh/kg and a 'continuous power density' exceeding 350 W/kg;
   b. 'Secondary cells' having an 'energy density' exceeding 350 Wh/kg at 20° C;

***Technical Notes:***

*1. For the purpose of 1-3.A.1.e.1., 'energy density' (Wh/kg) is calculated from the nominal voltage multiplied by the nominal capacity in ampere-hours (Ah) divided by the mass in kilograms. If the nominal capacity is not stated, energy density is calculated from the nominal voltage squared then multiplied by the discharge duration in hours divided by the discharge load in Ohms and the mass in kilograms.*

*2. For the purpose of 1-3.A.1.e.1., a 'cell' is defined as an electrochemical device, which has positive and negative electrodes, an electrolyte, and is a source of electrical energy. It is the basic building block of a battery.*

*3. For the purpose of 1-3.A.1.e.1.a., a 'primary cell' is a 'cell' that is not designed to be charged by any other source.*

4. *For the purpose of 1-3.A.1.e.1.b., a 'secondary cell' is a 'cell' that is designed to be charged by an external electrical source.*
5. *For the purpose of 1-3.A.1.e.1.a., 'continuous power density' (W/kg) is calculated from the nominal voltage multiplied by the specified maximum continuous discharge current in ampere (A) divided by the mass in kilograms. 'Continuous power density' is also referred to as specific power.*

***Note:***

*1-3.A.1.e. does not apply to batteries, including single-cell batteries.*

2. High energy storage capacitors as follows:
   a. Capacitors with a repetition rate of less than 10 Hz (single shot capacitors) and having all of the following:
      1. A voltage rating equal to or more than 5 kV;
      2. An energy density equal to or more than 250 J/kg; **and**
      3. A total energy equal to or more than 25 kJ;
   b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) and 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;

   ***N.B.:***

   *See also the Munitions List.*

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

   ***Note:***

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

   a. Energy delivered during the discharge exceeding 10 kJ in the first second;
   b. Inner diameter of the current carrying windings of more than 250 mm; **and**
   c. Rated for a magnetic induction of more than 8 T or "overall current density" in the winding of more than 300 A/mm$^2$;

4. Solar cells, cell-interconnect-coverglass (CIC) assemblies, solar panels, and solar arrays, which are "space-qualified", having a minimum average efficiency exceeding 20% at an operating temperature of 301 K (28° C) under simulated 'AM0' illumination with an irradiance of 1,367 Watts per square meter (W/m$^2$);

   ***Technical Note:***

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

1-3.A.1.f. Rotary input type absolute position encoders having an "accuracy" equal to or less (better) than 1.0 second of arc and specially designed encoder rings, discs or scales therefor;

1-3.A.1.g. Solid-state pulsed power switching thyristor devices and ‘thyristor modules’, using either electrically, optically, or electron radiation controlled switch methods and having any of the following:

1. A maximum turn-on current rate of rise (di/dt) greater than 30,000 A/μs and off-state voltage greater than 1,100 V; **or**
2. A maximum turn-on current rate of rise (di/dt) greater than 2,000 A/μs and having all of the following:
   a. An off-state peak voltage equal to or greater than 3,000 V; **and**
   b. A peak (surge) current equal to or greater than 3,000 A;

***Note 1:***

*1-3.A.1.g. includes:*

*- Silicon Controlled Rectifiers (SCRs);*

*- Electrical Triggering Thyristors (ETTs);*

*- Light Triggering Thyristors (LTTs);*

*- Integrated Gate Commutated Thyristors (IGCTs);*

*- Gate Turn-off Thyristors (GTOs);*

*- MOS Controlled Thyristors (MCTs);*

*- Solidtrons.*

***Note 2:***

*1-3.A.1.g. does not apply to thyristor devices and ‘thyristor modules’ incorporated into equipment designed for civil railway or “civil aircraft” applications.*

***Technical Note:***

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

1-3.A.1.h. Solid-state power semiconductor switches, diodes, or ‘modules’, having all of the following:

1. Rated for a maximum operating junction temperature greater than 488 K (215° C);
2. Repetitive peak off-state voltage (blocking voltage) exceeding 300 V; **and**
3. Continuous current greater than 1 A;

***Note 1:***

*Repetitive peak off-state voltage in 1-3.A.1.h. includes drain to source voltage, collector to emitter voltage, repetitive peak reverse voltage and peak repetitive off-state blocking voltage.*

***Note 2:***

*1-3.A.1.h. includes:*

*- Junction Field Effect Transistors (JFETs);*

*- Vertical Junction Field Effect Transistors (VJFETs);*

*- Metal Oxide Semiconductor Field Effect Transistors (MOSFETs);*

*- Double Diffused Metal Oxide Semiconductor Field Effect Transistor (DMOSFET);*

*- Insulated Gate Bipolar Transistor (IGBT);*

*- High Electron Mobility Transistors (HEMTs);*

*- Bipolar Junction Transistors (BJTs);*

*- Thyristors and Silicon Controlled Rectifiers (SCRs);*

*- Gate Turn-Off Thyristors (GTOs);*

*- Emitter Turn-Off Thyristors (ETOs);*

*- PiN Diodes;*

*- Schottky Diodes.*

***Note 3:***

*1-3.A.1.h. does not apply to switches, diodes, or 'modules', incorporated into equipment designed for civil automobile, civil railway, or "civil aircraft" applications.*

***Technical Note:***

*For the purposes of 1-3.A.1.h., 'modules' contain one or more solid-state power semiconductor switches or diodes.*

1-3.A.1.i. Intensity, amplitude, or phase electro-optic modulators, designed for analogue signals and having any of the following:

1. A maximum operating frequency of more than 10 GHz but less than 20 GHz, an optical insertion loss equal to or less than 3 dB and having any of the following:
   a. A 'half-wave voltage' ('Vπ') less than 2.7 V when measured at a frequency of 1 GHz or below; **or**
   b. A 'Vπ' of less than 4 V when measured at a frequency of more than 1 GHz; **or**
2. A maximum operating frequency equal to or greater than 20 GHz, an optical insertion loss equal to or less than 3 dB and having any of the following:
   a. A 'Vπ' less than 3.3 V when measured at a frequency of 1 GHz or below; **or**
   b. A 'Vπ' less than 5 V when measured at a frequency of more than 1 GHz.

***Note:***

*1-3.A.1.i. includes electro-optic modulators having optical input and output connectors (e.g., fibre-optic pigtails).*

***Technical Note:***

*For the purposes of 1-3.A.1.i., a 'half-wave voltage' ('Vπ') is the applied voltage necessary to make a phase change of 180 degrees in the wavelength of light propagating through the optical modulator.*

1-3.A.2. General purpose "electronic assemblies", modules and equipment, as follows:

1-3.A.2.a. Recording equipment and oscilloscopes, as follows:

1. Not used since 2013
2. Not used since 2013
3. Not used since 2013
4. Not used since 2013
5. Not used since 2015

   ***N.B.:***

   *For waveform digitizers and transient recorders, see 1-3.A.2.h.*

6. Digital data recorders having all of the following:
   a. A sustained 'continuous throughput' of more than 6.4 Gbit/s to disk or solid-state drive memory; **and**
   b. "Signal processing" of the radio frequency signal data while it is being recorded;

***Technical Notes:***

1. *For recorders with a parallel bus architecture, the 'continuous throughput' rate is the highest word rate multiplied by the number of bits in a word.*
2. *'Continuous throughput' is the fastest data rate the instrument can record to disk or solid-state drive memory without the loss of any information while sustaining the input digital data rate or digitizer conversion rate.*

7. Real-time oscilloscopes having a vertical root-mean-square (rms) noise voltage of less than 2% of full-scale at the vertical scale setting that provides the lowest noise value for any input 3 dB bandwidth of 60 GHz or greater per channel;

***Note:***

*1-3.A.2.a.7. does not apply to equivalent-time sampling oscilloscopes.*

1-3.A.2.b. Not used since 2009

1-3.A.2.c. "Signal analysers" as follows:

1. "Signal analysers" having a 3 dB resolution bandwidth (RBW) exceeding 40 MHz anywhere within the frequency range exceeding 31.8 GHz but not exceeding 37 GHz;
2. "Signal analysers" having Displayed Average Noise Level (DANL) less (better) than -150 dBm/Hz anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
3. "Signal analysers" having a frequency exceeding 90 GHz;
4. "Signal analysers" having all of the following:
   a. 'Real-time bandwidth' exceeding 170 MHz; **and**
   b. Having any of the following:
      1. 100% probability of discovery, with less than a 3 dB reduction from full amplitude due to gaps or windowing effects, of signals having a duration of 15 µs or less; **or**
      2. A 'frequency mask trigger' function with 100% probability of trigger (capture) for signals having a duration of 15 µs or less;

***Technical Notes:***

1. *'Real-time bandwidth' is the widest frequency range for which the analyser can continuously transform time-domain data entirely into frequency-domain results, using a Fourier or other discrete time transform that processes every incoming time point, without a reduction of measured amplitude of more than 3 dB below the actual signal amplitude caused by gaps or windowing effects, while outputting or displaying the transformed data.*
2. *Probability of discovery in 1-3.A.2.c.4.b.1. is also referred to as probability of intercept or probability of capture.*
3. *For the purposes of 1-3.A.2.c.4.b.1., the duration for 100% probability of discovery is equivalent to the minimum signal duration necessary for the specified level measurement uncertainty.*
4. *A 'frequency mask trigger' is a mechanism where the trigger function is able to select a frequency range to be triggered on as a subset of the acquisition bandwidth while ignoring other signals that may also be present within the same acquisition bandwidth. A 'frequency mask trigger' may contain more than one independent set of limits.*

***Note:***

*1-3.A.2.c.4. does not apply to those "signal analysers" using only constant percentage bandwidth filters (also known as octave or fractional octave filters).*

5. Not used since 2016

1-3.A.2.d. Signal generators having any of the following:

1. Specified to generate pulse-modulated signals having all of the following, anywhere within the frequency range exceeding 31.8 GHz but not exceeding 37 GHz:
   a. 'Pulse duration' of less than 25 ns; **and**
   b. On/off ratio equal to or exceeding 65 dB;
2. An output power exceeding 100 mW (20 dBm) anywhere within the frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
3. A "frequency switching time" as specified by any of the following:
   a. Not used since 2012
   b. Less than 100 µs for any frequency change exceeding 2.2 GHz within the frequency range exceeding 4.8 GHz but not exceeding 31.8 GHz;
   c. Not used since 2014
   d. Less than 500 µs for any frequency change exceeding 550 MHz within the frequency range exceeding 31.8 GHz but not exceeding 37 GHz; **or**
   e. Less than 100 µs for any frequency change exceeding 2.2 GHz within the frequency range exceeding 37 GHz but not exceeding 90 GHz;
   f. Not used since 2014
4. Single sideband (SSB) phase noise, in dBc/Hz, specified as being any of the following:
   a. Less (better) than $-(126+20 \log_{10}F-20 \log_{10}f)$ anywhere within the range of 10 Hz $\leq F \leq$ 10 kHz anywhere within the frequency range exceeding 3.2 GHz but not exceeding 90 GHz; **or**
   b. Less (better) than $-(206-20 \log_{10}f)$ anywhere within the range of 10 kHz $< F \leq$ 100 kHz anywhere within the frequency range exceeding 3.2 GHz but not exceeding 90 GHz;

   ***Technical Note:***

   *In 1-3.A.2.d.4., F is the offset from the operating frequency in Hz and f is the operating frequency in MHz.*
5. An 'RF modulation bandwidth' of digital baseband signals as specified by any of the following:
   a. Exceeding 2.2 GHz within the frequency range exceeding 4.8 GHz but not exceeding 31.8 GHz;
   b. Exceeding 550 MHz within the frequency range exceeding 31.8 GHz but not exceeding 37 GHz; **or**
   c. Exceeding 2.2 GHz within the frequency range exceeding 37 GHz but not exceeding 90 GHz;

   ***Technical Note:***

   *'RF modulation bandwidth' is the Radio Frequency (RF) bandwidth occupied by a digitally encoded baseband signal modulated onto an RF signal. It is also referred to as information bandwidth or vector modulation bandwidth. I/Q digital modulation is the technical method for producing a vector-modulated RF output*

*signal, and that output signal is typically specified as having an 'RF modulation bandwidth'.*

***Note 1:***

*For the purpose of 1-3.A.2.d., signal generators include arbitrary waveform and function generators.*

***Note 2:***

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

***Technical Notes:***

1. *The maximum frequency of an arbitrary waveform or function generator is calculated by dividing the sample rate, in samples/second, by a factor of 2.5.*
2. *For the purposes of 1-3.A.2.d.1.a., 'pulse duration' is defined as the time interval from the point on the leading edge that is 50% of the pulse amplitude to the point on the trailing edge that is 50% of the pulse amplitude.*

1-3.A.2.e. Network analysers having any of the following:

1. An output power exceeding 31.62 mW (15 dBm) anywhere within the operating frequency range exceeding 43.5 GHz but not exceeding 90 GHz;
2. An output power exceeding 1 mW (0 dBm) anywhere within the operating frequency range exceeding 90 GHz but not exceeding 110 GHz;
3. 'Nonlinear vector measurement functionality' at frequencies exceeding 50 GHz but not exceeding 110 GHz; **or**

***Technical Note***

*'Nonlinear vector measurement functionality' is an instrument's ability to analyse the test results of devices driven into the large-signal domain or the non-linear distortion range.*

4. A maximum operating frequency exceeding 110 GHz;

1-3.A.2.f. Microwave test receivers having all of the following:

1. A maximum operating frequency exceeding 110 GHz; **and**
2. Being capable of measuring amplitude and phase simultaneously;

1-3.A.2.g. Atomic frequency standards being any of the following:

1. "Space-qualified";
2. Non-rubidium and having a long-term stability less (better) than $1 \times 10^{-11}$/month; **or**
3. Non-"space-qualified" and having all of the following:
   a. Being a rubidium standard;
   b. Long-term stability less (better) than $1 \times 10^{-11}$/month; **and**
   c. Total power consumption of less than 1 Watt;

1-3.A.2.h. "Electronic assemblies", modules or equipment, specified to perform all of the following:

1. Analogue-to-digital conversions meeting any of the following:
   a. A resolution of 8 bit or more, but less than 10 bit, with a "sample rate" greater than 1.3 Giga Samples Per Second (GSPS);
   b. A resolution of 10 bit or more, but less than 12 bit, with a "sample rate" greater than 1.0 GSPS;

c. A resolution of 12 bit or more, but less than 14 bit, with a "sample rate" greater than 1.0 GSPS;

d. A resolution of 14 bit or more but less than 16 bit, with a "sample rate" greater than 400 Mega Samples Per Second (MSPS); **or**

e. A resolution of 16 bit or more with a "sample rate" greater than 180 MSPS; **and**

2. Any of the following:

a. Output of digitized data;

b. Storage of digitized data; **or**

c. Processing of digitized data;

***N.B.:***

*Digital data recorders, oscilloscopes, "signal analysers", signal generators, network analysers and microwave test receivers, are specified by 1-3.A.2.a.6.,1-3.A.2.a.7., 1-3.A.2.c., 1-3.A.2.d., 1-3.A.2.e. and 1-3.A.2.f., respectively.*

***Technical Notes:***

1. *A resolution of n bit corresponds to a quantisation of $2^n$ levels.*
2. *The resolution of the ADC is the number of bits of the digital output of the ADC that represents the measured analogue input. Effective Number of Bits (ENOB) is not used to determine the resolution of the ADC.*
3. *For non-interleaved multiple-channel "electronic assemblies", modules, or equipment, the "sample rate" is not aggregated and the "sample rate" is the maximum rate of any single channel.*
4. *For interleaved channels on multiple-channel "electronic assemblies", modules, or equipment, the "sample rates" are aggregated and the "sample rate" is the maximum combined total rate of all the interleaved channels.*

***Note:***

*1-3.A.2.h. includes ADC cards, waveform digitizers, data acquisition cards, signal acquisition boards and transient recorders.*

1-3.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.

## 1-3.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1-3.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 designed or modified to produce a layer of any material other than silicon with a thickness uniform to less than ±2.5% across a distance of 75 mm or more;

***Note:***

*1-3.B.1.a.1. includes atomic layer epitaxy (ALE) equipment.*

2. Metal Organic Chemical Vapour Deposition (MOCVD) reactors designed for compound semiconductor epitaxial growth of material having two or more of the following elements: aluminium, gallium, indium, arsenic, phosphorus, antimony, or nitrogen;
3. Molecular beam epitaxial growth equipment using gas or solid sources;

b. Equipment designed for ion implantation and having any of the following:
   1. Not used since 2012
   2. Being designed and optimized to operate at a beam energy of 20 keV or more and a beam current of 10 mA or more for hydrogen, deuterium or helium implant;
   3. Direct write capability;
   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"; **or**
   5. Being designed and optimized to operate at a beam energy of 20 keV or more and a beam current of 10 mA or more for silicon implant into a semiconductor material "substrate" heated to 600° C or greater;

c. Not used since 2015

d. Not used since 2011

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 functionally different 'semiconductor process tools' specified by 1-3.B.1.a.1., 1-3.B.1.a.2., 1-3.B.1.a.3. or 1-3.B.1.b. are designed to be connected; **and**
   2. Designed to form an integrated system in a vacuum environment for 'sequential multiple wafer processing';

   ***Note:***
   *1-3.B.1.e. does not apply to automatic robotic wafer handling systems specially designed for parallel wafer processing.*

   ***Technical Notes:***
   1. *For the purpose of 1-3.B.1.e., 'semiconductor process tools' refers to modular tools that provide physical processes for semiconductor production that are functionally different, such as deposition, implant or thermal processing.*
   2. *For the purpose of 1-3.B.1.e., 'sequential multiple wafer processing' means the capability to process each wafer in different 'semiconductor process tools', such as by transferring each wafer from one tool to a second tool and on to a third tool with the automatic loading multi-chamber central wafer handling systems.*

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 and having any of the following:
      a. A light source wavelength shorter than 193 nm; **or**
      b. Capable of producing a pattern with a 'Minimum Resolvable Feature size' (MRF)of 45 nm or less;

      ***Technical Note:***
      *The 'Minimum Resolvable Feature size'(MRF) is calculated by the following formula:*

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

*where the K factor = 0.35*

2. Imprint lithography equipment capable of producing features of 45 nm or less;

***Note:***
*1-3.B.1.f.2. includes:*
*- Micro contact printing tools;*
*- Hot embossing tools;*
*- Nano-imprint lithography tools;*
*- Step and flash imprint lithography (S-FIL) tools.*

3. Equipment specially designed for mask making having all of the following:
   a. A deflected focused electron beam, ion beam or "laser" beam; **and**
   b. Having any of the following:
      1. A full-width half-maximum (FWHM) spot size smaller than 65 nm and an image placement less than 17 nm (mean +3 sigma); **or**
      2. Not used since 2015
      3. A second-layer overlay error of less than 23 nm (mean +3 sigma) on the mask;
4. Equipment designed for device processing using direct writing methods, having all of the following:
   a. A deflected focused electron beam; and
   b. Having any of the following:
      1. A minimum beam size equal to or smaller than 15 nm; **or**
      2. An overlay error less than 27 nm (mean +3 sigma);

g. Masks and reticles, designed for integrated circuits specified by 1-3.A.1.;

h. Multi-layer masks with a phase shift layer not specified by 1-3.B.1.g. and designed to be used by lithography equipment having a light source wavelength less than 245 nm;

***Note:***
*1-3.B.1.h. does not apply to multi-layer masks with a phase shift layer designed for the fabrication of memory devices not specified by 1-3.A.1.*

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

j. Mask "substrate blanks" with multilayer reflector structure consisting of molybdenum and silicon, and having all of the following:
   1. Specially designed for 'Extreme Ultraviolet' ('EUV') lithography; **and**
   2. Compliant with SEMI Standard P37.

***Technical Note***
*'Extreme Ultraviolet' ('EUV') refers to electromagnetic spectrum wavelengths greater than 5 nm and less than 124 nm.*

1-3.B.2. Test equipment specially designed for testing finished or unfinished semiconductor devices as follows and specially designed components and accessories therefor:

a. For testing S-parameters of items specified by 1-3.A.1.b.3.;

b. Not used since 2004

c. For testing items specified by 1-3.A.1.b.2.

## 1-3.C. MATERIALS

1-3.C.1. Hetero-epitaxial materials consisting of a "substrate" having stacked epitaxially grown multiple layers of any of the following:

a. Silicon (Si);
b. Germanium (Ge);
c. Silicon Carbide (SiC); **or**
d. "III/V compounds" of gallium or indium.

***Note:***
*1-3.C.1.d. does not apply to a "substrate" having one or more P-type epitaxial layers of GaN, InGaN, AlGaN, InAlN, InAlGaN, GaP, GaAs, AlGaAs, InP, InGaP, AlInP or InGaAlP, independent of the sequence of the elements, except if the P-type epitaxial layer is between N-type layers.*

1-3.C.2. Resist materials as follows and "substrates" coated with the following resists:

a. Resists designed for semiconductor lithography as follows:
   1. Positive resists adjusted (optimised) for use at wavelengths less than 193 nm but equal to or greater than 15 nm;
   2. Resists adjusted (optimised) for use at wavelengths less than 15 nm but greater than 1 nm;
b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 µcoulomb/mm$^2$ or better;
c. Not used since 2012
d. All resists optimised for surface imaging technologies;
e. All resists designed or optimised for use with imprint lithography equipment specified by 1-3.B.1.f.2. that use either a thermal or photo-curable process.

1-3.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:***
*1-3.C.3. only applies to compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.*

1-3.C.4. Hydrides of phosphorus, arsenic or antimony, having a purity better than 99.999%, even diluted in inert gases or hydrogen.

***Note:***
*1-3.C.4. does not apply to hydrides containing 20% molar or more of inert gases or hydrogen.*

1-3.C.5. High resistivity materials as follows:

a. Silicon carbide (SiC), gallium nitride (GaN), aluminium nitride (AlN) or aluminium gallium nitride (AlGaN) semiconductor "substrates", or ingots, boules, or other preforms of those materials, having resistivities greater than 10,000 ohm-cm at 20° C;

b. Polycrystalline “substrates” or polycrystalline ceramic “substrates”, having resistivities greater than 10,000 ohm-cm at 20° C and having at least one non-epitaxial single-crystal layer of silicon (Si), silicon carbide (SiC), gallium nitride (GaN), aluminium nitride (AlN), or aluminium gallium nitride (AlGaN) on the surface of the “substrate”.

1-3.C.6. Materials, not specified by 1-3.C.1., consisting of a “substrate” specified by 1-3.C.5. with at least one epitaxial layer of silicon carbide, gallium nitride, aluminium nitride or aluminium gallium nitride.

## 1-3.D. SOFTWARE

1-3.D.1. “Software” specially designed for the “development” or “production” of equipment specified by 1-3.A.1.b. to 1-3.A.2.h. or 1-3.B.

1-3.D.2. “Software” specially designed for the “use” of equipment specified by 1-3.B.1.a. to 1-3.B.1.f. or 1-3.B.2.

1-3.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 1-3.D.3. means using computations to determine a sequence of physical cause and effect events based on physical properties (e.g., temperature, pressure, diffusion constants and semiconductor materials properties).*

***Note:***

*Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as “technology”.*

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

1-3.D.5. “Software” specially designed to restore normal operation of a microcomputer, “microprocessor microcircuit” or “microcomputer microcircuit” within 1 ms after an Electromagnetic Pulse (EMP) or Electrostatic Discharge (ESD) disruption, without loss of continuation of operation.

## 1-3.E. TECHNOLOGY

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

***Note 1:***

*1-3.E.1. does not apply to “technology” for equipment or components specified by 1-3.A.3.*

***Note 2:***

*1-3.E.1. does not apply to “technology” for integrated circuits specified by 1-3.A.1.a.3. to 1-3.A.1.a.12., having all of the following:*

*a. Using “technology” at or above 0.130 µm;* ***and***

*b. Incorporating multi-layer structures with three or fewer metal layers.*

***Note 3:***

*1-3.E.1. does not apply to ‘Process Design Kits’ (‘PDKs’) unless they include libraries implementing functions or technologies for items specified by 1-3.A.1.*

***Technical Note:***

*A 'Process Design Kit' ('PDK') is a software tool provided by a semiconductor manufacturer to ensure that the required design practices and rules are taken into account in order to successfully produce a specific integrated circuit design in a specific semiconductor process, in accordance with technological and manufacturing constraints (each semiconductor manufacturing process has its particular 'PDK').*

1-3.E.2. "Technology" according to the General Technology Note other than that specified by 1-3.E.1. for the "development" or "production" of a "microprocessor microcircuit", "microcomputer microcircuit" or microcontroller microcircuit core, having an arithmetic logic unit with an access width of 32 bits or more and any of the following features or characteristics:

a. A 'vector processor unit' designed to perform more than two calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously;

***Technical Note:***

*A 'vector processor unit' is a processor element with built-in instructions that perform multiple calculations on floating-point vectors (one-dimensional arrays of 32-bit or larger numbers) simultaneously, having at least one vector arithmetic logic unit and vector registers of at least 32 elements each.*

b. Designed to perform more than four 64-bit or larger floating-point operation results per cycle; **or**

c. Designed to perform more than eight 16-bit fixed-point multiply-accumulate results per cycle (e.g., digital manipulation of analogue information that has been previously converted into digital form, also known as digital "signal processing").

***Note 1:***

*1-3.E.2. does not apply to "technology" for multimedia extensions.*

***Note 2:***

*1-3.E.2. does not apply to "technology" for micro-processor cores, having all of the following:*

*a. Using "technology" at or above 0.130 µm;* ***and***

*b. Incorporating multi-layer structures with five or fewer metal layers.*

***Note 3:***

*1-3.E.2. includes "technology" for the "development" or "production" of digital signal processors and digital array processors.*

1-3.E.3. Other "technology" for the "development" or "production" of the following:

a. Vacuum microelectronic devices;

b. Hetero-structure semiconductor electronic devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well and super lattice devices;

***Note:***

*1-3.E.3.b. does not apply to "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. ‘Vacuum electronic devices’ operating at frequencies of 31.8 GHz or higher.

# CATEGORY 4: COMPUTERS

***Note 1:***

*Computers, related equipment and "software" performing telecommunications or "local area network" functions must also be evaluated against the performance characteristics of Category 5 - Part 1 (Telecommunications).*

***Note 2:***

*Control units which directly interconnect the buses or channels of central processing units, 'main storage' or disk controllers are not regarded as telecommunications equipment described in Category 5 - Part 1 (Telecommunications).*

***N.B.:***

*For the status of "software" specially designed for packet switching, see Category 5.D.1. (Telecommunications).*

***Technical Note:***

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

***Note 3:***

*Not used since 2015*

## 1-4.A. SYSTEMS, EQUIPMENT AND COMPONENTS

1-4.A.1. Electronic computers and related equipment, having any of the following and "electronic assemblies" and specially designed components therefor:

a. Specially designed to have any of the following:

1. Rated for operation at an ambient temperature below 228 K (-45° C) or above 358 K (85° C); **or**

***Note:***

*1-4.A.1.a.1. does not apply to computers specially designed for civil automobile, railway train or "civil aircraft" applications.*

2. Radiation hardened to exceed any of the following specifications:

a. Total Dose $5 \times 10^3$ Gy (Si);

b. Dose Rate Upset $5 \times 10^6$ Gy (Si)/s; **or**

c. Single Event Upset $1 \times 10^{-8}$ Error/bit/day.

***Note:***

*1-4.A.1.a.2. does not apply to computers specially designed for "civil aircraft" applications.*

b. Not used since 2009

1-4.A.2. Not used since 2003

1-4.A.3. "Digital computers", "electronic assemblies", and related equipment therefor, as follows and specially designed components therefor:

***Note 1:***

*1-4.A.3. includes the following:*

*- 'Vector processors';*

*- Array processors;*

*- Digital signal processors;*

*- Logic processors;*

*- Equipment designed for "image enhancement".*

***Note 2:***

*The status of the "digital computers" and related equipment described in 1-4.A.3. is determined by the 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 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 status of the other equipment even if it exceeds the "principal element" criterion.*

***N.B. 2:***

*For the status of "digital computers" or related equipment for telecommunications equipment, see Category 5 - Part 1 (Telecommunications).*

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

1-4.A.3.a. Not used since 2011

b. "Digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 29 Weighted TeraFLOPS (WT);

c. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of processors so that the 'APP' of the aggregation exceeds the limit specified by 1-4.A.3.b.;

***Note 1:***

*1-4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit specified by 1-4.A.3.b. when shipped as unintegrated "electronic assemblies".*

***Note 2:***

*1-4.A.3.c. does not apply to "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit specified by 1-4.A.3.b.*

d. Not used since 2001

e. Not used since 2015

***N.B.:***

*For "electronic assemblies", modules or equipment, performing analogue-to-digital conversions, see 1-3.A.2.h.*

f. Not used since 1998

g. Equipment specially designed for aggregating the performance of "digital computers" by providing external interconnections which allow communications at unidirectional data rates exceeding 2.0 Gbyte/s per link.

***Note:***

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

1-4.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'.

***Technical Notes:***

1. *'Systolic array computers' are computers where the flow and modification of the data is dynamically controllable at the logic gate level by the user.*
2. *'Neural computers' are computational devices designed or modified to mimic the behaviour of a neuron or a collection of neurons, i.e., computational devices which are distinguished by their hardware capability to modulate the weights and numbers of the interconnections of a multiplicity of computational components based on previous data.*
3. *'Optical computers' are computers designed or modified to use light to represent data and whose computational logic elements are based on directly coupled optical devices.*

1-4.A.5. Systems, equipment, and components therefor, specially designed or modified for the generation, command and control, or delivery of "intrusion software".

## 1-4.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

None

## 1-4.C. MATERIALS

None

## 1-4.D. SOFTWARE

***Note:***

*The status of "software" for equipment described in other Categories is dealt with in the appropriate Category.*

1-4.D.1. "Software" as follows:

a. "Software" specially designed or modified for the "development" or "production" of equipment or "software" specified by 1-4.A. or 1-4.D.
b. "Software", other than that specified by 1-4.D.1.a., specially designed or modified for the "development" or "production" of equipment as follows:
   1. "Digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 15 Weighted TeraFLOPS (WT);
   2. "Electronic assemblies" specially designed or modified for enhancing performance by aggregation of processors so that the 'APP' of the aggregation exceeds the limit in 1-4.D.1.b.1.

1-4.D.2. Not used since 2014

1-4.D.3. Not used since 2009

1-4.D.4. "Software" specially designed or modified for the generation, command and control, or delivery of "intrusion software".

***Note:***

*1-4.D.4 does not apply to "software" specially designed and limited to provide "software" updates or upgrades meeting all the following:*

*a. The update or upgrade operates only with the authorisation of the owner or administrator of the system receiving it; and*

*b. After the update or upgrade, the "software" updated or upgraded is not any of the following:*

*1. "Software" specified by 1-4.D.4.; or*

*2. "Intrusion software".*

## 1-4.E. TECHNOLOGY

1-4.E.1. "Technology" as follows:

a. "Technology" according to the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified by 1-4.A. or 1-4.D.

b. "Technology" according to the General Technology Note, other than that specified by 1-4.E.1.a., for the "development" or "production" of equipment as follows:

1. "Digital computers" having an 'Adjusted Peak Performance' ('APP') exceeding 15 Weighted TeraFLOPS (WT);

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

c. "Technology" for the "development" of "intrusion software".

***Note 1:***

*1-4.E.1.a. and 1-4.E.1.c. do not apply to 'vulnerability disclosure' or 'cyber incident response'.*

***Note 2:***

*Note 1 does not diminish national authorities' rights to ascertain compliance with 1-4.E.1.a. and 1-4.E.1.c.*

***Technical Notes:***

*1. 'Vulnerability disclosure' means the process of identifying, reporting, or communicating a vulnerability to, or analysing a vulnerability with, individuals or organizations responsible for conducting or coordinating remediation for the purpose of resolving the vulnerability.*

*2. 'Cyber incident response' means the process of exchanging necessary information on a cyber security incident with individuals or organizations responsible for conducting or coordinating remediation to address the cyber security incident.*

## TECHNICAL NOTE ON 'ADJUSTED PEAK PERFORMANCE' ('APP')

'APP' is an adjusted peak rate at which "digital computers" perform 64-bit or larger floating point additions and multiplications.

Abbreviations used in this Technical Note

n number of processors in the "digital computer"

i processor number (i,...n)

$t_i$ processor cycle time ($t_i = 1/F_i$)

$F_i$ processor frequency

$R_i$ peak floating point calculating rate

$W_i$ architecture adjustment factor

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

OUTLINE OF 'APP' CALCULATION METHOD

1. For each processor i, determine the peak number of 64-bit or larger floating point operations, $FPO_i$, performed per cycle for each processor in the "digital computer".

Note: In determining FPO, include only 64-bit or larger floating point additions or multiplications. All floating point operations must be expressed in operations per processor cycle; operations requiring multiple cycles may be expressed in fractional results per cycle. For processors not capable of performing calculations on floating point operands of 64-bit or more, the effective calculating rate R is zero.

2. Calculate the floating point rate R for each processor $R_i = FPO_i/t_i$
3. Calculate 'APP' as 'APP' = $W_1 \times R_1 + W_2 \times R_2 + \ldots + W_n \times R_n$.
4. For 'vector processors', $W_i = 0.9$. For non-'vector processors', $W_i = 0.3$.

Note 1: For processors that perform compound operations in a cycle, such as addition and multiplication, each operation is counted.

Note 2: For a pipelined processor the effective calculating rate R is the faster of the pipelined rate, once the pipeline is full, or the non-pipelined rate.

Note 3: The calculating rate R of each contributing processor is to be calculated at its maximum value theoretically possible before the 'APP' of the combination is derived. Simultaneous operations are assumed to exist when the computer manufacturer claims concurrent, parallel, or simultaneous operation or execution in a manual or brochure for the computer.

Note 4: Do not include processors that are limited to input/output and peripheral functions (e.g., disk drive, communication and video display) when calculating 'APP'.

Note 5: 'APP' values are not to be calculated for processor combinations (inter)connected by "Local Area Networks", Wide Area Networks, I/O shared connections/devices, I/O controllers and any communication interconnection implemented by "software".

Note 6: 'APP' values must be calculated for processor combinations containing processors specially designed to enhance performance by aggregation, operating simultaneously and sharing memory;

***Technical Notes:***

1. *Aggregate all processors and accelerators operating simultaneously and located on the same die.*
2. *Processor combinations share memory when any processor is capable of accessing any memory location in the system through the hardware transmission of cache lines or memory words, without the involvement of any software mechanism, which may be achieved using "electronic assemblies" specified in 1-4.A.3.c.*

Note 7: A ‘vector processor’ is defined as a processor with built-in instructions that perform multiple calculations on floating-point vectors (one-dimensional arrays of 64-bit or larger numbers) simultaneously, having at least 2 vector functional units and at least 8 vector registers of at least 64 elements each.

# CATEGORY 5 - PART 1: TELECOMMUNICATIONS

***Note 1:***

*The status of components, test and "production" equipment and "software" therefor which are specially designed for telecommunications equipment or systems is determined in Category 5 - Part 1.*

***N.B.:***

*For "lasers" specially designed for telecommunications equipment or systems, see 1-6.A.5.*

***Note 2:***

*"Digital computers", related equipment or "software", when essential for the operation and support of telecommunications equipment described in this Category, are regarded as specially designed components, provided they are the standard models customarily supplied by the manufacturer. This includes operation, administration, maintenance, engineering or billing computer systems.*

## 1-5.A.1. SYSTEMS, EQUIPMENT AND COMPONENTS

1-5.A.1. Telecommunications systems, equipment, components and accessories, as follows:

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;
   3. Specially designed to operate below 218 K (-55° C); **or**
   4. Specially designed to operate above 397 K (124° C);

   ***Note 1:***

   *1-5.A.1.a.3. and 1-5.A.1.a.4. apply only to electronic equipment.*

   ***Note 2:***

   *1-5.A.1.a.2, 1-5.A.1.a.3. and 1-5.A.1.a.4. do not apply to equipment designed or modified for use on board satellites.*

b. Telecommunication systems and equipment, and specially designed components and accessories therefor, having any of the following characteristics, functions or features:
   1. Being underwater untethered communications systems having any of the following:
      a. An acoustic carrier frequency outside the range from 20 kHz to 60 kHz;
      b. Using an electromagnetic carrier frequency below 30 kHz;
      c. Using electronic beam steering techniques; **or**
      d. Using "lasers" or light-emitting diodes (LEDs), with an output wavelength greater than 400 nm and less than 700 nm, in a "local area network";
   2. Being radio equipment operating in the 1.5 MHz to 87.5 MHz band and having all of the following:
      a. Automatically predicting and selecting frequencies and "total digital transfer rates" per channel to optimise the transmission; **and**

b. Incorporating a linear power amplifier configuration having a capability to support multiple signals simultaneously at an output power of 1 kW or more in the frequency range of 1.5 MHz or more but less than 30 MHz, or 250 W or more in the frequency range of 30 MHz or more but not exceeding 87.5 MHz, over an "instantaneous bandwidth" of one octave or more and with an output harmonic and distortion content of better than -80 dB;

3. Being radio equipment employing "spread spectrum" techniques, including "frequency hopping" techniques, not specified by 1-5.A.1.b.4. and having any of the following:
   a. User programmable spreading codes; **or**
   b. A total transmitted bandwidth which is 100 or more times the bandwidth of any one information channel and in excess of 50 kHz;

   ***Note:***

   *1-5.A.1.b.3.b. does not apply to radio equipment specially designed for use with any of the following:*

   *a. Civil cellular radio-communications systems;* ***or***

   *b. Fixed or mobile satellite earth stations for commercial civil telecommunications.*

   ***Note:***

   *1-5.A.1.b.3. does not apply to equipment designed to operate at an output power of 1 W or less.*

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

   ***Note:***

   *1-5.A.1.b.5. does not apply to radio equipment specially designed for use with civil cellular radio-communications systems.*

   ***Technical Note:***

   *'Channel switching time': the time (i.e., delay) to change from one receiving frequency to another, to arrive at or within ±0.05% of the final specified receiving frequency. Items having a specified frequency range of less than ±0.05% around their centre frequency are defined to be incapable of channel frequency switching.*

6. Employing functions of digital "signal processing" to provide 'voice coding' output at rates of less than 700 bit/s.

   ***Technical Notes:***

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

2. *For the purpose of 1-5.A.1.b.6., 'voice coding' is defined as the technique to take samples of human voice and then convert these samples into a digital signal, taking into account specific characteristics of human speech.*

c. Optical fibres of more than 500 m in length and specified by the manufacturer as being capable of withstanding a 'proof test' tensile stress of 2 x $10^9$ N/$m^2$ or more;

***N. B.:***

*For underwater umbilical cables, see 1-8.A.2.a.3.*

***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 (20° C) and relative humidity 40%. Equivalent national standards may be used for executing the proof test.*

d. 'Electronically steerable phased array antennae' as follows:

1. Rated for operation above 31.8 GHz, but not exceeding 57 GHz, and having an Effective Radiated Power (ERP) equal to or greater than +20 dBm (22.15 dBm Effective Isotropic Radiated Power (EIRP));
2. Rated for operation above 57 GHz, but not exceeding 66 GHz, and having an ERP equal to or greater than +24 dBm (26.15 dBm EIRP);
3. Rated for operation above 66 GHz, but not exceeding 90 GHz, and having an ERP equal to or greater than +20 dBm (22.15 dBm EIRP);
4. Rated for operation above 90 GHz;

***Note 1:***

*1-5.A.1.d. does not apply to 'electronically steerable phased array antennae' for landing systems with instruments meeting ICAO standards covering Microwave Landing Systems (MLS).*

***Note 2:***

*1-5.A.1.d. does not apply to antennae specially designed for any of the following:*

*a. Civil cellular or WLAN radio-communications systems;*

*b. IEEE 802.15 or wireless HDMI;* ***or***

*c. Fixed or mobile satellite earth stations for commercial civil telecommunications.*

***Technical Note:***

*For the purposes of 1-5.A.1.d. 'electronically steerable phased array antenna' is an antenna which forms a beam by means of phase coupling, (i.e., the beam direction is controlled by the complex excitation coefficients of the radiating elements) and the direction of that beam can be varied (both in transmission and reception) in azimuth or in elevation, or both, by application of an electrical signal.*

e. Radio direction finding equipment operating at frequencies above 30 MHz and having all of the following, and specially designed components therefor:

1. "Instantaneous bandwidth" of 10 MHz or more; **and**
2. Capable of finding a Line Of Bearing (LOB) to non-cooperating radio transmitters with a signal duration of less than 1 ms;

f. Mobile telecommunications interception or jamming equipment, and monitoring equipment therefor, as follows, and specially designed components therefor:

1. Interception equipment designed for the extraction of voice or data, transmitted over the air interface;

2. Interception equipment not specified in 1-5.A.1.f.1., designed for the extraction of client device or subscriber identifiers (e.g., IMSI, TIMSI or IMEI), signalling, or other metadata transmitted over the air interface;
3. Jamming equipment specially designed or modified to intentionally and selectively interfere with, deny, inhibit, degrade or seduce mobile telecommunication services and performing any of the following:
   a. Simulate the functions of Radio Access Network (RAN) equipment;
   b. Detect and exploit specific characteristics of the mobile telecommunications protocol employed (e.g., GSM); **or**
   c. Exploit specific characteristics of the mobile telecommunications protocol employed (e.g., GSM);
4. RF monitoring equipment designed or modified to identify the operation of items specified in 1-5.A.1.f.1., 1-5.A.1.f.2. or 1-5.A.1.f.3.;

***Note:***

*1-5.A.1.f.1. and 1-5.A.1.f.2. do not apply to any of the following:*

*a. Equipment specially designed for the interception of analogue Private Mobile Radio (PMR), IEEE 802.11 WLAN;*

*b. Equipment designed for mobile telecommunications network operators;* ***or***

*c. Equipment designed for the "development" or "production" of mobile telecommunications equipment or systems.*

***N.B.:***

*1. See also the Munitions List.*

*2. For radio receivers see 1-5.A.1.b.5.*

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

***Technical Note:***

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

***Note:***

*1-5.A.1.g. does not apply to any of the following:*

*a. Radio-astronomical equipment;* ***or***

*b. Systems or equipment, that require any radio transmission from the target.*

h. Counter Improvised Explosive Device (IED) equipment and related equipment, as follows:
   1. Radio Frequency (RF) transmitting equipment, not specified by 1-5.A.1.f., designed or modified for prematurely activating or preventing the initiation of Improvised Explosive Devices;
   2. Equipment using techniques designed to enable radio communications in the same frequency channels on which co-located equipment specified by 1-5.A.1.h.1. is transmitting.

***N.B.:***

*See also the Munitions List.*

i. Not used since 2012

***N.B.:***

*See 1-5.A.1.f. for items previously specified by 1-5.A.1.i.*

j. IP network communications surveillance systems or equipment, and specially designed components therefor, having all of the following:
   1. Performing all of the following on a carrier class IP network (e.g., national grade IP backbone):
      a. Analysis at the application layer (e.g., Layer 7 of Open Systems Interconnection (OSI) model (ISO/IEC 7498-1));
      b. Extraction of selected metadata and application content (e.g., voice, video, messages, attachments); **and**
      c. Indexing of extracted data; **and**
   2. Being specially designed to carry out all of the following:
      a. Execution of searches on the basis of 'hard selectors'; **and**
      b. Mapping of the relational network of an individual or of a group of people.

***Note:***
*1-5.A.1.j. does not apply to systems or equipment, specially designed for any of the following:*
*a. Marketing purpose;*
*b. Network Quality of Service (QoS);* ***or***
*c. Quality of Experience (QoE).*

***Technical Note:***
*'Hard selectors': data or set of data, related to an individual (e.g., family name, given name, e-mail, street address, phone number or group affiliations).*

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

1-5.B.1. Telecommunication test, inspection and production equipment, components and accessories, as follows:

a. Equipment and specially designed components or accessories therefor, specially designed for the "development" or "production" of equipment, functions or features, specified by 1-5.A.1.;

***Note:***
*1-5.B.1.a. does not apply to optical fibre characterization equipment.*

b. Equipment and specially designed components or accessories therefor, specially designed for the "development" of any of the following telecommunication transmission or switching equipment:
   1. Not used since 2009
   2. Equipment employing a "laser" and having any of the following:
      a. A transmission wavelength exceeding 1,750 nm; **or**
      b. Not used since 2015
      c. Not used since 2016
      d. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz; **or**

      ***Note:***
      *1-5.B.1.b.2.d. does not apply to equipment specially designed for the "development" of commercial TV systems.*
   3. Not used since 2009

4. Radio equipment employing Quadrature-Amplitude-Modulation (QAM) techniques above level 1,024.
5. Not used since 2011

1-5.C.1. MATERIALS

None

1-5.D.1. SOFTWARE

1-5.D.1. "Software" as follows:

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment, functions or features, specified by 1-5.A.1.;
b. Not used since 2014
c. Specific "software" specially designed or modified to provide characteristics, functions or features of equipment, specified by 1-5.A.1. or 1-5.B.1.;
d. "Software" specially designed or modified for the "development" of any of the following telecommunication transmission or switching equipment:
   1. Not used since 2009
   2. Equipment employing a "laser" and having any of the following:
      a. A transmission wavelength exceeding 1,750 nm; **or**
      b. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz; **or**

      ***Note:***
      *1-5.D.1.d.2.b. does not apply to "software" specially designed or modified for the "development" of commercial TV systems.*
   3. Not used since 2009
   4. Radio equipment employing Quadrature-Amplitude-Modulation (QAM) techniques above level 1,024.

1-5.E.1. TECHNOLOGY

1-5.E.1. "Technology" as follows:

a. "Technology" according to the General Technology Note for the "development", "production" or "use" (excluding operation) of equipment, functions or features specified by 1-5.A.1. or "software" specified by 1-5.D.1.a.;
b. Specific "technology" as follows:
   1. "Technology" "required" 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;

***Note:***

*1-5.E.1.b.4. does not apply to "technology" for the "development" of any of the following:*

*a. Civil cellular radio-communications systems;* ***or***

*b. Fixed or mobile satellite earth stations for commercial civil telecommunications.*

c. "Technology" according to the General Technology Note for the "development" or "production" of any of the following:
1. Not used since 2016
2. Equipment employing a "laser" and having any of the following:
   a. A transmission wavelength exceeding 1,750 nm;
   b. Not used since 2015
   c. Not used since 2016
   d. Employing wavelength division multiplexing techniques of optical carriers at less than 100 GHz spacing; **or**
   e. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

   ***Note:***

   *1-5.E.1.c.2.e. does not apply to "technology" for commercial TV systems.*

   ***N.B.:***

   *For "technology" for the "development" or "production" of non-telecommunications equipment employing a "laser", see 1-6.E.*
3. Equipment employing "optical switching" and having a switching time less than 1 ms;
4. Radio equipment having any of the following:
   a. Quadrature-Amplitude-Modulation (QAM) techniques above level 1,024;
   b. Operating at input or output frequencies exceeding 31.8 GHz; **or**

   ***Note:***

   *1-5.E.1.c.4.b. does not apply to "technology" for equipment designed or modified for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.*

   c. Operating in the 1.5 MHz to 87.5 MHz band and incorporating adaptive techniques providing more than 15 dB suppression of an interfering signal; **or**
5. Not used since 2011
6. Mobile equipment having all of the following:
   a. Operating at an optical wavelength greater than or equal to 200 nm and less than or equal to 400 nm; **and**
   b. Operating as a "local area network";

d. "Technology" according to the General Technology Note for the "development" or "production" of "Monolithic Microwave Integrated Circuit" ("MMIC") amplifiers specially designed for telecommunications and that are any of the following:

***Technical Note:***

*For purposes of 1-5.E.1.d., the parameter peak saturated power output may also be referred to on product data sheets as output power, saturated power output, maximum power output, peak power output, or peak envelope power output.*

1. Rated for operation at frequencies exceeding 2.7 GHz up to and including 6.8 GHz with a "fractional bandwidth" greater than 15%, and having any of the following:
   a. A peak saturated power output greater than 75 W (48.75 dBm) at any frequency exceeding 2.7 GHz up to and including 2.9 GHz;
   b. A peak saturated power output greater than 55 W (47.4 dBm) at any frequency exceeding 2.9 GHz up to and including 3.2 GHz;
   c. A peak saturated power output greater than 40 W (46 dBm) at any frequency exceeding 3.2 GHz up to and including 3.7 GHz; **or**
   d. A peak saturated power output greater than 20 W (43 dBm) at any frequency exceeding 3.7 GHz up to and including 6.8 GHz;
2. Rated for operation at frequencies exceeding 6.8 GHz up to and including 16 GHz with a "fractional bandwidth" greater than 10%, and having any of the following:
   a. A peak saturated power output greater than 10 W (40 dBm) at any frequency exceeding 6.8 GHz up to and including 8.5 GHz; **or**
   b. A peak saturated power output greater than 5 W (37 dBm) at any frequency exceeding 8.5 GHz up to and including 16 GHz;
3. Rated for operation with a peak saturated power output greater than 3 W (34.77 dBm) at any frequency exceeding 16 GHz up to and including 31.8 GHz, and with a "fractional bandwidth" of greater than 10%;
4. Rated for operation with a peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 31.8 GHz up to and including 37 GHz;
5. Rated for operation with a peak saturated power output greater than 1 W (30 dBm) at any frequency exceeding 37 GHz up to and including 43.5 GHz, and with a "fractional bandwidth" of greater than 10%;
6. Rated for operation with a peak saturated power output greater than 31.62 mW (15 dBm) at any frequency exceeding 43.5 GHz up to and including 75 GHz, and with a "fractional bandwidth" of greater than 10%;
7. Rated for operation with a peak saturated power output greater than 10 mW (10 dBm) at any frequency exceeding 75 GHz up to and including 90 GHz, and with a "fractional bandwidth" of greater than 5%; **or**
8. Rated for operation with a peak saturated power output greater than 0.1 nW (-70 dBm) at any frequency exceeding 90 GHz;

e. "Technology" according to the General Technology Note for the "development" or "production" of electronic devices and circuits, specially designed for telecommunications and containing components manufactured from "superconductive" materials, specially designed for operation at temperatures

below the “critical temperature” of at least one of the “superconductive” constituents and having 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.

# CATEGORY 5 - PART 2: “INFORMATION SECURITY”

***Note 1:***

*Not used since 2015*

***Note 2:***

*Category 5 - Part 2 does not apply to products when accompanying their user for the user’s personal use.*

***Note 3: Cryptography Note***

*1-5.A.2., 1-5.D.2.a.1., 1-5.D.2.b. and 1-5.D.2.c.1. do not apply to items as follows:*

*a. Items meeting all of the following:*
   *1. Generally available to the public by being sold, without restriction, from stock at retail selling points by means of any of the following:*
      *a. Over-the-counter transactions;*
      *b. Mail order transactions;*
      *c. Electronic transactions;* ***or***
      *d. Telephone call transactions;*
   *2. The cryptographic functionality cannot easily be changed by the user;*
   *3. Designed for installation by the user without further substantial support by the supplier;* ***and***
   *4. 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 1. to 3. above;*

*b. Hardware components or ‘executable software’, of existing items described in paragraph a. of this Note, that have been designed for these existing items, and meeting all of the following:*
   *1. “Information security” is not the primary function or set of functions of the component or ‘executable software’;*
   *2. The component or ‘executable software’ does not change any cryptographic functionality of the existing items, or add new cryptographic functionality to the existing items;*
   *3. The feature set of the component or ‘executable software’ is fixed and is not designed or modified to customer specification;* ***and***
   *4. When necessary as determined by the appropriate authority in the exporter’s country, details of the component or ‘executable software’, and details of relevant end-items are accessible and will be provided to the authority upon request, in order to ascertain compliance with conditions described above.*

***Technical Note:***

*For the purpose of the Cryptography Note, ‘executable software’ means “software” in executable form, from an existing hardware component excluded from 1-5.A.2 by the Cryptography Note.*

***Note:***

*‘Executable software’ does not include complete binary images of the “software” running on an end-item.*

***Note to the Cryptography Note:***

*1. To meet paragraph a. of Note 3, all of the following must apply:*
   *a. The item is of potential interest to a wide range of individuals and businesses;* ***and***

*b. The price and information about the main functionality of the item are available before purchase without the need to consult the vendor or supplier. A simple price enquiry is not considered to be a consultation.*

*2. In determining eligibility of paragraph a. of Note 3, national authorities may take into account relevant factors such as quantity, price, required technical skill, existing sales channels, typical customers, typical use or any exclusionary practices of the supplier.*

## 1-5.A.2. SYSTEMS, EQUIPMENT AND COMPONENTS

## CRYPTOGRAPHIC “INFORMATION SECURITY”

1-5.A.2. “Information security” systems, equipment and components, as follows:

***N.B.:***

*For “satellite navigation system” receiving equipment containing or employing decryption see 1-7.A.5., and for related decryption “software” and “technology” see 1-7.D.5. and 1-7.E.1.*

a. Designed or modified to use ‘cryptography for data confidentiality’ having a ‘described security algorithm’, where that cryptographic capability is usable, has been activated, or can be activated by means of “cryptographic activation” not employing a secure mechanism, as follows:

1. Items having “information security” as a primary function;
2. Digital communication or networking systems, equipment or components, not specified in paragraph 1-5.A.2.a.1.;
3. Computers, other items having information storage or processing as a primary function, and components therefor, not specified in paragraphs 1-5.A.2.a.1. or 1-5.A.2.a.2.;

***N.B.:***

*For operating systems, see also 1-5.D.2.a.1. and 1-5.D.2.c.1.*

4. Items, not specified in paragraphs 1-5.A.2.a.1. to a.3., where the ‘cryptography for data confidentiality’ having a ‘described security algorithm’ meets all of the following:
   a. It supports a non-primary function of the item; **and**
   b. It is performed by incorporated equipment or “software” that would, as a standalone item, be specified by Category 5 – Part 2.

***Technical Notes:***

*1. For the purposes of 1-5.A.2.a., ‘cryptography for data confidentiality’ means “cryptography” that employs digital techniques and performs any cryptographic function other than any of the following:*

*a. “Authentication”;*

*b. Digital signature;*

*c. Data integrity;*

*d. Non-repudiation;*

*e. Digital rights management, including the execution of copy-protected “software”;*

*f. Encryption or decryption in support of entertainment, mass commercial broadcasts or medical records management;* ***or***

*g. Key management in support of any function described in paragraph a. to f. above.*

2. *For the purposes of 1-5.A.2.a., 'described security algorithm' means any of the following:*
   a. *A "symmetric algorithm" employing a key length in excess of 56 bits, not including parity bits;*
   b. *An "asymmetric algorithm" where the security of the algorithm is based on any of the following:*
      1. *Factorisation of integers in excess of 512 bits (e.g., RSA);*
      2. *Computation of discrete logarithms in a multiplicative group of a finite field of size greater than 512 bits (e.g., Diffie-Hellman over Z/pZ);* ***or***
      3. *Discrete logarithms in a group other than mentioned in paragraph b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve);* ***or***
   c. *An "asymmetric algorithm" where the security of the algorithm is based on any of the following:*
      1. *Shortest vector or closest vector problems associated with lattices (e.g., NewHope, Frodo, NTRUEncrypt, Kyber, Titanium);*
      2. *Finding isogenies between Supersingular elliptic curves (e.g., Supersingular Isogeny Key Encapsulation);* ***or***
      3. *Decoding random codes (e.g., McEliece, Niederreiter).*

   ***Technical Note:***

   *An algorithm described by Technical Note 2.c. may be referred to as being post-quantum, quantum-safe or quantum-resistant.*

***Note 1:***

*When necessary as determined by the appropriate authority in the exporter's country, details of items must be accessible and provided to the authority upon request, in order to establish any of the following:*

a. *Whether the item meets the criteria of 1-5.A.2.a.1. to a.4.;* ***or***
b. *Whether the cryptographic capability for data confidentiality specified by 1-5.A.2.a. is usable without "cryptographic activation".*

***Note 2:***

*1-5.A.2.a. does not apply to any of the following items, or specially designed "information security" components therefor:*

a. *Smart cards and smart card 'readers/writers' as follows:*
   1. *A smart card or an electronically readable personal document (e.g., token coin, e-passport) that meets any of the following:*
      a. *The cryptographic capability meets all of the following:*
         1. *It is restricted for use in any of the following:*
            a. *Equipment or systems not described by 1-5.A.2.a.1. to a.4.;*
            b. *Equipment or systems not using 'cryptography for data confidentiality' having a 'described security algorithm';* ***or***
            c. *Equipment or systems excluded from 1-5.A.2.a. by entries b. to f. of this Note;* ***and***
         2. *It cannot be reprogrammed for any other use;* ***or***
      b. *Having all of the following:*
         1. *It is specially designed and limited to allow protection of 'personal data' stored within;*
         2. *Has been, or can only be, personalized for public or commercial transactions or individual identification;* ***and***
         3. *Where the cryptographic capability is not user-accessible;*

***Technical Note:***

*'Personal data' includes any data specific to a particular person or entity, such as the amount of money stored and data necessary for "authentication".*

2. *'Readers/writers' specially designed or modified, and limited, for items specified by paragraph a.1. of this Note;*

***Technical Note:***

*'Readers/writers' include equipment that communicates with smart cards or electronically readable documents through a network.*

b. *Cryptographic equipment specially designed and limited for banking use or 'money transactions';*

***Technical Note:***

*'Money transactions' in 1-5.A.2. Note 2.b. includes the collection and settlement of fares or credit functions.*

c. *Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular radio communication systems) that are not capable of transmitting encrypted data directly to another radiotelephone or equipment (other than Radio Access Network (RAN) equipment), nor of passing encrypted data through RAN equipment (e.g., Radio Network Controller (RNC) or Base Station Controller (BSC));*

d. *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;*

e. *Portable or mobile radiotelephones and similar client wireless devices for civil use, that implement only published or commercial cryptographic standards (except for anti-piracy functions, which may be non-published) and also meet the provisions of paragraphs a.2. to a.4. of the Cryptography Note (Note 3 in Category 5 - Part 2), that have been customised for a specific civil industry application with features that do not affect the cryptographic functionality of these original non-customised devices;*

f. *Items, where the "information security" functionality is limited to wireless "personal area network" functionality, meeting all of the following:*

   1. *Implement only published or commercial cryptographic standards;* ***and***
   2. *The cryptographic capability is limited to a nominal operating range not exceeding 30 metres according to the manufacturer's specifications, or not exceeding 100 metres according to the manufacturer's specifications for equipment that cannot interconnect with more than seven devices;*

g. *Mobile telecommunications Radio Access Network (RAN) equipment designed for civil use, which also meet the provisions of paragraphs a.2. to a.4. of the Cryptography Note (Note 3 in Category 5 - Part 2), having an RF output power limited to 0.1W (20 dBm) or less, and supporting 16 or fewer concurrent users;*

h. *Routers, switches or relays, where the "information security" functionality is limited to the tasks of "Operations, Administration or Maintenance" ("OAM") implementing only published or commercial cryptographic standards;*

i. *General purpose computing equipment or servers, where the "information security" functionality meets all of the following:*

   1. *Uses only published or commercial cryptographic standards;* ***and***
   2. *Is any of the following:*

      a. *Integral to a CPU that meets the provisions of Note 3 in Category 5 - Part 2;*
      b. *Integral to an operating system that is not specified by 1-5.D.2.;* ***or***

*c. Limited to “OAM” of the equipment;* ***or***

*j. Items specially designed for a ‘connected civil industry application’, meeting all of the following:*

*1. Being any of the following:*

*a. A network-capable endpoint device meeting any of the following:*

*1. The “information security” functionality is limited to securing ‘non-arbitrary data’ or the tasks of “Operations, Administration or Maintenance” (“OAM”);* ***or***

*2. The device is limited to a specific ‘connected civil industry application’;* ***or***

*b. Networking equipment meeting all of the following:*

*1. Being specially designed to communicate with the devices specified by paragraph j.1.a. above;* ***and***

*2. The “information security” functionality is limited to supporting the ‘connected civil industry application’ of devices specified by paragraph j.1.a. above, or the tasks of “OAM” of this networking equipment or of other items specified by paragraph j. of this Note;* ***and***

*2. Where the “information security” functionality implements only published or commercial cryptographic standards, and the cryptographic functionality cannot easily be changed by the user.*

***Technical Notes:***

*1. ‘Connected civil industry application’ means a network-connected consumer or civil industry application other than “information security”, digital communication, general purpose networking or computing.*

*2. ‘Non-arbitrary data’ means sensor or metering data directly related to the stability, performance or physical measurement of a system (e.g., temperature, pressure, flow rate, mass, volume, voltage, physical location etc.), that cannot be changed by the user of the device.*

b. Being a ‘cryptographic activation token’;

***Technical Note:***

*A ‘cryptographic activation token’ is an item designed or modified for any of the following:*

*1. Converting, by means of “cryptographic activation”, an item not specified by Category 5 – Part 2 into an item specified by 1-5.A.2.a. or 1-5.D.2.c.1., and not released by the Cryptography Note (Note 3 in Category 5 – Part 2);* ***or***

*2. Enabling, by means of “cryptographic activation”, additional functionality specified by 1-5.A.2.a. of an item already specified by Category 5 – Part 2.*

c. Designed or modified to use or perform “quantum cryptography”;

***Technical Note:***

*“Quantum cryptography” is also known as Quantum Key Distribution (QKD).*

d. Designed or modified to use cryptographic techniques to generate channelising codes, scrambling codes or network identification codes, for systems using ultra-wideband modulation techniques and having any of the following:

1. A bandwidth exceeding 500 MHz; **or**
2. A “fractional bandwidth” of 20% or more;

e. Designed or modified to use cryptographic techniques to generate the spreading code for "spread spectrum" systems, not specified by 1-5.A.2.d., including the hopping code for “frequency hopping” systems.

NON-CRYPTOGRAPHIC “INFORMATION SECURITY”

1-5.A.3. Systems, equipment and components, for non-cryptographic “information security”, as follows:

a. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion;

***Note:***
*1-5.A.3.a. applies only to physical layer security. For the purpose of 1-5.A.3.a., the physical layer includes Layer 1 of the Reference Model of Open Systems Interconnection (OSI) (ISO/IEC 7498-1).*

b. Specially designed or modified to reduce the compromising emanations of information-bearing signals beyond what is necessary for health, safety or electromagnetic interference standards.

DEFEATING, WEAKENING OR BYPASSING “INFORMATION SECURITY”

1-5.A.4. Systems, equipment and components for defeating, weakening or bypassing “information security”, as follows:

a. Designed or modified to perform ‘cryptanalytic functions’.

***Note:***
*1-5.A.4.a. includes systems or equipment, designed or modified to perform ‘cryptanalytic functions’ by means of reverse engineering.*

***Technical Note:***
*‘Cryptanalytic functions’ are functions designed to defeat cryptographic mechanisms in order to derive confidential variables or sensitive data, including clear text, passwords or cryptographic keys.*

1-5.B.2. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1-5.B.2. “Information security” test, inspection and “production” equipment, as follows:

a. Equipment specially designed for the “development” or “production” of equipment specified by 1-5.A.2., 1-5.A.3., 1-5.A.4. or 1-5.B.2.b.;

b. Measuring equipment specially designed to evaluate and validate the “information security” functions of equipment specified by 1-5.A.2., 1-5.A.3. or 1-5.A.4., or of “software” specified by 1-5.D.2.a. or 1-5.D.2.c.

1-5.C.2. MATERIALS

None

1-5.D.2. SOFTWARE

1-5.D.2. “Software” as follows:

a. “Software” specially designed or modified for the “development”, “production” or “use” of any of the following:

1. Equipment specified by 1-5.A.2. or “software” specified by 1-5.D.2.c.1.;
2. Equipment specified by 1-5.A.3. or “software” specified by 1-5.D.2.c.2.; **or**
3. Equipment specified by 1-5.A.4. or “software” specified by 1-5.D.2.c.3.;

b. “Software” having the characteristics of a ‘cryptographic activation token’ specified by 1-5.A.2.b.;

c. “Software” having the characteristics of, or performing or simulating the functions of, any of the following:

1. Equipment specified by 1-5.A.2.a., 1-5.A.2.c., 1-5.A.2.d. or 1-5.A.2.e.;

***Note:***
*1-5.D.2.c.1. does not apply to “software” limited to the tasks of “OAM” implementing only published or commercial cryptographic standards.*

2. Equipment specified by 1-5.A.3.; **or**

3. Equipment specified by 1-5.A.4.

d. Not used since 2016

***N.B.:***
*See 1-5.D.2.b. for items formerly specified in 1-5.D.2.d.*

## 1-5.E.2. TECHNOLOGY

1-5.E.2. “Technology” as follows:

a. “Technology” according to the General Technology Note for the “development”, “production” or “use” of equipment specified by 1-5.A.2., 1-5.A.3., 1-5.A.4. or 1-5.B.2., or of “software” specified by 1-5.D.2.a. or 1-5.D.2.c.;

b. “Technology” having the characteristics of a ‘cryptographic activation token’ specified by 1-5.A.2.b.;

***Note:***
*1-5.E.2. includes “information security” technical data resulting from procedures carried out to evaluate or determine the implementation of functions, features or techniques specified in Category 5 - Part 2.*

# CATEGORY 6: SENSORS AND “LASERS”

## 1-6.A. SYSTEMS, EQUIPMENT AND COMPONENTS

### 1-6.A.1. ACOUSTICS

Acoustic systems, equipment and components, as follows:

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

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

***Note:***

*1-6.A.1.a.1. does not apply to equipment as follows:*

*a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding ± 20°, and limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;*

*b. Acoustic beacons, as follows:*

*1. Acoustic emergency beacons;*

*2. Pingers specially designed for relocating or returning to an underwater position.*

a. Acoustic seabed survey equipment as follows:

1. Surface vessel survey equipment designed for seabed topographic mapping and having all of the following:

a. Designed to take measurements at an angle exceeding 20° from the vertical;

b. Designed to measure seabed topography at seabed depths exceeding 600 m;

c. ‘Sounding resolution’ less than 2; **and**

d. ‘Enhancement’ of the depth “accuracy” through compensation for all the following:

1. Motion of the acoustic sensor;

2. In-water propagation from sensor to the seabed and back; **and**

3. Sound speed at the sensor;

***Technical Notes:***

*1. ‘Sounding resolution’ is the swath width (degrees) divided by the maximum number of soundings per swath.*

*2. ‘Enhancement’ includes the ability to compensate by external means.*

2. Underwater survey equipment designed for seabed topographic mapping and having any of the following:

***Technical Note:***

*The acoustic sensor pressure rating determines the depth rating of the equipment specified by 1-6.A.1.a.1.a.2.*

a. Having all of the following:

1. Designed or modified to operate at depths exceeding 300 m; **and**

2. 'Sounding rate' greater than 3,800 m/s; **or**

***Technical Note:***

*'Sounding rate' is the product of the maximum speed (m/s) at which the sensor can operate and the maximum number of soundings per swath assuming 100% coverage. For systems that produce soundings in two directions (3D sonars), the maximum of the 'sounding rate' in either direction should be used.*

b. Survey equipment, not specified by 1-6.A.1.a.1.a.2.a., having all of the following:
   1. Designed or modified to operate at depths exceeding 100 m;
   2. Designed to take measurements at an angle exceeding 20° from the vertical;
   3. Having any of the following:
      a. Operating frequency below 350 kHz; **or**
      b. Designed to measure seabed topography at a range exceeding 200 m from the acoustic sensor; **and**
   4. 'Enhancement' of the depth "accuracy" through compensation of all of the following:
      a. Motion of the acoustic sensor;
      b. In-water propagation from sensor to the seabed and back; **and**
      c. Sound speed at the sensor.

3. Side Scan Sonar (SSS) or Synthetic Aperture Sonar (SAS), designed for seabed imaging and having all of the following, and specially designed transmitting and receiving acoustic arrays therefor:
   a. Designed or modified to operate at depths exceeding 500 m;
   b. An 'area coverage rate' of greater than 570 $m^2/s$ while operating at the maximum range that it can operate with an 'along track resolution' of less than 15 cm; **and**
   c. An 'across track resolution' of less than 15 cm;

***Technical Notes:***

*1. 'Area coverage rate' ($m^2/s$) is twice the product of the sonar range (m) and the maximum speed (m/s) at which the sensor can operate at that range.*

*2. 'Along track resolution' (cm), for SSS only, is the product of azimuth (horizontal) beamwidth (degrees) and sonar range (m) and 0.873.*

*3. 'Across track resolution' (cm) is 75 divided by the signal bandwidth (kHz).*

b. Systems or transmitting and receiving arrays, designed for object detection or location, having any of the following:
   1. A transmitting frequency below 10 kHz;
   2. Sound pressure level exceeding 224 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band from 10 kHz to 24 kHz inclusive;

3. Sound pressure level exceeding 235 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band between 24 kHz and 30 kHz;
4. Forming beams of less than 1° on any axis and having an operating frequency of less than 100 kHz;
5. Designed to operate with an unambiguous display range exceeding 5,120 m; **or**
6. Designed to withstand pressure during normal operation at depths exceeding 1,000 m and having transducers with any of the following:
   a. Dynamic compensation for pressure; **or**
   b. Incorporating other than lead zirconate titanate as the transduction element;

c. Acoustic projectors (including transducers), incorporating piezoelectric, magnetostrictive, electrostrictive, electrodynamic or hydraulic elements operating individually or in a designed combination, and having any of the following:

***Note 1:***

*The status of acoustic projectors, including transducers, specially designed for other equipment not specified by 1-6.A.1. is determined by the status of the other equipment.*

***Note 2:***

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

***Note 3:***

*Piezoelectric elements specified in 1-6.A.1.a.1.c. include those made from lead-magnesium-niobate/lead-titanate ($Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$, or PMN-PT) single crystals grown from solid solution or lead-indium-niobate/lead-magnesium niobate/lead-titanate ($Pb(In_{1/2}Nb_{1/2})O_3$–$Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$, or PIN-PMN-PT) single crystals grown from solid solution.*

1. Operating at frequencies below 10 kHz and having any of the following:
   a. Not designed for continuous operation at 100% duty cycle and having a radiated ‘free-field Source Level ($SL_{RMS}$)’ exceeding (10 log (f)+169.77)dB (reference 1 µPa at 1 m) where f is the frequency in Hertz of maximum Transmitting Voltage Response (TVR) below 10 kHz; **or**
   b. Designed for continuous operation at 100% duty cycle and having a continuously radiated ‘free-field Source Level ($SL_{RMS}$)’ at 100% duty cycle exceeding (10 log (f)+159.77)dB (reference 1 µPa at 1 m) where f is the frequency in Hertz of maximum Transmitting Voltage Response (TVR) below 10 kHz; **or**

***Technical Note:***

*The ‘free-field Source Level ($SL_{RMS}$)’ is defined along the maximum response axis and in the far field of the acoustic projector. It can be obtained from the Transmitting Voltage Response using the following equation: $SL_{RMS}$ = (TVR +*

*20log $V_{RMS}$) dB (ref 1µPa at 1 m), where $SL_{RMS}$ is the source level, TVR is the Transmitting Voltage Response and $V_{RMS}$ is the Driving Voltage of the Projector.*

2. Not used since 2014

***N.B.:***

*See 1-6.A.1.a.1.c.1. for items previously specified in 1-6.A.1.a.1.c.2.*

3. Side-lobe suppression exceeding 22 dB;

d. Acoustic systems and equipment, designed to determine the position of surface vessels or underwater vehicles and having all of the following, and specially designed components therefor:

1. Detection range exceeding 1,000 m; **and**
2. Determined position error of less than 10 m rms (root mean square) when measured at a range of 1,000 m;

***Note:***

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

*a. Equipment using coherent "signal processing" between two or more beacons and the hydrophone unit carried by the surface vessel or underwater vehicle;*

*b. Equipment capable of automatically correcting speed-of-sound propagation errors for calculation of a point.*

e. Active individual sonars, specially designed or modified to detect, locate and automatically classify swimmers or divers, having all of the following, and specially designed transmitting and receiving acoustic arrays therefor:

1. Detection range exceeding 530 m;
2. Determined position error of less than 15 m rms (root mean square) when measured at a range of 530 m; **and**
3. Transmitted pulse signal bandwidth exceeding 3 kHz;

***N.B.:***

*For diver detection systems specially designed or modified for military use, see the Munitions List.*

***Note:***

*For 1-6.A.1.a.1.e., where multiple detection ranges are specified for various environments, the greatest detection range is used.*

1-6.A.1.a.2. Passive systems, equipment and specially designed components therefor, as follows:

***Note:***

*1-6.A.1.a.2. also applies to receiving equipment, whether or not related in normal application to separate active equipment, and specially designed components therefor.*

a. Hydrophones having any of the following:

***Note:***

*The status of hydrophones specially designed for other equipment is determined by the status of the other equipment.*

***Technical Notes:***

*1. Hydrophones consist of one or more sensing elements producing a single acoustic output channel. Those that contain multiple elements can be referred to as a hydrophone group.*

*2. For the purposes of 1-6.A.1.a.2.a., underwater acoustic transducers designed to operate as passive receivers are hydrophones.*

1. Incorporating continuous flexible sensing elements;
2. Incorporating flexible assemblies of discrete sensing elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;
3. Having any of the following sensing elements:
   a. Optical fibres;
   b. 'Piezoelectric polymer films' other than polyvinylidene-fluoride (PVDF) and its co-polymers {P(VDF-TrFE) and P(VDF-TFE)};
   c. 'Flexible piezoelectric composites';
   d. Lead-magnesium-niobate/lead-titanate (i.e., $Pb(Mg_{1/3}Nb_{2/3})O_3$-$PbTiO_3$, or PMN-PT) piezoelectric single crystals grown from solid solution; **or**
   e. Lead-indium-niobate/lead-magnesium niobate/lead-titanate (i.e., $Pb(In_{1/2}Nb_{1/2})O_3$–$Pb(Mg_{1/3}Nb_{2/3})O_3$–$PbTiO_3$, or PIN-PMN-PT) piezoelectric single crystals grown from solid solution;
4. A 'hydrophone sensitivity' better than -180 dB at any depth with no acceleration compensation;
5. Designed to operate at depths exceeding 35 m with acceleration compensation; **or**
6. Designed for operation at depths exceeding 1,000 m and having a 'hydrophone sensitivity' better than -230 dB below 4 kHz;

***Technical Notes:***

*1. 'Piezoelectric polymer film' sensing elements consist of polarized polymer film that is stretched over and attached to a supporting frame or spool (mandrel).*

*2. 'Flexible piezoelectric composite' sensing elements consist of piezoelectric ceramic particles or fibres combined with an electrically insulating, acoustically transparent rubber, polymer or epoxy compound, where the compound is an integral part of the sensing elements.*

*3. 'Hydrophone sensitivity' is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydrophone sensor, without a pre-amplifier, is placed in a plane wave acoustic field with an rms pressure of 1 µPa. For example, a hydrophone of -160 dB (reference 1 V per µPa) would yield an output voltage of $10^{-8}$ V in such a field, while one of -180 dB sensitivity would yield only $10^{-9}$ V output. Thus, -160 dB is better than -180 dB.*

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

***Technical Note:***

*Hydrophone arrays consist of a number of hydrophones providing multiple acoustic output channels.*

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

   ***Technical Note:***

   *'Able to be modified' in 1-6.A.1.a.2.b. means having provisions to allow a change of the wiring or interconnections to alter hydrophone group spacing or operating depth limits. These provisions are: spare wiring exceeding 10% of the number of wires, hydrophone group spacing adjustment blocks or internal depth limiting devices that are adjustable or that control more than one hydrophone group.*
3. Heading sensors specified by 1-6.A.1.a.2.d.;
4. Longitudinally reinforced array hoses;
5. An assembled array of less than 40 mm in diameter;
6. Not used since 2007;
7. Hydrophone characteristics specified by 1-6.A.1.a.2.a.; **or**
8. Accelerometer-based hydro-acoustic sensors specified by 1-6.A.1.a.2.g.;

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

d. Heading sensors having all of the following:
   1. An "accuracy" of better than 0.5°; **and**
   2. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m;

   ***N.B.:***

   *For inertial heading systems, see 1-7.A.3.c.*

e. Bottom or bay-cable hydrophone arrays having any of the following:
   1. Incorporating hydrophones specified by 1-6.A.1.a.2.a.;
   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; **or**
   3. Incorporating accelerometer-based hydro-acoustic sensors specified by 1-6.A.1.a.2.g.;

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;

g. Accelerometer-based hydro-acoustic sensors having all of the following:

1. Composed of three accelerometers arranged along three distinct axes;
2. Having an overall 'acceleration sensitivity' better than 48 dB (reference 1,000 mV rms per 1 g);
3. Designed to operate at depths greater than 35 meters; **and**
4. Operating frequency below 20 kHz.

***Note:***

*1-6.A.1.a.2.g. does not apply to particle velocity sensors or geophones.*

***Technical Notes:***

1. *Accelerometer-based hydro-acoustic sensors are also known as vector sensors.*
2. *'Acceleration 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 hydro-acoustic sensor, without a preamplifier, is placed in a plane wave acoustic field with an rms acceleration of 1 g (i.e., 9.81 m/s$^2$).*

1-6.A.1.b. Correlation-velocity and Doppler-velocity sonar log equipment, designed to measure the horizontal speed of the equipment carrier relative to the sea bed, as follows:

1. Correlation-velocity sonar log equipment having any of the following characteristics:
   a. Designed to operate at distances between the carrier and the sea bed exceeding 500 m; **or**
   b. Having speed "accuracy" better than 1% of speed;
2. Doppler-velocity sonar log equipment having speed "accuracy" better than 1% of speed.

***Note 1:***

*1-6.A.1.b. does not apply to depth sounders limited to any of the following:*

*a. Measuring the depth of water;*

*b. Measuring the distance of submerged or buried objects;* ***or***

*c. Fish finding.*

***Note 2:***

*1-6.A.1.b. does not apply to equipment specially designed for installation on surface vessels.*

1-6.A.1.c. Not used since 2010

***N.B.:***

*For diver deterrent acoustic systems, see 1-8.A.2.r.*

1-6.A.2. OPTICAL SENSORS

Optical sensors or equipment and components therefor, as follows:

1-6.A.2.a. Optical detectors as follows:

1-6.A.2.a.1. "Space-qualified" solid-state detectors as follows:

***Note:***

*For the purpose of 1-6.A.2.a.1., solid-state detectors include "focal plane arrays".*

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;

d. "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.

1-6.A.2.a.2. Image intensifier tubes and specially designed components therefor, as follows:

***Note:***

*1-6.A.2.a.2. does not apply to non-imaging photomultiplier tubes having an electron sensing device in the vacuum space limited solely to any of the following:*

*a. A single metal anode;* ***or***

*b. Metal anodes with a centre to centre spacing greater than 500 µm.*

***Technical Note:***

*'Charge multiplication' is a form of electronic image amplification and is defined as the generation of charge carriers as a result of an impact ionization gain process. 'Charge multiplication' sensors may take the form of an image intensifier tube, solid state detector or "focal plane array".*

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. Electron image amplification using any of the following:
   a. A microchannel plate with a hole pitch (centre-to-centre spacing) of 12 µm or less; **or**
   b. An electron sensing device with a non-binned pixel pitch of 500 µm or less, specially designed or modified to achieve 'charge multiplication' other than by a microchannel plate; **and**
3. Any of the following photocathodes:
   a. Multialkali photocathodes (e.g., S-20 and S-25) having a luminous sensitivity exceeding 350 µA/lm;
   b. GaAs or GaInAs photocathodes; **or**
   c. Other "III/V compound" semiconductor photocathodes having a maximum "radiant sensitivity" exceeding 10 mA/W;

b. Image intensifier tubes having all of the following:
1. A peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,800 nm;
2. Electron image amplification using any of the following:
   a. A microchannel plate with a hole pitch (centre-to-centre spacing) of 12 µm or less; **or**

b. An electron sensing device with a non-binned pixel pitch of 500 µm or less, specially designed or modified to achieve 'charge multiplication' other than by a microchannel plate; **and**

3. "III/V compound" semiconductor (e.g., GaAs or GaInAs) photocathodes and transferred electron photocathodes, having a maximum "radiant sensitivity" exceeding 15 mA/W;

c. Specially designed components as follows:

1. Microchannel plates having a hole pitch (centre-to-centre spacing) of 12 µm or less;
2. An electron sensing device with a non-binned pixel pitch of 500 µm or less, specially designed or modified to achieve 'charge multiplication' other than by a microchannel plate;
3. "III/V compound" semiconductor (e.g., GaAs or GaInAs) photocathodes and transferred electron photocathodes;

***Note:***

*1-6.A.2.a.2.c.3. does not apply to compound semiconductor photocathodes designed to achieve a maximum "radiant sensitivity" of any of the following:*

*a. 10 mA/W or less at the peak response in the wavelength range exceeding 400 nm but not exceeding 1,050 nm;* ***or***

*b. 15 mA/W or less at the peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,800 nm.*

1-6.A.2.a.3. Non-"space-qualified" "focal plane arrays" as follows:

***N.B.:***

*'Microbolometer' non-"space-qualified" "focal plane arrays" are only specified by 1-6.A.2.a.3.f.*

***Technical Note:***

*Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays";*

***Note 1:***

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

***Note 2:***

*1-6.A.2.a.3. does not apply to:*

*a. Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;*

*b. Pyroelectric detectors using any of the following:*

*1. Triglycine sulphate and variants;*
*2. Lead-lanthanum-zirconium titanate and variants;*
*3. Lithium tantalate;*
*4. Polyvinylidene fluoride and variants;* ***or***
*5. Strontium barium niobate and variants.*

*c. "Focal plane arrays" specially designed or modified to achieve 'charge multiplication' and limited by design to have a maximum "radiant sensitivity" of 10 mA/W or less for wavelengths exceeding 760 nm, having all of the following:*

*1. Incorporating a response limiting mechanism designed not to be removed or modified;* ***and***

*2. Any of the following:*

*a. The response limiting mechanism is integral to or combined with the detector element;* ***or***

*b. The "focal plane array" is only operable with the response limiting mechanism in place.*

***Technical Note:***

*A response limiting mechanism integral to the detector element is designed not to be removed or modified without rendering the detector inoperable.*

*d. Thermopile arrays having less than 5,130 elements;*

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. Any of the following:
   a. A response "time constant" of less than 0.5 ns; **or**
   b. Specially designed or modified to achieve 'charge multiplication' and having a maximum "radiant sensitivity" exceeding 10 mA/W;

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. Any of the following:
   a. A response "time constant" of 95 ns or less; **or**
   b. Specially designed or modified to achieve 'charge multiplication' and having a maximum "radiant sensitivity" exceeding 10 mA/W;

c. Non-"space-qualified" non-linear (2-dimensional) "focal plane arrays" having individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

***N.B.:***

*Silicon and other material based 'microbolometer' non-"space-qualified" "focal plane arrays" are only specified by 1-6.A.2.a.3.f.*

d. Non-"space-qualified" linear (1-dimensional) "focal plane arrays" having all of the following :

1. Individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 3,000 nm; **and**
2. Any of the following:
   a. A ratio of 'scan direction' dimension of the detector element to the 'cross-scan direction' dimension of the detector element of less than 3.8; **or**
   b. Signal processing in the detector elements;

***Note:***

*1-6.A.2.a.3.d. does not apply to "focal plane arrays" (not to exceed 32 elements) having detector elements limited solely to germanium material.*

***Technical Note:***

*For the purposes of 1-6.A.2.a.3.d., '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.*

e. Non-"space-qualified" linear (1-dimensional) "focal plane arrays" having individual elements with a peak response in the wavelength range exceeding 3,000 nm but not exceeding 30,000 nm;

f. Non-"space-qualified" non-linear (2-dimensional) infrared "focal plane arrays" based on 'microbolometer' material having individual elements with an unfiltered response in the wavelength range equal to or exceeding 8,000 nm but not exceeding 14,000 nm;

***Technical Note:***

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

g. Non-"space-qualified" "focal plane arrays" having all of the following:

1. Individual detector elements with a peak response in the wavelength range exceeding 400 nm but not exceeding 900 nm;
2. Specially designed or modified to achieve 'charge multiplication' and having a maximum "radiant sensitivity" exceeding 10 mA/W for wavelengths exceeding 760 nm; **and**
3. Greater than 32 elements;

1-6.A.2.b. "Monospectral imaging sensors" and "multispectral imaging sensors", designed for remote sensing applications and having any of the following:

1. An Instantaneous-Field-Of-View (IFOV) of less than 200 µrad (microradians); **or**
2. 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. Having any of the following characteristics:
      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);

***Note:***

*1-6.A.2.b.1. does not apply to "monospectral imaging sensors" with a peak response in the wavelength range exceeding 300 nm but not exceeding 900 nm and only incorporating any of the following non-"space-qualified" detectors or non-"space-qualified" "focal plane arrays":*

*a. Charge Coupled Devices (CCD) not designed or modified to achieve 'charge multiplication'; **or***

*b. Complementary Metal Oxide Semiconductor (CMOS) devices not designed or modified to achieve 'charge multiplication'.*

1-6.A.2.c. 'Direct view' imaging equipment incorporating any of the following:

1. Image intensifier tubes having the characteristics listed in 1-6.A.2.a.2.a. or 1-6.A.2.a.2.b.;
2. "Focal plane arrays" having the characteristics listed in 1-6.A.2.a.3.; **or**
3. Solid state detectors specified by 1-6.A.2.a.1.;

***Technical Note:***

*'Direct view' refers to imaging equipment that presents a visual image to a human observer without converting the image into an electronic signal for television display,*

*and that cannot record or store the image photographically, electronically or by any other means.*

***Note:***

*1-6.A.2.c. does not apply to equipment as follows, when 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.*

1-6.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;

***Note:***

*1-6.A.2.d.3. does not apply to encapsulated optical sensing fibres specially designed for bore hole sensing applications.*

1-6.A.2.e. Not used since 2008

1-6.A.2.f. 'Read-out integrated circuits' ('ROIC') specially designed for "focal plane arrays" specified by 1-6.A.2.a.3.

***Note:***

*1-6.A.2.f. does not apply to 'read-out integrated circuits' specially designed for civil automotive applications.*

***Technical Note:***

*A 'Read-Out Integrated Circuit' ('ROIC') is an integrated circuit designed to underlie or be bonded to a "focal plane array" ("FPA") and used to read-out (i.e., extract and register) signals produced by the detector elements. At a minimum the 'ROIC' reads the charge from the detector elements by extracting the charge and applying a multiplexing function in a manner that retains the relative spatial position and orientation information of the detector elements for processing inside or outside the 'ROIC'.*

1-6.A.3. CAMERAS

Cameras, systems or equipment, and components therefor, as follows:

1-6.A.3.a. Instrumentation cameras and specially designed components therefor, as follows:

***Note:***

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

1. Not used since 2017
2. Not used since 2017
3. Electronic streak cameras having temporal resolution better than 50 ns;
4. Electronic framing cameras having a speed exceeding 1,000,000 frames/s;
5. Electronic cameras having all of the following:
   a. An electronic shutter speed (gating capability) of less than 1 µs per full frame; **and**
   b. A read out time allowing a framing rate of more than 125 full frames per second;
6. Plug-ins having all of the following characteristics:
   a. Specially designed for instrumentation cameras which have modular structures and which are specified by 1-6.A.3.a.; **and**
   b. Enabling these cameras to meet the characteristics specified by 1-6.A.3.a.3., 1-6.A.3.a.4. or 1-6.A.3.a.5., according to the manufacturer's specifications;

1-6.A.3.b. Imaging cameras as follows:

***Note:***

*1-6.A.3.b. does not apply to television or video cameras, specially designed for television broadcasting.*

1-6.A.3.b.1. Video cameras incorporating solid state sensors, having a peak response in the wavelength range exceeding 10 nm, but not exceeding 30,000 nm and having all of the following:

a. Having any of the following:
   1. More than 4 x $10^6$ "active pixels" per solid state array for monochrome (black and white) cameras;
   2. More than 4 x $10^6$ "active pixels" per solid state array for colour cameras incorporating three solid state arrays; **or**
   3. More than 12 x $10^6$ "active pixels" for solid state array colour cameras incorporating one solid state array; **and**

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

***Technical Notes:***

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

*2. For the purpose of this entry, 'camera tracking data' is the information necessary to define camera line of sight orientation with respect to the earth. This includes: 1) the horizontal angle the camera line of sight makes with respect to the earth's magnetic field direction and; 2) the vertical angle between the camera line of sight and the earth's horizon.*

1-6.A.3.b.2. Scanning cameras and scanning camera systems, having all of the following:

a. A peak response in the wavelength range exceeding 10 nm, but not exceeding 30,000 nm;

b. Linear detector arrays with more than 8,192 elements per array; **and**

c. Mechanical scanning in one direction;

***Note:***

*1-6.A.3.b.2. does not apply to scanning cameras and scanning camera systems, specially designed for any of the following:*

*a. Industrial or civilian photocopiers;*

*b. Image scanners specially designed for civil, stationary, close proximity scanning applications (e.g., reproduction of images or print contained in documents, artwork or photographs);* ***or***

*c. Medical equipment.*

1-6.A.3.b.3. Imaging cameras incorporating image intensifier tubes having the characteristics listed in 1-6.A.2.a.2.a. or 1-6.A.2.a.2.b.;

1-6.A.3.b.4. Imaging cameras incorporating "focal plane arrays" having any of the following:

a. Incorporating "focal plane arrays" specified by 1-6.A.2.a.3.a. to 1-6.A.2.a.3.e.;

b. Incorporating "focal plane arrays" specified by 1-6.A.2.a.3.f.; **or**

c. Incorporating "focal plane arrays" specified by 1-6.A.2.a.3.g.;

***Note 1:***

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

***Note 2:***

*1-6.A.3.b.4.a. does not apply to imaging cameras incorporating linear "focal plane arrays" with 12 elements or fewer, not employing time-delay-and-integration within the element and designed for any of the following:*

*a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;*

*b. Industrial equipment used for inspection or monitoring of heat flows in buildings, equipment or industrial processes;*

*c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;*

*d. Equipment specially designed for laboratory use;* ***or***

*e. Medical equipment.*

***Note 3:***

*1-6.A.3.b.4.b. does not apply to imaging cameras having any of the following:*

*a. A maximum frame rate equal to or less than 9 Hz;*

*b. Having all of the following:*

*1. Having a minimum horizontal or vertical 'Instantaneous-Field-of-View (IFOV)' of at least 2 mrad (milliradians);*

*2. Incorporating a fixed focal-length lens that is not designed to be removed;*

*3. Not incorporating a 'direct view' display;* ***and***

***Technical Note:***

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

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

***Technical Note:***

*'Instantaneous Field of View (IFOV)' specified in Note 3.b. is the lesser figure of the 'Horizontal IFOV' or the 'Vertical IFOV'.*

*'Horizontal IFOV' = horizontal Field of View (FOV)/number of horizontal detector elements*

*'Vertical IFOV'= vertical Field of View (FOV)/number of vertical detector elements.*

c. *The camera is specially designed for installation into a civilian passenger land vehicle and having all of the following:*
   1. *The placement and configuration of the camera within the vehicle are solely to assist the driver in the safe operation of the vehicle;*
   2. *Is only operable when installed in any of the following:*
      a. *The civilian passenger land vehicle for which it was intended and the vehicle weighs less than 4,500 kg (gross vehicle weight);* ***or***
      b. *A specially designed, authorized maintenance test facility;* ***and***
   3. *Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended.*

***Note:***

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

***Note 4:***

*1-6.A.3.b.4.c. does not apply to imaging cameras having any of the following characteristics:*

a. *Having all of the following:*
   1. *Where the camera is specially designed for installation as an integrated component into indoor and wall-plug-operated systems or equipment, limited by design for a single kind of application, as follows:*
      a. *Industrial process monitoring, quality control, or analysis of the properties of materials;*
      b. *Laboratory equipment specially designed for scientific research;*
      c. *Medical equipment;*
      d. *Financial fraud detection equipment;* ***and***
   2. *Is only operable when installed in any of the following:*
      a. *The system(s) or equipment for which it was intended;* ***or***
      b. *A specially designed, authorised maintenance facility;* ***and***
   3. *Incorporates an active mechanism that forces the camera not to function when it is removed from the system(s) or equipment for which it was intended;*

*b. Where the camera is specially designed for installation into a civilian passenger land vehicle or passenger and vehicle ferries, and having all of the following:*

*1. The placement and configuration of the camera within the vehicle or ferry is solely to assist the driver or operator in the safe operation of the vehicle or ferry;*

*2. Is only operable when installed in any of the following:*

*a. The civilian passenger land vehicle for which it was intended and the vehicle weighs less than 4,500 kg (gross vehicle weight);*

*b. The passenger and vehicle ferry for which it was intended and having a length overall (LOA) 65 m or greater;* ***or***

*c. A specially designed, authorised maintenance test facility;* ***and***

*3. Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended;*

*c. Limited by design to have a maximum "radiant sensitivity" of 10 mA/W or less for wavelengths exceeding 760 nm, having all of the following:*

*1. Incorporating a response limiting mechanism designed not to be removed or modified;*

*2. Incorporates an active mechanism that forces the camera not to function when the response limiting mechanism is removed;* ***and***

*3. Not specially designed or modified for underwater use;* ***or***

*d. Having all of the following:*

*1. Not incorporating a 'direct view' or electronic image display;*

*2. Has no facility to output a viewable image of the detected field of view;*

*3. The "focal plane array" is only operable when installed in the camera for which it was intended;* ***and***

*4. The "focal plane array" incorporates an active mechanism that forces it to be permanently inoperable when removed from the camera for which it was intended.*

***Note:***

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

1-6.A.3.b.5. Imaging cameras incorporating solid-state detectors specified by 1-6.A.2.a.1.

1-6.A.4. OPTICS

Optical equipment and components, as follows:

1-6.A.4.a. Optical mirrors (reflectors) as follows:

***Technical Note:***

*For the purpose of 1-6.A.4.a., Laser Induced Damage Threshold (LIDT) is measured according to ISO 21254-1:2011.*

1. 'Deformable mirrors' having an active optical aperture greater than 10 mm and having any of the following, and specially designed components therefor:

a. Having all the following:

1. A mechanical resonant frequency of 750 Hz or more; **and**

2. More than 200 actuators; **or**

b. A Laser Induced Damage Threshold (LIDT) being any of the following:
   1. Greater than 1 kW/cm$^2$ using a "CW laser"; **or**
   2. Greater than 2 J/cm$^2$ using 20 ns "laser" pulses at 20 Hz repetition rate;

***Technical Note:***

*'Deformable mirrors' are mirrors having any of the following:*

*a. A single continuous optical reflecting surface which is dynamically deformed by the application of individual torques or forces to compensate for distortions in the optical waveform incident upon the mirror;* ***or***

*b. Multiple optical reflecting elements that can be individually and dynamically repositioned by the application of torques or forces to compensate for distortions in the optical waveform incident upon the mirror.*

*'Deformable mirrors' are also known as adaptive optic mirrors.*

2. Lightweight monolithic mirrors having an average "equivalent density" of less than 30 kg/m$^2$ and a total mass exceeding 10 kg;
3. Lightweight "composite" or foam mirror structures having an average "equivalent density" of less than 30 kg/m$^2$ and a total mass exceeding 2 kg;

***Note:***

*1-6.A.4.a.2. and 1-6.A.4.a.3. do not apply to mirrors specially designed to direct solar radiation for terrestrial heliostat installations.*

4. Mirrors specially designed for beam steering mirror stages specified in 1-6.A.4.d.2.a. with a flatness of $\lambda/10$ or better ($\lambda$ is equal to 633 nm) and having any of the following:
   a. Diameter or major axis length greater than or equal to 100 mm; or
   b. Having all of the following:
      1. Diameter or major axis length greater than 50 mm but less than 100 mm; **and**
      2. A Laser Induced Damage Threshold (LIDT) being any of the following:
         a. Greater than 10 kW/cm$^2$ using a "CW laser"; **or**
         b. Greater than 20 J/cm$^2$ using 20 ns "laser" pulses at 20 Hz repetition rate;

***N.B.:***

*For optical mirrors specially designed for lithography equipment, see 1-3.B.1.*

1-6.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 cm$^3$ in volume; **or**
2. Exceeding 80 mm in diameter or length of major axis and 20 mm in thickness (depth);

1-6.A.4.c. "Space-qualified" components for optical systems, as follows:
1. Components 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. Components manufactured from "composite" materials having a coefficient of linear thermal expansion equal to or less than $5 \times 10^{-6}$ in any coordinate direction;

1-6.A.4.d. Optical control equipment as follows:

1. Equipment specially designed to maintain the surface figure or orientation of the "space-qualified" components specified by 1-6.A.4.c.1. or 1-6.A.4.c.3.;
2. Steering, tracking, stabilisation and resonator alignment equipment as follows:
   a. Beam steering mirror stages designed to carry mirrors having diameter or major axis length greater than 50 mm and having all of the following, and specially designed electronic control equipment therefor:
      1. A maximum angular travel of ±26 mrad or more;
      2. A mechanical resonant frequency of 500 Hz or more; **and**
      3. An angular "accuracy" of 10 µrad (microradians) or less (better);
   b. Resonator alignment equipment having bandwidths equal to or more than 100 Hz and an "accuracy" of 10 µrad or less (better);
3. Gimbals having all of the following:
   a. A maximum slew exceeding 5°;
   b. A bandwidth of 100 Hz or more;
   c. Angular pointing errors of 200 µrad (microradians) or less; **and**
   d. Having any of the following:
      1. Exceeding 0.15 m but not exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 2 rad (radians)/$s^2$; **or**
      2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 rad (radians)/$s^2$;
4. Not used since 2014

1-6.A.4.e. 'Aspheric optical elements' having all of the following:

1. Largest dimension of the optical-aperture greater than 400 mm;
2. Surface roughness less than 1 nm (rms) for sampling lengths equal to or greater than 1 mm; **and**
3. Coefficient of linear thermal expansion's absolute magnitude 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 1-6.A.4.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the specified parameter.*

***Note:***

*1-6.A.4.e. does not apply to 'aspheric optical elements' having any of the following:*

a. *Largest optical-aperture dimension less than 1 m and focal length to aperture ratio equal to or greater than 4.5:1;*
b. *Largest optical-aperture dimension equal to or greater than 1 m and focal length to aperture ratio equal to or greater than 7:1;*
c. *Designed as Fresnel, flyeye, stripe, prism or diffractive optical elements;*
d. *Fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than 2.5 x $10^{-6}$/K at 25° C;* ***or***
e. *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 1-3.B.1.*

1-6.A.4.f. Dynamic wavefront measuring equipment having all of the following:

1. 'Frame rates' equal to or more than 1 kHz; **and**
2. A wavefront accuracy equal to or less (better) than λ/20 at the designed wavelength.

***Technical Note***

*For the purposes of 1-6.A.4.f., 'frame rate' is a frequency at which all "active pixels" in the "focal plane array" are integrated for recording images projected by the wavefront sensor optics.*

1-6.A.5. LASERS

"Lasers", components and optical equipment, as follows:

***Note 1:***

*Pulsed "lasers" include those that run in a continuous wave (CW) mode with pulses superimposed.*

***Note 2:***

*Excimer, semiconductor, chemical, CO, $CO_2$, and 'non-repetitive pulsed' Nd: glass "lasers" are only specified by 1-6.A.5.d.*

***Technical Note:***

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

***Note 3:***

*1-6.A.5. includes fibre "lasers".*

***Note 4:***

*The status of "lasers" incorporating frequency conversion (i.e., wavelength change) by means other than one "laser" pumping another "laser" is determined by applying the specified parameters for both the output of the source "laser" and the frequency-converted optical output.*

***Note 5:***

*1-6.A.5. does not apply to "lasers" as follows:*

a. *Ruby with output energy below 20 J;*

*b. Nitrogen;*

*c. Krypton.*

***Note 6:***

*For the purposes of 1-6.A.5.a. and 1-6.A.5.b., 'single transverse mode' refers to "lasers" with a beam profile having an $M^2$-factor of less than 1.3, while 'multiple transverse mode' refers to "lasers" with a beam profile having an $M^2$-factor of 1.3 or higher.*

1-6.A.5.a. Non-"tunable" continuous wave "(CW) lasers" having any of the following:

1. Output wavelength less than 150 nm and output power exceeding 1 W;
2. Output wavelength of 150 nm or more but not exceeding 510 nm and output power exceeding 30 W;

   ***Note:***

   *1-6.A.5.a.2. does not apply to Argon "lasers" having an output power equal to or less than 50 W.*
3. Output wavelength exceeding 510 nm but not exceeding 540 nm and any of the following:
   a. 'Single transverse mode' output and output power exceeding 50 W; **or**
   b. 'Multiple transverse mode' output and output power exceeding 150 W;
4. Output wavelength exceeding 540 nm but not exceeding 800 nm and output power exceeding 30 W;
5. Output wavelength exceeding 800 nm but not exceeding 975 nm and any of the following:
   a. 'Single transverse mode' output and output power exceeding 50 W; **or**
   b. 'Multiple transverse mode' output and output power exceeding 80 W;
6. Output wavelength exceeding 975 nm but not exceeding 1,150 nm and any of the following:
   a. 'Single transverse mode' output and any of the following:
      1. Average output power exceeding 1,000 W; **or**
      2. Having all of the following:
         a. Average output power exceeding 500 W; **and**
         b. Spectral bandwidth less than 40 GHz; **or**
   b. 'Multiple transverse mode' output and any of the following:
      1. 'Wall-plug efficiency' exceeding 18% and output power exceeding 1,000 W; **or**
      2. Output power exceeding 2 kW;

      ***Note 1:***

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

      ***Note 2:***

      *1-6.A.5.a.6.b. does not apply to 'multiple transverse mode', industrial "lasers" having any of the following:*

      *a. Not used since 2018*

*b. Output power exceeding 1 kW but not exceeding 1.6 kW and having a BPP exceeding 1.25 mm•mrad;*

*c. Output power exceeding 1.6 kW but not exceeding 2.5 kW and having a BPP exceeding 1.7 mm•mrad;*

*d. Output power exceeding 2.5 kW but not exceeding 3.3 kW and having a BPP exceeding 2.5 mm•mrad;*

*e. Output power exceeding 3.3 kW but not exceeding 6 kW and having a BPP exceeding 3.5 mm•mrad;*

*f. Not used since 2018*

*g. Not used since 2018*

*h. Output power exceeding 6 kW but not exceeding 8 kW and having a BPP exceeding 12 mm•mrad;* ***or***

*i. Output power exceeding 8 kW but not exceeding 10 kW and having a BPP exceeding 24 mm•mrad;*

***Technical Note***

*For the purpose of 1-6.A.5.a.6.b., Note 2.a., 'brightness' is defined as the output power of the "laser" divided by the squared Beam Parameter Product (BPP), i.e., (output power)/BPP$^2$.*

***Technical Note:***

*'Wall-plug efficiency' is defined as the ratio of "laser" output power (or "average output power") to total electrical input power required to operate the "laser", including the power supply/conditioning and thermal conditioning/heat exchanger.*

7. Output wavelength exceeding 1,150 nm but not exceeding 1,555 nm and any of the following:
   a. 'Single transverse mode' and output power exceeding 50 W; **or**
   b. 'Multiple transverse mode' and output power exceeding 80 W;
8. Output wavelength exceeding 1,555 nm but not exceeding 1,850 nm, and output power exceeding 1 W;
9. Output wavelength exceeding 1,850 nm but not exceeding 2,100 nm, and any of the following:
   a. 'Single transverse mode' and output power exceeding 1 W; **or**
   b. 'Multiple transverse mode' output and output power exceeding 120 W; **or**
10. Output wavelength exceeding 2,100 nm and output power exceeding 1 W;

1-6.A.5.b. Non-"tunable" "pulsed lasers" having any of the following:

1. Output wavelength less than 150 nm and any of the following:
   a. Output energy exceeding 50 mJ per pulse and "peak power" exceeding 1 W; **or**
   b. "Average output power" exceeding 1 W;
2. Output wavelength of 150 nm or more but not exceeding 510 nm and any of the following:
   a. Output energy exceeding 1.5 J per pulse and "peak power" exceeding 30 W; **or**
   b. "Average output power" exceeding 30 W;

***Note:***

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

3. Output wavelength exceeding 510 nm but not exceeding 540 nm and any of the following:
   a. ‘Single transverse mode’ output and any of the following:
      1. Output energy exceeding 1.5 J per pulse and “peak power” exceeding 50 W; **or**
      2. “Average output power” exceeding 50 W; **or**
   b. ‘Multiple transverse mode’ output and any of the following:
      1. Output energy exceeding 1.5 J per pulse and “peak power” exceeding 150 W; **or**
      2. “Average output power” exceeding 150 W;
4. Output wavelength exceeding 540 nm but not exceeding 800 nm and any of the following:
   a. “Pulse duration” less than 1 ps and any of the following:
      1. Output energy exceeding 0.005 J per pulse and “peak power” exceeding 5 GW; **or**
      2. “Average output power” exceeding 20 W; **or**
   b. “Pulse duration” equal to or exceeding 1 ps and any of the following:
      1. Output energy exceeding 1.5 J per pulse and “peak power” exceeding 30 W; **or**
      2. “Average output power” exceeding 30 W;
5. Output wavelength exceeding 800 nm but not exceeding 975 nm and any of the following:
   a. “Pulse duration” less than 1 ps and any of the following:
      1. Output energy exceeding 0.005 J per pulse and “peak power” exceeding 5 GW; **or**
      2. ‘Single transverse mode’ output and “average output power” exceeding 20 W;
   b. “Pulse duration” equal to or exceeding 1 ps and not exceeding 1 μs and any of the following:
      1. Output energy exceeding 0.5 J per pulse and “peak power” exceeding 50 W;
      2. ‘Single transverse mode’ output and “average output power” exceeding 20 W; **or**
      3. ‘Multiple transverse mode’ output and “average output power” exceeding 50 W; **or**
   c. “Pulse duration” exceeding 1 μs and any of the following:
      1. Output energy exceeding 2 J per pulse and “peak power” exceeding 50 W;
      2. ‘Single transverse mode’ output and “average output power” exceeding 50 W; **or**
      3. ‘Multiple transverse mode’ output and “average output power” exceeding 80 W;
6. Output wavelength exceeding 975 nm but not exceeding 1,150 nm and any of the following:
   a. “Pulse duration” of less than 1 ps, and any of the following:
      1. Output “peak power” exceeding 2 GW per pulse;
      2. “Average output power” exceeding 30 W; **or**

3. Output energy exceeding 0.002 J per pulse;

b. “Pulse duration” equal to or exceeding 1 ps and less than 1 ns, and any of the following:
   1. Output “peak power” exceeding 5 GW per pulse;
   2. “Average output power” exceeding 50 W; **or**
   3. Output energy exceeding 0.1 J per pulse;

c. “Pulse duration” equal to or exceeding 1 ns but not exceeding 1 μs and any of the following:
   1. ‘Single transverse mode’ output and any of the following:
      a. “Peak power” exceeding 100 MW;
      b. “Average output power” exceeding 20 W limited by design to a maximum pulse repetition frequency less than or equal to 1 kHz;
      c. ‘Wall-plug efficiency’ exceeding 12%, “average output power” exceeding 100 W and capable of operating at a pulse repetition frequency greater than 1 kHz;
      d. “Average output power” exceeding 150 W and capable of operating at a pulse repetition frequency greater than 1 kHz; **or**
      e. Output energy exceeding 2 J per pulse; **or**
   2. ‘Multiple transverse mode’ output and any of the following:
      a. “Peak power” exceeding 400 MW;
      b. ‘Wall-plug efficiency’ exceeding 18% and “average output power” exceeding 500 W;
      c. “Average output power” exceeding 2 kW; **or**
      d. Output energy exceeding 4 J per pulse; **or**

d. “Pulse duration” exceeding 1 μs and any of the following:
   1. ‘Single transverse mode’ output and any of the following:
      a. “Peak power” exceeding 500 kW;
      b. ‘Wall-plug efficiency’ exceeding 12% and “average output power” exceeding 100 W; **or**
      c. “Average output power” exceeding 150 W; **or**
   2. ‘Multiple transverse mode’ output and any of the following:
      a. “Peak power” exceeding 1 MW;
      b. ‘Wall-plug efficiency’ exceeding 18% and “average output power” exceeding 500 W; **or**
      c. “Average output power” exceeding 2 kW;

7. Output wavelength exceeding 1,150 nm but not exceeding 1,555 nm, and any of the following:
   a. “Pulse duration” not exceeding 1 μs and any of the following:
      1. Output energy exceeding 0.5 J per pulse and “peak power” exceeding 50 W;
      2. ‘Single transverse mode’ output and “average output power” exceeding 20 W; **or**
      3. ‘Multiple transverse mode’ output and “average output power” exceeding 50 W; **or**

b. "Pulse duration" exceeding 1 μs and any of the following:
   1. Output energy exceeding 2 J per pulse and "peak power" exceeding 50 W;
   2. 'Single transverse mode' output and "average output power" exceeding 50 W; **or**
   3. 'Multiple transverse mode' output and "average output power" exceeding 80 W;

8. Output wavelength exceeding 1,555 nm but not exceeding 1,850 nm, and any of the following:
   a. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 1 W; **or**
   b. "Average output power" exceeding 1 W;
9. Output wavelength exceeding 1,850 nm but not exceeding 2,100 nm, and any of the following:
   a. 'Single transverse mode' and any of the following:
      1. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 1 W; **or**
      2. "Average output power" exceeding 1 W; **or**
   b. 'Multiple transverse mode' and any of the following:
      1. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 10 kW; **or**
      2. "Average output power" exceeding 120 W; **or**
10. Output wavelength exceeding 2,100 nm and any of the following:
    a. Output energy exceeding 100 mJ per pulse and "peak power" exceeding 1 W; **or**
    b. "Average output power" exceeding 1 W;

1-6.A.5.c. "Tunable" "lasers" having any of the following:

1. Output wavelength less than 600 nm and any of the following:
   a. Output energy exceeding 50 mJ per pulse and "peak power" exceeding 1 W; **or**
   b. Average or CW output power exceeding 1 W;

   ***Note:***
   *1-6.A.5.c.1. does not apply to dye "lasers" or other liquid "lasers", having a multimode output and a wavelength of 150 nm or more but not exceeding 600 nm and all of the following:*
   *1. Output energy less than 1.5 J per pulse or a "peak power" less than 20 W;* ***and***
   *2. Average or CW output power less than 20 W.*
2. Output wavelength of 600 nm or more but not exceeding 1,400 nm, and any of the following:
   a. Output energy exceeding 1 J per pulse and "peak power" exceeding 20 W; **or**
   b. Average or CW output power exceeding 20 W; **or**
3. Output wavelength exceeding 1,400 nm and any of the following:
   a. Output energy exceeding 50 mJ per pulse and "peak power" exceeding 1 W; **or**
   b. Average or CW output power exceeding 1 W;

1-6.A.5.d. Other “lasers”, not specified by 1-6.A.5.a., 1-6.A.5.b. or 1-6.A.5.c. as follows:

1. Semiconductor “lasers” as follows:

***Note 1:***

*1-6.A.5.d.1. includes semiconductor “lasers” having optical output connectors (e.g. fibre optic pigtails).*

***Note 2:***

*The status of semiconductor “lasers” specially designed for other equipment is determined by the status of the other equipment.*

a. Individual single-transverse mode semiconductor “lasers” having any of the following:
   1. Wavelength equal to or less than 1,510 nm and average or CW output power, exceeding 1.5 W; **or**
   2. Wavelength greater than 1,510 nm and average or CW output power, exceeding 500 mW;

b. Individual multiple-transverse mode semiconductor “lasers” having any of the following:
   1. Wavelength of less than 1,400 nm and average or CW output power, exceeding 15 W;
   2. Wavelength equal to or greater than 1,400 nm and less than 1,900 nm and average or CW output power, exceeding 2.5 W; **or**
   3. Wavelength equal to or greater than 1,900 nm and average or CW output power, exceeding 1 W;

c. Individual semiconductor “laser” ‘bars’ having any of the following:
   1. Wavelength of less than 1,400 nm and average or CW output power, exceeding 100 W;
   2. Wavelength equal to or greater than 1,400 nm and less than 1,900 nm and average or CW output power, exceeding 25 W; **or**
   3. Wavelength equal to or greater than 1,900 nm and average or CW output power, exceeding 10 W;

d. Semiconductor “laser” ‘stacked arrays’ (two-dimensional arrays) having any of the following:
   1. Wavelength less than 1,400 nm and having any of the following:
      a. Average or CW total output power less than 3 kW and having average or CW output ‘power density’ greater than 500 W/cm$^2$;
      b. Average or CW total output power equal to or exceeding 3 kW but less than or equal to 5 kW, and having average or CW output ‘power density’ greater than 350W/cm$^2$;
      c. Average or CW total output power exceeding 5 kW;
      d. Peak pulsed ‘power density’ exceeding 2,500 W/cm$^2$; **or**

      ***Note:***

      *1-6.A.5.d.1.d.1.d. does not apply to epitaxially-fabricated monolithic devices.*

      e. Spatially coherent average or CW total output power, greater than 150 W;

2. Wavelength greater than or equal to 1,400 nm but less than 1,900 nm, and having any of the following:
   a. Average or CW total output power less than 250 W and average or CW output 'power density' greater than 150 W/cm$^2$;
   b. Average or CW total output power equal to or exceeding 250 W but less than or equal to 500 W, and having average or CW output 'power density' greater than 50 W/cm$^2$;
   c. Average or CW total output power exceeding 500 W;
   d. Peak pulsed 'power density' exceeding 500 W/cm$^2$; **or**

   ***Note:***
   *1-6.A.5.d.1.d.2.d. does not apply to epitaxially-fabricated monolithic devices.*

   e. Spatially coherent average or CW total output power, exceeding 15 W;
3. Wavelength greater than or equal to 1,900 nm and having any of the following:
   a. Average or CW output 'power density' greater than 50 W/cm$^2$;
   b. Average or CW output power greater than 10 W; **or**
   c. Spatially coherent average or CW total output power, exceeding 1.5 W; **or**
4. At least one "laser" 'bar' specified by 1-6.A.5.d.1.c.;

***Technical Note:***
*For the purposes of 1-6.A.5.d.1.d., 'power density' means the total "laser" output power divided by the emitter surface area of the 'stacked array'.*

e. Semiconductor "laser" 'stacked arrays', other than those specified by 1-6.A.5.d.1.d., having all of the following:
   1. Specially designed or modified to be combined with other 'stacked arrays' to form a larger 'stacked array'; **and**
   2. Integrated connections, common for both electronics and cooling;

   ***Note 1:***
   *'Stacked arrays', formed by combining semiconductor "laser" 'stacked arrays' specified by 1-6.A.5.d.1.e., that are not designed to be further combined or modified are specified by 1-6.A.5.d.1.d.*

   ***Note 2:***
   *'Stacked arrays', formed by combining semiconductor "laser" 'stacked arrays' specified by 1-6.A.5.d.1.e., that are designed to be further combined or modified are specified by 1-6.A.5.d.1.e.*

   ***Note 3:***
   *1-6.A.5.d.1.e. does not apply to modular assemblies of single 'bars' designed to be fabricated into end-to-end stacked linear arrays.*

***Technical Notes:***

1. *Semiconductor "lasers" are commonly called "laser" diodes.*

2. *A 'bar' (also called a semiconductor "laser" 'bar', a "laser" diode 'bar' or diode 'bar') consists of multiple semiconductor "lasers" in a one-dimensional array.*
3. *A 'stacked array' consists of multiple 'bars' forming a two-dimensional array of semiconductor "lasers".*

2. Carbon monoxide (CO) "lasers" having any of the following:
   a. Output energy exceeding 2 J per pulse and "peak power" exceeding 5 kW; **or**
   b. Average or CW output power exceeding 5 kW;
3. Carbon dioxide ($CO_2$) "lasers" having any of the following:
   a. CW output power exceeding 15 kW;
   b. Pulsed output with a "pulse duration" exceeding 10 µs and any of the following:
      1. "Average output power" exceeding 10 kW; **or**
      2. "Peak power" exceeding 100 kW; **or**
   c. Pulsed output with a "pulse duration" equal to or less than 10 µs and any of the following:
      1. Pulse energy exceeding 5 J per pulse; **or**
      2. "Average output power" exceeding 2.5 kW;
4. Excimer "lasers" having any of the following:
   a. Output wavelength not exceeding 150 nm and any of the following:
      1. Output energy exceeding 50 mJ per pulse; **or**
      2. "Average output power" exceeding 1 W;
   b. Output wavelength exceeding 150 nm but not exceeding 190 nm and any of the following:
      1. Output energy exceeding 1.5 J per pulse; **or**
      2. "Average output power" exceeding 120 W;
   c. Output wavelength exceeding 190 nm but not exceeding 360 nm and any of the following:
      1. Output energy exceeding 10 J per pulse; **or**
      2. "Average output power" exceeding 500 W; **or**
   d. Output wavelength exceeding 360 nm and any of the following:
      1. Output energy exceeding 1.5 J per pulse; **or**
      2. "Average output power" exceeding 30 W;

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

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

***Technical Note:***
*'Transfer lasers' are "lasers" in which the lasing species are excited through the transfer of energy by collision of a non-lasing atom or molecule with a lasing atom or molecule species.*

6. ‘Non-repetitive pulsed’ Nd: glass “lasers” having any of the following:
   a. “Pulse duration” not exceeding 1 μs and output energy exceeding 50 J per pulse; **or**
   b. “Pulse duration” exceeding 1 μs and output energy exceeding 100 J per pulse;

1-6.A.5.e. Components as follows:

1. Mirrors cooled either by ‘active cooling’ or by heat pipe cooling;

   ***Technical Notes:***

   *‘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, other than fused tapered fibre combiners and Multi-Layer Dielectric gratings (MLDs), specially designed for use with specified “lasers”;

   ***Note:***

   *Fibre combiners and MLDs are specified by 1-6.A.5.e.3.*

3. Fibre “laser” components as follows:
   a. Multimode to multimode fused tapered fibre combiners having all of the following:
      1. An insertion loss better (less) than or equal to 0.3 dB maintained at a rated total average or CW output power (excluding output power transmitted through the single mode core if present) exceeding 1,000 W; **and**
      2. Number of input fibres equal to or greater than 3;
   b. Single mode to multimode fused tapered fibre combiners having all of the following:
      1. An insertion loss better (less) than 0.5 dB maintained at a rated total average or CW output power exceeding 4,600 W;
      2. Number of input fibres equal to or greater than 3; **and**
      3. Having any of the following:
         a. A Beam Parameter Product (BPP) measured at the output not exceeding 1.5 mm mrad for a number of input fibres less than or equal to 5; **or**
         b. A BPP measured at the output not exceeding 2.5 mm mrad for a number of input fibres greater than 5;
   c. MLDs having all of the following:
      1. Designed for spectral or coherent beam combination of 5 or more fibre “lasers”; **and**
      2. CW “Laser” Induced Damage Threshold (LIDT) greater than or equal to 10 kW/cm$^2$.

1-6.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 2-19. Note 2.d.*

1. Not used since 2017

***N.B.:***

*For items previously specified by 1-6.A.5.f.1., see 1-6.A.4.f.*

2. “Laser” diagnostic equipment specially designed for dynamic measurement of “SHPL” system angular beam steering errors and having an angular “accuracy” of 10 µrad (microradians) or less (better);
3. Optical equipment and components, specially designed for coherent beam combination in a phased-array “SHPL” system and having any of the following:
   a. An “accuracy” of 0.1µm or less, for wavelengths greater than 1 µm; **or**
   b. An “accuracy” of λ/10 or less (better) at the designed wavelength, for wavelengths equal to or less than 1 µm;
4. Projection telescopes specially designed for use with “SHPL” systems;

1-6.A.5.g. ‘Laser acoustic detection equipment’ having all of the following:

1. CW “laser” output power equal to or exceeding 20 mW;
2. “Laser” frequency stability equal to or better (less) than 10 MHz;
3. “Laser” wavelengths equal to or exceeding 1,000 nm but not exceeding 2,000 nm;
4. Optical system resolution better (less) than 1 nm; **and**
5. Optical Signal to Noise ratio equal to or exceeding $10^3$.

***Technical Note:***

*‘Laser acoustic detection equipment’ is sometimes referred to as a “Laser” Microphone or Particle Flow Detection Microphone.*

1-6.A.6. MAGNETIC AND ELECTRIC FIELD SENSORS

“Magnetometers”, “magnetic gradiometers”, “intrinsic magnetic gradiometers”, underwater electric field sensors, “compensation systems”, and specially designed components therefor, as follows:

***Note:***

*1-6.A.6. does not apply to instruments specially designed for fishery applications or biomagnetic measurements for medical diagnostics.*

1-6.A.6.a. “Magnetometers” and subsystems, as follows:

1. “Magnetometers” using “superconductive” (SQUID) “technology” and having any of the following:
   a. SQUID systems designed for stationary operation, without specially designed subsystems designed to reduce in-motion noise, and having a ‘sensitivity’ equal to or lower (better) than 50 fT (rms) per square root Hz at a frequency of 1 Hz; **or**
   b. SQUID systems having an in-motion-magnetometer ‘sensitivity’ lower (better) than 20 pT (rms) per square root Hz at a frequency of 1 Hz and specially designed to reduce in-motion noise;
2. “Magnetometers” using optically pumped or nuclear precession (proton/Overhauser) “technology” having a ‘sensitivity’ lower (better) than 20 pT (rms) per square root Hz at a frequency of 1 Hz;

3. "Magnetometers" using fluxgate "technology" having a 'sensitivity' equal to or lower (better) than 10 pT (rms) per square root Hz at a frequency of 1 Hz;
4. Induction coil "magnetometers" having a 'sensitivity' lower (better) than any of the following:
   a. 0.05 nT (rms)/square root Hz at frequencies of less than 1 Hz;
   b. $1 \times 10^{-3}$ nT (rms)/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; **or**
   c. $1 \times 10^{-4}$ nT (rms)/square root Hz at frequencies exceeding 10 Hz;
5. Fibre optic "magnetometers" having a 'sensitivity' lower (better) than 1 nT (rms) per square root Hz;

1-6.A.6.b. Underwater Electric Field Sensors having a 'sensitivity' lower (better) than 8 nanovolt per meter per square root Hz when measured at 1 Hz;

1-6.A.6.c. "Magnetic gradiometers" as follows:

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

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

1-6.A.6.e. Underwater electromagnetic receivers incorporating magnetic field sensors specified by 1-6.A.6.a. or underwater electric field sensors specified by 1-6.A.6.b.

***Technical Note:***

*For the purposes of 1-6.A.6., 'sensitivity' (noise level) is the root mean square of the device-limited noise floor which is the lowest signal that can be measured.*

1-6.A.7. GRAVIMETERS

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

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

   ***Note:***

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

b. Gravity meters designed for mobile platforms and 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;

***Technical Note:***

*For the purposes of 1-6.A.7.b., 'time-to-steady-state registration' (also referred to as the gravimeter's response time) is the time over which the disturbing effects of platform induced accelerations (high frequency noise) are reduced.*

c. Gravity gradiometers.

1-6.A.8. RADAR

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

***Note:***

*1-6.A.8. does not apply to:*

*- Secondary Surveillance Radar (SSR);*

*- Civil Automotive Radar;*

*- Displays or monitors used for Air Traffic Control (ATC);*

*- Meteorological (weather) Radar;*

*- Precision Approach Radar (PAR) equipment conforming to ICAO standards and employing electronically steerable linear (1-dimensional) arrays or mechanically positioned passive antennae.*

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

b. A tunable bandwidth exceeding ± 6.25% of the 'centre operating frequency';

***Technical Note:***

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

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

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

e. Incorporating electronically scanned array antennae;

***Technical Note:***

*Electronically scanned array antennae are also known as electronically steerable array antennae.*

f. Capable of heightfinding non-cooperative targets;

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 and using any of the following:
   1. "Radar spread spectrum" techniques; **or**
   2. "Radar frequency agility" techniques;

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

***Note:***

*1-6.A.8.i. does not apply to:*

*a. Fishing ground surveillance radar;*

*b. Ground radar equipment specially designed for enroute air traffic control and having all of the following:*

1. *A maximum "instrumented range" of 500 km or less;*
2. *Configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres;*
3. *Contains no provisions for remote control of the radar scan rate from the enroute ATC centre;* ***and***
4. *Permanently installed.*

c. *Weather balloon tracking radars.*

j. Being "laser" radar or Light Detection and Ranging (LIDAR) equipment and having any of the following:
1. "Space-qualified";
2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 µrad (microradians); **or**
3. Designed for carrying out airborne bathymetric littoral surveys to International Hydrographic Organization (IHO) Order 1a Standard ($5^{th}$ Edition February 2008) for Hydrographic Surveys or better, and using one or more "lasers" with a wavelength exceeding 400 nm but not exceeding 600 nm;

***Note 1:***

*LIDAR equipment specially designed for surveying is only specified by 1-6.A.8.j.3.*

***Note 2:***

*1-6.A.8.j. does not apply to LIDAR equipment specially designed for meteorological observation.*

***Note 3:***

*Parameters in the IHO Order 1a Standard 5th Edition February 2008 are summarized as follows:*

*Horizontal Accuracy (95% Confidence Level) = 5 m + 5% of depth.*

*Depth Accuracy for Reduced Depths (95% confidence level)*

$= \pm \sqrt{(a2+(b*d)2)}$ *where:*

*a = 0.5 m = constant depth error, i.e. the sum of all constant depth errors*

*b = 0.013 = factor of depth dependent error*

*b*d = depth dependent error, i.e. the sum of all depth dependent errors*

*d = depth*

*Feature Detection*

*= Cubic features > 2 m in depths up to 40 m;*

*10% of depth beyond 40 m.*

k. Having "signal processing" sub-systems using "pulse compression" and having any of the following:
1. A "pulse compression" ratio exceeding 150; **or**
2. A compressed pulse width of less than 200 ns; **or**

***Note:***

*1-6.A.8.k.2. does not apply to two dimensional 'marine radar' or 'vessel traffic service' radar, having all of the following:*

a. *"Pulse compression" ratio not exceeding 150;*
b. *Compressed pulse width of greater than 30 ns;*
c. *Single and rotating mechanically scanned antenna;*
d. *Peak output power not exceeding 250 W;* ***and***
e. *Not capable of "frequency hopping".*

l. Having data processing sub-systems and having 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; **or**

***Note:***

*1-6.A.8.l.1. does not apply to conflict alert capability in ATC systems, or 'marine radar'.*

***Technical Note:***

*'Automatic target tracking' is a processing technique that automatically determines and provides as output an extrapolated value of the most probable position of the target in real time.*

2. Not used since 2010
3. Not used since 2010
4. Configured to provide superposition and correlation, or fusion, of target data within six seconds from two or more 'geographically dispersed' radar sensors to improve the aggregate performance beyond that of any single sensor specified by 1-6.A.8.f. or 1-6.A.8.i.

***Technical Note:***

*Sensors are considered 'geographically dispersed' when each location is distant from any other more than 1,500 m in any direction. Mobile sensors are always considered 'geographically dispersed'.*

***N.B.:***

*See also 2-5.b.*

***Note:***

*1-6.A.8.l. does not apply to systems, equipment and assemblies used for 'vessel traffic services'.*

***Technical Notes:***

1. *For the purposes of 1-6.A.8., 'marine radar' is a radar that is used to navigate safely at sea, inland waterways or near-shore environments.*
2. *For the purposes of 1-6.A.8., 'vessel traffic service' is a vessel traffic monitoring and control service similar to air traffic control for "aircraft".*

## 1-6.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

### 1-6.B.1. ACOUSTICS

None

### 1-6.B.2. OPTICAL SENSORS

Masks and reticles, specially designed for optical sensors specified by 1-6.A.2.a.1.b. or 1-6.A.2.a.1.d.

### 1-6.B.3. CAMERAS

None

### 1-6.B.4. OPTICS

Optical equipment as follows:

a. Equipment for measuring absolute reflectance to an "accuracy" of equal to or better than 0.1% of the reflectance value;

b. Equipment other than optical surface scattering measurement equipment, having an unobscured aperture of more than 10 cm, specially designed for the non-contact optical measurement of a non-planar optical surface figure (profile) to an "accuracy" of 2 nm or less (better) against the required profile.

***Note:***
*1-6.B.4. does not apply to microscopes.*

1-6.B.5. LASERS

None

1-6.B.6. MAGNETIC AND ELECTRIC FIELD SENSORS

None

1-6.B.7. GRAVIMETERS

Equipment to produce, align and calibrate land-based gravity meters with a static "accuracy" of better than 0.1 mGal.

1-6.B.8. RADAR

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

## 1-6.C. MATERIALS

1-6.C.1. ACOUSTICS

None

1-6.C.2. OPTICAL SENSORS

. Optical sensor materials as follows:

a. Elemental tellurium (Te) of purity levels of 99.9995% or more;
b. Single crystals (including epitaxial wafers) of any of the following:
   1. Cadmium zinc telluride (CdZnTe) with zinc content of less than 6% by 'mole fraction';
   2. Cadmium telluride (CdTe) of any purity level; **or**
   3. Mercury cadmium telluride (HgCdTe) of any purity level.

***Technical Note:***
*'Mole fraction' is defined as the ratio of moles of ZnTe to the sum of the moles of CdTe and ZnTe present in the crystal.*

1-6.C.3. CAMERAS

None

1-6.C.4. OPTICS

Optical materials as follows:

a. Zinc selenide (ZnSe) and zinc sulphide (ZnS) "substrate blanks", produced by the chemical vapour deposition process and having any of the following:
   1. A volume greater than 100 $cm^3$; **or**
   2. A diameter greater than 80 mm and a thickness of 20 mm or more;
b. Electro-optic materials and non-linear optical materials, as follows:
   1. Potassium titanyl arsenate (KTA) (CAS 59400-80-5);

2. Silver gallium selenide ($AgGaSe_2$, also known as AGSE) (CAS 12002-67-4);
3. Thallium arsenic selenide ($Tl_3AsSe_3$, also known as TAS) (CAS 16142-89-5);
4. Zinc germanium phosphide ($ZnGeP_2$, also known as ZGP, zinc germanium biphosphide or zinc germanium diphosphide); **or**
5. Gallium selenide (GaSe) (CAS 12024-11-2);

c. Non-linear optical materials, other than those specified by 1-6.C.4.b., having any of the following:
   1. Having all of the following:
      a. Dynamic (also known as non-stationary) third order non-linear susceptibility ($\chi^{(3)}$, chi 3) of $10^{-6}$ $m^2/V^2$ or more; **and**
      b. Response time of less than 1 ms; **or**
   2. Second order non-linear susceptibility ($\chi^{(2)}$, chi 2) of $3.3\times10^{-11}$ m/V or more;

d. "Substrate blanks" of silicon carbide or beryllium beryllium (Be/Be) deposited materials, exceeding 300 mm in diameter or major axis length;

e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride ($ZrF_4$) (CAS 7783-64-4) and hafnium fluoride ($HfF_4$) (CAS 13709-52-9) and 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 $5 \times 10^{-6}$;

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.

1-6.C.5. LASERS

"Laser" materials as follows:

a. Synthetic crystalline "laser" host material in unfinished form as follows:
   1. Titanium doped sapphire.
   2. Not used since 2012

b. Rare-earth-metal doped double-clad fibres having any of the following:
   1. Nominal "laser" wavelength of 975 nm to 1,150 nm and having all of the following:
      a. Average core diameter equal to or greater than 25 µm; and
      b. Core 'Numerical Aperture' ('NA') less than 0.065; **or**

      ***Note:***
      *1-6.C.5.b.1. does not apply to double-clad fibres having an inner glass cladding diameter exceeding 150 µm and not exceeding 300 µm.*
   2. Nominal "laser" wavelength exceeding 1,530 nm and having all of the following:
      a. Average core diameter equal to or greater than 20 µm; **and**
      b. Core 'NA' less than 0.1.

***Technical Notes:***

*1. For the purposes of 1-6.C.5., the core 'Numerical Aperture' ('NA') is measured at the emission wavelengths of the fibre.*

*2. 1-6.C.5.b. includes fibres assembled with end caps.*

1-6.C.6. MAGNETIC AND ELECTRIC FIELD SENSORS

None

1-6.C.7. GRAVIMETERS

None

1-6.C.8. RADAR

None

## 1-6.D. SOFTWARE

1-6.D.1. "Software" specially designed for the "development" or "production" of equipment specified by 1-6.A.4., 1-6.A.5., 1-6.A.8. or 1-6.B.8.

1-6.D.2. "Software" specially designed for the "use" of equipment specified by 1-6.A.2.b., 1-6.A.8. or 1-6.B.8.

1-6.D.3. Other "software" as follows:

a. ACOUSTICS

"Software" as follows:

1. "Software" specially designed for acoustic beam forming for the "real-time processing" of acoustic data for passive reception using towed hydrophone arrays;
2. "Source code" for the "real-time processing" of acoustic data for passive reception using towed hydrophone arrays;
3. "Software" specially designed for acoustic beam forming for the "real-time processing" of acoustic data for passive reception using bottom or bay cable systems;
4. "Source code" for the "real-time processing" of acoustic data for passive reception using bottom or bay cable systems;
5. "Software" or "source code", specially designed for all of the following:
   a. "Real-time processing" of acoustic data from sonar systems specified by 1-6.A.1.a.1.e.; **and**
   b. Automatically detecting, classifying and determining the location of divers or swimmers;

   ***N.B.:***
   *For diver detection "software" or "source code", specially designed or modified for military use, see the Munitions List.*

b. OPTICAL SENSORS

None

c. CAMERAS

"Software" designed or modified for cameras incorporating "focal plane arrays" specified by 1-6.A.2.a.3.f. and designed or modified to remove a frame rate restriction and allow the camera to exceed the frame rate specified in 1-6.A.3.b.4. Note 3.a.

d. OPTICS

"Software" specially designed to maintain the alignment and phasing of segmented mirror systems consisting of mirror segments having a diameter or major axis length equal to or larger than 1 m;

e. LASERS

None

f. MAGNETIC AND ELECTRIC FIELD SENSORS

"Software" as follows:

1. "Software" specially designed for magnetic and electric field "compensation systems" for magnetic sensors designed to operate on mobile platforms;
2. "Software" specially designed for magnetic and electric field anomaly detection on mobile platforms;
3. "Software" specially designed for "real-time processing" of electromagnetic data using underwater electromagnetic receivers specified by 1-6.A.6.e.;
4. "Source code" for "real-time processing" of electromagnetic data using underwater electromagnetic receivers specified by 1-6.A.6.e.;

g. GRAVIMETERS

"Software" specially designed to correct motional influences of gravity meters or gravity gradiometers;

h. RADAR

"Software" as follows:

1. Air Traffic Control (ATC) "software" application "programs" designed to be hosted on general purpose computers located at Air Traffic Control centres and capable of accepting radar target data from more than four primary radars;
2. "Software" for the design or "production" of radomes having all of the following:
   a. Specially designed to protect the electronically scanned array antennae specified by 1-6.A.8.e.; **and**
   b. Resulting in an antenna pattern having an 'average side lobe level' more than 40 dB below the peak of the main beam level.

   ***Technical Note:***

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

## 1-6.E. TECHNOLOGY

1-6.E.1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" specified by 1-6.A., 1-6.B., 1-6.C. or 1-6.D.

1-6.E.2. "Technology" according to the General Technology Note for the "production" of equipment or materials specified by 1-6.A., 1-6.B. or 1-6.C.

1-6.E.3. Other "technology" as follows:

a. ACOUSTICS

None

b. OPTICAL SENSORS

None

c. CAMERAS

None

d. OPTICS

“Technology” as follows:

1. “Technology” “required” for the coating and treatment of optical surfaces to achieve an ‘optical thickness’ 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 $5 \times 10^{-3}$;

   ***N.B.:***

   *See also 1-2.E.3.f.*

   ***Technical Note:***

   *‘Optical thickness’ is the mathematical product of the index of refraction and the physical thickness of the coating.*

2. “Technology” for the fabrication of optics using single point diamond turning techniques to produce surface finish “accuracies” of better than 10 nm rms on non-planar surfaces exceeding 0.5 $m^2$;

e. LASERS

“Technology” “required” for the “development”, “production” or “use” of specially designed diagnostic instruments or targets in test facilities for “SHPL” testing or testing or evaluation of materials irradiated by “SHPL” beams;

f. MAGNETIC AND ELECTRIC FIELD SENSORS

Not used since 2004

g. GRAVIMETERS

None

h. RADAR

None

# CATEGORY 7: NAVIGATION AND AVIONICS

## 1-7.A. SYSTEMS, EQUIPMENT AND COMPONENTS

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

1-7.A.1. Accelerometers as follows and specially designed components therefor:

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

a. Linear accelerometers having any of the following:
   1. Specified to function at linear acceleration levels less than or equal to 15 g and having any of the following:
      a. A "bias" "stability" of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year; **or**
      b. A "scale factor" "stability" of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year;
   2. Specified to function at linear acceleration levels exceeding 15 g but less than or equal to 100 g and having all of the following:
      a. A "bias" "repeatability" of less (better) than 1,250 micro g over a period of one year; **and**
      b. A "scale factor" "repeatability" of less (better) than 1,250 ppm over a period of one year; **or**
   3. Designed for use in inertial navigation or guidance systems and specified to function at linear acceleration levels exceeding 100 g;

   ***Note:***
   *1-7.A.1.a.1. and 1-7.A.1.a.2. do not apply to accelerometers limited to measurement of only vibration or shock.*

b. Angular or rotational accelerometers, specified to function at linear acceleration levels exceeding 100 g.

1-7.A.2. Gyros or angular rate sensors, having any of the following and specially designed components therefor:

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

a. Specified to function at linear acceleration levels less than or equal to 100 g and having any of the following:
   1. An angular rate range of less than 500 degrees per second and having any of the following:
      a. A "bias" "stability" of less (better) than 0.5 degree per hour, when measured in a 1 g environment over a period of one month, and with respect to a fixed calibration value; **or**
      b. An "angle random walk" of less (better) than or equal to 0.0035 degree per square root hour; **or**

      ***Note:***
      *1-7.A.2.a.1.b. does not apply to "spinning mass gyros".*

2. An angular rate range greater than or equal to 500 degrees per second and having any of the following:
   a. A "bias" "stability" of less (better) than 4 degrees per hour, when measured in a 1 g environment over a period of three minutes, and with respect to a fixed calibration value; **or**
   b. An "angle random walk" of less (better) than or equal to 0.1 degree per square root hour; **or**

   ***Note:***
   *1-7.A.2.a.2.b. does not apply to "spinning mass gyros".*

b. Specified to function at linear acceleration levels exceeding 100 g.

1-7.A.3. 'Inertial measurement equipment or systems', having any of the following:

***Note 1:***
*'Inertial measurement equipment or systems' incorporate accelerometers or gyroscopes to measure changes in velocity and orientation in order to determine or maintain heading or position without requiring an external reference once aligned. 'Inertial measurement equipment or systems' include:*
*- Attitude and Heading Reference Systems (AHRSs);*
*- Gyrocompasses;*
*- Inertial Measurement Units (IMUs);*
*- Inertial Navigation Systems (INSs);*
*- Inertial Reference Systems (IRSs);*
*- Inertial Reference Units (IRUs).*

***Note 2:***
*1-7.A.3. does not apply to 'inertial measurement equipment or systems' which are certified for use on "civil aircraft" by civil aviation authorities of one or more Wassenaar Arrangement Participating States.*

***Technical Note:***
*'Positional aiding references' independently provide position, and include:*
*a. "Satellite navigation system";*
*b. "Data-Based Referenced Navigation" ("DBRN").*

a. Designed for "aircraft", land vehicles or vessels, providing position without the use of 'positional aiding references', and having any of the following "accuracies" subsequent to normal alignment:
   1. 0.8 nautical miles per hour (nm/hr) "Circular Error Probable" ("CEP") rate or less (better);
   2. 0.5% distanced travelled "CEP" or less (better); **or**
   3. Total drift of 1 nautical mile "CEP" or less (better) in a 24 hr period;

   ***Technical Note:***
   *The performance parameters in 1-7.A.3.a.1., 1-7.A.3.a.2. and 1-7.A.3.a.3. typically apply to 'inertial measurement equipment or systems' designed for "aircraft", vehicles and vessels, respectively. These parameters result from the utilisation of specialised non-positional aiding references (e.g., altimeter, odometer, velocity log). As a consequence, the specified performance values cannot be readily converted between these parameters. Equipment designed for multiple platforms are evaluated against each applicable entry 1-7.A.3.a.1., 1-7.A.3.a.2., or 1-7.A.3.a.3.*

b. Designed for "aircraft", land vehicles or vessels, with an embedded 'positional aiding reference' and providing position after loss of all 'positional aiding

references' for a period of up to 4 minutes, having an "accuracy" of less (better) than 10 meters "CEP";

***Technical Note:***

*1-7.A.3.b. refers to systems in which 'inertial measurement equipment or systems' and other independent 'positional aiding references' are built into a single unit (i.e., embedded) in order to achieve improved performance.*

c. Designed for "aircraft", land vehicles or vessels, providing heading or True North determination and having any of the following:
   1. A maximum operating angular rate less (lower) than 500 deg/s and a heading "accuracy" without the use of 'positional aiding references' equal to or less (better) than 0.07 deg sec(Lat) (equivalent to 6 arc minutes rms at 45 degrees latitude); **or**
   2. A maximum operating angular rate equal to or greater (higher) than 500 deg/s and a heading "accuracy" without the use of 'positional aiding references' equal to or less (better) than 0.2 deg sec(Lat) (equivalent to 17 arc minutes rms at 45 degrees latitude);

d. Providing acceleration measurements or angular rate measurements, in more than one dimension, and having any of the following:
   1. Performance specified by 1-7.A.1. or 1-7.A.2. along any axis, without the use of any aiding references; **or**
   2. Being "space-qualified" and providing angular rate measurements having an "angle random walk" along any axis of less (better) than or equal to 0.1 degree per square root hour.

***Note:***

*1-7.A.3.d.2. does not apply to 'inertial measurement equipment or systems' that contain "spinning mass gyros" as the only type of gyro.*

1-7.A.4. 'Star trackers' and components therefor, as follows:

a. 'Star trackers' with a specified azimuth "accuracy" of equal to or less (better) than 20 seconds of arc throughout the specified lifetime of the equipment;

b. Components specially designed for equipment specified in 1-7.A.4.a. as follows:
   1. Optical heads or baffles;
   2. Data processing units.

***Technical Note:***

*'Star trackers' are also referred to as stellar attitude sensors or gyro-astro compasses.*

1-7.A.5. "Satellite navigation system" receiving equipment having any of the following and specially designed components therefor:

***N.B.:***

*For equipment specially designed for military use, see 2-11.*

a. Employing a decryption algorithm specially designed or modified for government use to access the ranging code for position and time; **or**

b. Employing 'adaptive antenna systems'.

***Note:***

*1-7.A.5.b. does not apply to "satellite navigation system" receiving equipment that only uses components designed to filter, switch, or combine signals from multiple omni-directional antennae that do not implement adaptive antenna techniques.*

***Technical Note:***

*For the purposes of 1-7.A.5.b. 'adaptive antenna systems' dynamically generate one or more spatial nulls in an antenna array pattern by signal processing in the time domain or frequency domain.*

1-7.A.6. Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz inclusive and having any of the following:

a. 'Power management'; **or**

b. Using phase shift key modulation.

***Technical Note:***

*'Power management' is changing the transmitted power of the altimeter signal so that received power at the "aircraft" altitude is always at the minimum necessary to determine the altitude.*

1-7.A.7. Not used since 2004

1-7.A.8. Underwater sonar navigation systems using doppler velocity or correlation velocity logs integrated with a heading source and having a positioning "accuracy" of equal to or less (better) than 3% of distance travelled "Circular Error Probable" ("CEP") and specially designed components therefor.

***Note:***

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

***N.B.:***

*See 1-6.A.1.a. for acoustic systems, and 1-6.A.1.b. for correlation-velocity and Doppler-velocity sonar log equipment.*

*See 1-8.A.2. for other marine systems.*

## 1-7.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

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

***Note:***

*1-7.B.1. does not apply to 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 disassembly or repair of specified accelerometers or gyro sensors.*

1-7.B.2. Equipment specially designed to characterize mirrors for ring "laser" gyros, as follows:

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).

1-7.B.3. Equipment specially designed for the "production" of equipment specified by 1-7.A.

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

## 1-7.C. MATERIALS

None

## 1-7.D. SOFTWARE

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

1-7.D.2. "Source code" for the operation or maintenance of any inertial navigation equipment, including inertial equipment not specified by 1-7.A.3. or 1-7.A.4., or Attitude and Heading Reference Systems ('AHRS').

***Note:***
*1-7.D.2. does not apply to "source code" for the operation or maintenance 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.*

1-7.D.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 by 1-7.A.3., 1-7.A.4. or 1-7.A.8.;
b. "Source code" for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified by 1-7.A.3. or 1-7.A.8. by continuously combining heading data with any of the following:
    1. Doppler radar or sonar velocity data;
    2. "Satellite navigation system" reference data; **or**
    3. Data from "Data-Based Referenced Navigation" ("DBRN") systems;
c. Not used since 2013

d. Not used since 2012

***N.B.:***
*For flight control "source code", see 1-7.D.4.*

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 specified by 1-7.E.4.b.1., 1-7.E.4.b.3. to 1-7.E.4.b.5., 1-7.E.4.b.7., 1-7.E.4.b.8., 1-7.E.4.c.1. or 1-7.E.4.c.2.

1-7.D.4. "Source code" incorporating "development" "technology" specified by 1-7.E.4.a.2., 1-7.E.4.a.3., 1-7.E.4.a.5., 1-7.E.4.a.6. or 1-7.E.4.b., for any of the following:

a. Digital flight management systems for "total control of flight";
b. Integrated propulsion and flight control systems;
c. "Fly-by-wire systems" or "fly-by-light systems";
d. Fault-tolerant or self-reconfiguring "active flight control systems";
e. Not used since 2012
f. Air data systems based on surface static data; **or**
g. Three dimensional displays.

***Note:***
*1-7.D.4. does not apply to "source code" associated with common computer elements and utilities (e.g., input signal acquisition, output signal transmission, computer program and data loading, built-in test, task scheduling mechanisms) not providing a specific flight control system function.*

1-7.D.5. "Software" specially designed to decrypt "Satellite navigation system" ranging code designed for government use.

## 1-7.E. TECHNOLOGY

1-7.E.1. "Technology" according to the General Technology Note for the "development" of equipment or "software", specified by 1-7.A., 1-7.B., 1-7.D.1., 1-7.D.2., 1-7.D.3. or 1-7.D.5.

***Note:***
*1-7.E.1. includes key management "technology" exclusively for equipment specified in 1-7.A.5.a.*

1-7.E.2. "Technology" according to the General Technology Note for the "production" of equipment specified by 1-7.A. or 1-7.B.

1-7.E.3. "Technology" according to the General Technology Note for the repair, refurbishing or overhaul of equipment specified by 1-7.A.1. to 1-7.A.4.

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

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

1-7.E.4. Other "technology" as follows:

a. "Technology" for the "development" or "production" of any of the following:

1. Not used since 2011
2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;
3. Three dimensional displays for "aircraft";
4. Not used since 2010
5. Electric actuators (i.e., electromechanical, electrohydrostatic and integrated actuator package) specially designed for 'primary flight control';

***Technical Note:***

*'Primary flight control' is "aircraft" stability or manoeuvring control using force/moment generators, i.e. aerodynamic control surfaces or propulsive thrust vectoring.*

6. 'Flight control optical sensor array' specially designed for implementing "active flight control systems"; **or**

***Technical Note:***

*A 'flight control optical sensor array' is a network of distributed optical sensors, using "laser" beams, to provide real-time flight control data for on-board processing.*

7. "DBRN" systems designed to navigate underwater, using sonar or gravity databases, that provide a positioning "accuracy" equal to or less (better) than 0.4 nautical miles;

b. "Development" "technology", as follows, for "active flight control systems" (including "fly-by-wire systems" or "fly-by-light systems"):

1. Photonic-based "technology" for sensing "aircraft" or flight control component state, transferring flight control data, or commanding actuator movement, "required" for "fly-by-light systems" "active flight control systems";
2. Not used since 2012
3. Real-time algorithms to analyze component sensor information to predict and preemptively mitigate impending degradation and failures of components within an "active flight control system";

***Note:***

*1-7.E.4.b.3. does not include algorithms for the purpose of off-line maintenance.*

4. Real-time algorithms to identify component failures and reconfigure force and moment controls to mitigate "active flight control system" degradations and failures;

***Note:***

*1-7.E.4.b.4. does not include algorithms for the elimination of fault effects through comparison of redundant data sources, or off-line pre-planned responses to anticipated failures.*

5. Integration of digital flight control, navigation and propulsion control data, into a digital flight management system for "total control of flight";

***Note:***

*1-7.E.4.b.5. does not apply to:*

1. *"Technology" for integration of digital flight control, navigation and propulsion control data, into a digital flight management system for 'flight path optimisation';*
2. *"Technology" for "aircraft" flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches.*

***Technical Note:***

*'Flight path optimisation' is a procedure that minimises deviations from a four-dimensional (space and time) desired trajectory based on maximising performance or effectiveness for mission tasks.*

6. Not used since 2013
7. "Technology" "required" for deriving the functional requirements for "fly-by-wire systems" having all of the following:
   a. 'Inner-loop' airframe stability controls requiring loop closure rates of 40 Hz or greater; **and**

   ***Technical Note***

   *'Inner-loop' refers to functions of "active flight control systems" that automate airframe stability controls.*

   b. Having any of the following:
      1. Corrects an aerodynamically unstable airframe, measured at any point in the design flight envelope, that would lose recoverable control if not corrected within 0.5 seconds;
      2. Couples controls in two or more axes while compensating for 'abnormal changes in aircraft state';

      ***Technical Note***

      *'Abnormal changes in aircraft state' include in-flight structural damage, loss of engine thrust, disabled control surface, or destabilizing shifts in cargo load.*

      3. Performs the functions specified in 1-7.E.4.b.5.; **or**

      ***Note:***

      *1-7.E.4.b.7.b.3. does not apply to autopilots.*

      4. Enables "aircraft" to have stable controlled flight, other than during take-off or landing, at greater than 18 degrees angle of attack, 15 degrees side slip, 15 degrees/second pitch or yaw rate, or 90 degrees/second roll rate;
8. "Technology" "required" for deriving the functional requirements for "fly-by-wire systems" to achieve all of the following:
   a. No loss of control of the "aircraft" in the event of a consecutive sequence of any two individual faults within the "fly-by-wire system"; **and**
   b. Probability of loss of control of the "aircraft" being less (better) than $1x10^{-9}$ failures per flight hour;

***Note:***

*1-7.E.4.b. does not apply to "technology" associated with common computer elements and utilities (e.g., input signal acquisition, output signal transmission, computer program and data loading, built-in test, task scheduling mechanisms) not providing a specific flight control system function.*

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 direction control systems";
   3. Rotor blades incorporating 'variable geometry airfoils', for use in systems using individual blade control.

      ***Technical Note:***
      *'Variable geometry airfoils' use trailing edge flaps or tabs, or leading edge slats or pivoted nose droop, the position of which can be controlled in flight.*

# CATEGORY 8: MARINE

## 1-8.A. SYSTEMS, EQUIPMENT AND COMPONENTS

1-8.A.1. Submersible vehicles and surface vessels, as follows:

***N.B.:***
*For the status of equipment for submersible vehicles, see:*
*- Category 6 for sensors;*
*- Categories 7 and 8 for navigation equipment;*
*- Category 1-8.A. for underwater equipment.*

a. Manned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m;

b. Manned, untethered submersible vehicles having any of the following:
   1. Designed to 'operate autonomously' and having a lifting capacity of all the following:
      a. 10% or more of their weight in air; **and**
      b. 15 kN or more;
   2. Designed to operate at depths exceeding 1,000 m; **or**
   3. Having all of the following:
      a. Designed to continuously 'operate autonomously' for 10 hours or more; **and**
      b. 'Range' of 25 nautical miles or more;

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

c. Unmanned submersible vehicles, as follows:
   1. Unmanned submersible vehicles having any of the following:
      a. Designed for deciding a course relative to any geographical reference without real-time human assistance;
      b. Acoustic data or command link; **or**
      c. Optical data or command link exceeding 1,000 m;
   2. Unmanned submersible vehicles, not specified in 1-8.A.1.c.1., having all of the following:
      a. Designed to operate with a tether;
      b. Designed to operate at depths exceeding 1,000 m; **and**
      c. Having any of the following:
         1. Designed for self-propelled manoeuvre using propulsion motors or thrusters specified by 1-8.A.2.a.2.; **or**
         2. Fibre optic data link;

d. Not used since 2018

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 and with positioning "accuracies" to within 10 m of a predetermined point.

f. Not used since 2014

g. Not used since 2014

h. Not used since 2014

i. Not used since 2014

1-8.A.2. Marine systems, equipment and components, as follows:

***N.B.:***

*For underwater communications systems, see Category 5 - Part 1 - Telecommunications.*

a. Systems, equipment and components, specially designed or modified for submersible vehicles and designed to operate at depths exceeding 1,000 m, as follows:
   1. Pressure housings or pressure hulls with a maximum inside chamber diameter exceeding 1.5 m;
   2. Direct current propulsion motors or thrusters;
   3. Umbilical cables, and connectors therefor, using optical fibre and having synthetic strength members;
   4. Components manufactured from material specified by 1-8.C.1.;

      ***Technical Note:***

      *The objective of 1-8.A.2.a.4. should not be defeated by the export of 'syntactic foam' specified by 1-8.C.1. when an intermediate stage of manufacture has been performed and it is not yet in its final component form.*

b. Systems specially designed or modified for the automated control of the motion of submersible vehicles specified by 1-8.A.1., using navigation data, having closed loop servo-controls and having any of the following:
   1. Enabling a vehicle to move within 10 m of a predetermined point in the water column;
   2. Maintaining the position of the vehicle within 10 m of a predetermined point in the water column; **or**
   3. Maintaining the position of the vehicle within 10 m while following a cable on or under the seabed;

c. Fibre optic pressure hull penetrators;

d. Underwater vision systems having all of the following:
   1. Specially designed or modified for remote operation with an underwater vehicle; **and**
   2. Employing any of the following techniques to minimise the effects of back scatter:
      a. Range-gated illuminators; **or**
      b. Range-gated laser systems;

e. Not used since 2015

f. Not used since 2009

1. Not used since 2009

***N.B.:***
*For electronic imaging systems specially designed or modified for underwater use incorporating image intensifier tubes specified by 1-6.A.2.a.2.a. or 1-6.A.2.a.2.b., see 1-6.A.3.b.3.*

2. Not used since 2009

***N.B.:***
*For electronic imaging systems specially designed or modified for underwater use incorporating "focal plane arrays" specified by 1-6.A.2.a.3.g., see 1-6.A.3.b.4.c.*

g. Light systems specially designed or modified for underwater use, as follows:
   1. Stroboscopic light systems capable of a light output energy of more than 300 J per flash and a flash rate of more than 5 flashes per second;
   2. Argon arc light systems specially designed for use below 1,000 m;

h. "Robots" specially designed for underwater use, controlled by using a dedicated computer and 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 "composite" "fibrous or filamentary materials" in their structural members;

i. Remotely controlled articulated manipulators specially designed or modified for use with submersible vehicles and having any of the following:
   1. Systems which control the manipulator using information from sensors which measure any of the following:
      a. Torque or force applied to an external object; **or**
      b. Tactile sense between the manipulator and an external object; **or**
   2. Controlled by proportional master-slave techniques and having 5 degrees of 'freedom of movement' or more;

***Technical Note:***
*Only functions having proportionally related motion control using positional feedback are counted when determining the number of degrees of 'freedom of movement'.*

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

1. Specially designed to pressurise the products of reaction or for fuel reformation;
2. Specially designed to store the products of the reaction; **and**
3. Specially designed 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 and 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 having all of the following:
      1. Specially designed to pressurise the products of reaction or for fuel reformation;
      2. Specially designed to store the products of the reaction; **and**
      3. Specially designed to discharge the products of the reaction against a pressure of 100 kPa or more;
4. Stirling cycle engine air independent power systems having all of the following:
   a. Devices or enclosures, specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; **and**
   b. Specially designed exhaust systems which discharge the products of combustion against a pressure of 100 kPa or more;

k. Not used since 2014

l. Not used since 2014

m. Not used since 2014

n. Not used since 2014

o. Propellers, power transmission systems, power generation systems and noise reduction systems, as follows:
   1. Not used since 2014
   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 and capable of transmitting more than 2 MW;

e. Ventilated or base-ventilated propeller systems, rated at more than 2.5 MW;

3. Noise reduction systems designed for use on vessels of 1,000 tonnes displacement or more, as follows:

a. Systems that attenuate underwater noise at frequencies below 500 Hz and consist of compound acoustic mounts for the acoustic isolation of diesel engines, diesel generator sets, gas turbines, gas turbine generator sets, propulsion motors or propulsion reduction gears, specially designed for sound or vibration isolation and 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;

***Technical Note:***

*'Active noise reduction or cancellation systems' incorporate electronic control systems capable of actively reducing equipment vibration by the generation of anti-noise or anti-vibration signals directly to the source.*

p. Pumpjet propulsion systems having all of the following:

1. Power output exceeding 2.5 MW; **and**

2. Using divergent nozzle and flow conditioning vane techniques to improve propulsive efficiency or reduce propulsion-generated underwater-radiated noise;

q. Underwater swimming and diving equipment as follows:

1. Closed circuit rebreathers;

2. Semi-closed circuit rebreathers;

***Note:***

*1-8.A.2.q. does not apply to individual rebreathers for personal use when accompanying their users.*

***N.B.:***

*For equipment and devices specially designed for military use, see 2-17.a. on the Munitions List.*

r. Diver deterrent acoustic systems specially designed or modified to disrupt divers and having a sound pressure level equal to or exceeding 190 dB (reference 1 µPa at 1 m) at frequencies of 200 Hz and below.

***Note 1:***

*1-8.A.2.r. does not apply to diver deterrent systems based on underwater explosive devices, air guns or combustible sources.*

***Note 2:***
*1-8.A.2.r. includes diver deterrent acoustic systems that use spark gap sources, also known as plasma sound sources.*

## 1-8.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1-8.B.1. Water tunnels designed to have a background noise of less than 100 dB (reference 1 µPa, 1 Hz) within the frequency range exceeding 0 Hz but not exceeding 500 Hz and designed for measuring acoustic fields generated by a hydro-flow around propulsion system models.

## 1-8.C. MATERIALS

1-8.C.1. 'Syntactic foam' designed for underwater use and having all of the following:

a. Designed for marine depths exceeding 1,000 m; **and**
b. A density less than 561 kg/m$^3$.

***Technical Note:***
*'Syntactic foam' consists of hollow spheres of plastic or glass embedded in a resin "matrix".*

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

## 1-8.D. SOFTWARE

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

1-8.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.

## 1-8.E. TECHNOLOGY

1-8.E.1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials, specified by 1-8.A., 1-8.B. or 1-8.C.

1-8.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 specified by 1-8.A.1., 1-8.A.2.b., 1-8.A.2.j., 1-8.A.2.o. or 1-8.A.2.p.
c. "Technology" according to the General Technology Note for the "development" or "production" of any of the following:
    1. Surface-effect vehicles (fully skirted variety) having all of the following:
        a. Maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1.25 m or more;
        b. Cushion pressure exceeding 3,830 Pa; **and**
        c. Light-ship-to-full-load displacement ratio of less than 0.70;

2. Surface-effect vehicles (rigid sidewalls) with a maximum design speed, fully loaded, exceeding 40 knots in a significant wave height of 3.25 m or more;
3. 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 or more; **or**
4. 'Small waterplane area vessels' having any of the following:
   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 or more; **or**
   b. 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 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)*$^{2/3}$.

# CATEGORY 9: AEROSPACE AND PROPULSION

## 1-9.A. SYSTEMS, EQUIPMENT AND COMPONENTS

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

1-9.A.1. Aero gas turbine engines having any of the following:

a. Incorporating any of the "technologies" specified by 1-9.E.3.a., 1-9.E.3.h. or 1-9.E.3.i.; **or**

***Note 1:***
*1-9.A.1.a. does not apply to aero gas turbine engines which meet all of the following:*

*a. Certified by civil aviation authorities of one or more Wassenaar Arrangement Participating States;* ***and***

*b. Intended to power non-military manned "aircraft" for which any of the following has been issued by civil aviation authorities of one or more Wassenaar Arrangement Participating States for the "aircraft" with this specific engine type:*

*1. A civil type certificate;* ***or***

*2. An equivalent document recognised by the International Civil Aviation Organisation (ICAO).*

***Note 2:***
*1-9.A.1.a. does not apply to aero gas turbine engines designed for Auxiliary Power Units (APUs) approved by the civil aviation authority in a Wassenaar Arrangement Participating State.*

b. Designed to power an "aircraft" designed to cruise at Mach 1 or higher, for more than 30 minutes.

1-9.A.2. 'Marine gas turbine engines' designed to use liquid fuel and having all of the following, and specially designed assemblies and components therefor:

a. Maximum continuous power when operating in "steady state mode" at standard reference conditions specified by ISO 3977-2:1997 (or national equivalent) of 24,245 kW or more; **and**

b. 'Corrected specific fuel consumption' not exceeding 0.219 kg/kWh at 35% of the maximum continuous power when using liquid fuel.

***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.*

***Technical Note:***
*For the purposes of 1-9.A.2., 'corrected specific fuel consumption' is the specific fuel consumption of the engine corrected to a marine distillate liquid fuel having a net specific energy (i.e., net heating value) of 42 MJ/kg (ISO 3977-2:1997).*

1-9.A.3. Specially designed assemblies or components, incorporating any of the "technologies" specified by 1-9.E.3.a., 1-9.E.3.h. or 1-9.E.3.i., for any of the following aero gas turbine engines:

a. Specified by 1-9.A.1.; **or**

b. Whose design or production origins are either not from a Wassenaar Arrangement Participating State or unknown to the manufacturer.

1-9.A.4. Space launch vehicles, “spacecraft”, “spacecraft buses”, “spacecraft payloads”, “spacecraft” on-board systems or equipment, terrestrial equipment, and air-launch platforms, as follows:

a. Space launch vehicles;

b. “Spacecraft”;

c. “Spacecraft buses”;

d. “Spacecraft payloads” incorporating items specified by 1-3.A.1.b.1.a.4., 1-3.A.2.g., 1-5.A.1.a.1., 1-5.A.1.b.3., 1-5.A.2.c., 1-5.A.2.e., 1-6.A.2.a.1., 1-6.A.2.a.2., 1-6.A.2.b., 1-6.A.2.d., 1-6.A.3.b., 1-6.A.4.c., 1-6.A.4.e., 1-6.A.8.d., 1-6.A.8.e., 1-6.A.8.k., 1-6.A.8.l. or 1-9.A.10.c.;

e. On-board systems or equipment, specially designed for “spacecraft” and having any of the following functions:

1. ‘Command and telemetry data handling’;

***Note:***

*For the purpose of 1-9.A.4.e.1., ‘command and telemetry data handling’ includes bus data management, storage, and processing.*

2. ‘Payload data handling’; **or**

***Note:***

*For the purpose of 1-9.A.4.e.2., ‘payload data handling’ includes payload data management, storage, and processing.*

3. ‘Attitude and orbit control’;

***Note:***

*For the purpose of 1-9.A.4.e.3., ‘attitude and orbit control’ includes sensing and actuation to determine and control the position and orientation of a “spacecraft”.*

***N.B.:***

*For equipment specially designed for military use, see 2-11.c.*

f. Terrestrial equipment specially designed for “spacecraft”, as follows:

1. Telemetry and telecommand equipment specially designed for any of the following data processing functions:

a. Telemetry data processing of frame synchronisation and error corrections, for monitoring of operational status (also known as health and safe status) of the “spacecraft bus”; or

b. Command data processing for formatting command data being sent to the “spacecraft” to control the “spacecraft bus”;

2. Simulators specially designed for ‘verification of operational procedures’ of “spacecraft”.

***Technical Note:***

*For the purposes of 1-9.A.4.f.2., ‘verification of operational procedures’ is any of the following:*

*1. Command sequence confirmation;*

*2. Operational training;*

*3. Operational rehearsals;* ***or***

*4. Operational analysis.*

g. “Aircraft” specially designed or modified to be air-launch platforms for space launch vehicles.

1-9.A.5. Liquid rocket propulsion systems containing any of the systems or components, specified by 1-9.A.6.

1-9.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;

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 $1.14 \times 10^{-3}$ $cm^2$ or smaller for non-circular orifices) and 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.

1-9.A.7. Solid rocket propulsion systems having 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. Components specified by 1-9.A.8.; **or**

e. Insulation and propellant bonding systems, using direct-bonded motor designs to provide a 'strong mechanical bond' or a barrier to chemical migration between the solid propellant and case insulation material.

***Technical Note:***

*A 'strong mechanical bond' means bond strength equal to or more than propellant strength.*

1-9.A.8. Components specially designed for solid rocket propulsion systems, as follows:

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;

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

***Technical Note:***

*'Structural efficiency ratio (PV/W)' is the burst pressure (P) multiplied by the vessel volume (V) divided by the total pressure vessel weight (W).*

c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0.075 mm/s;

d. Movable nozzle or secondary fluid injection thrust vector control systems, capable of any of the following:
   1. Omni-axial movement exceeding ± 5°;
   2. Angular vector rotations of 20°/s or more; **or**
   3. Angular vector accelerations of $40°/s^2$ or more.

1-9.A.9. Hybrid rocket propulsion systems having any of the following:

a. Total impulse capacity exceeding 1.1 MNs; **or**
b. Thrust levels exceeding 220 kN in vacuum exit conditions.

1-9.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 and specially designed for launch vehicles manufactured using any of the following:
   1. "Composite" materials consisting of "fibrous or filamentary materials" specified by 1-1.C.10.e. and resins specified by 1-1.C.8. or 1-1.C.9.b.;
   2. Metal "matrix" "composites" reinforced by any of the following:
      a. Materials specified by 1-1.C.7.;
      b. "Fibrous or filamentary materials" specified by 1-1.C.10.; **or**
      c. Aluminides specified by 1-1.C.2.a.; **or**
   3. Ceramic "matrix" "composite" materials specified by 1-1.C.7.;

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

b. Components and structures, specially designed for launch vehicle propulsion systems specified by 1-9.A.5. to 1-9.A.9. manufactured using any of the following:
   1. "Fibrous or filamentary materials" specified by 1-1.C.10.e. and resins specified by 1-1.C.8. or 1-1.C.9.b.;
   2. Metal "matrix" "composite" materials reinforced by any of the following:
      a. Materials specified by 1-1.C.7.;
      b. "Fibrous or filamentary materials" specified by 1-1.C.10.; **or**
      c. Aluminides specified by 1-1.C.2.a.; **or**
   3. Ceramic "matrix" "composite" materials specified by 1-1.C.7.;

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' of less than 30 ms.

   ***Technical Note:***
   *For the purposes of 1-9.A.10.d., 'response time' is the time required to achieve 90% of total rated thrust from start-up.*

1-9.A.11. Ramjet, scramjet or combined cycle engines, and specially designed components therefor.

1-9.A.12. "Unmanned Aerial Vehicles" ("UAVs"), unmanned "airships", related equipment and components, as follows:

a. "UAVs" or unmanned "airships", designed to have controlled flight out of the direct 'natural vision' of the 'operator' and having any of the following:

1. Having all of the following:
   a. A maximum ‘endurance’ greater than or equal to 30 minutes but less than 1 hour; **and**
   b. Designed to take-off and have stable controlled flight in wind gusts equal to or exceeding 46.3 km/h (25 knots); **or**
2. A maximum ‘endurance’ of 1 hour or greater;

***Technical Notes:***

*1. For the purposes of 1-9.A.12.a., ‘operator’ is a person who initiates or commands the “UAV” or unmanned “airship” flight.*

*2. For the purposes of 1-9.A.12.a., ‘endurance’ is to be calculated for ISA conditions (ISO 2533:1975) at sea level in zero wind.*

*3. For the purposes of 1-9.A.12.a., ‘natural vision’ means unaided human sight, with or without corrective lenses.*

b. Related equipment and components, as follows:
   1. Not used since 2014
   2. Not used since 2014
   3. Equipment or components, specially designed to convert a manned “aircraft” or a manned “airship” to a “UAV” or unmanned “airship”, specified by 1-9.A.12.a.;
   4. Air breathing reciprocating or rotary internal combustion type engines, specially designed or modified to propel “UAVs” or unmanned “airships”, at altitudes above 15,240 meters (50,000 feet).

## 1-9.B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1-9.B.1. Manufacturing equipment, tooling or fixtures, as follows:

a. Directional solidification or single crystal casting equipment designed for “superalloys”;
b. Casting tooling, specially designed for manufacturing gas turbine engine blades, vanes or “tip shrouds”, manufactured from refractory metals or ceramics, as follows:
   1. Cores;
   2. Shells (moulds);
   3. Combined core and shell (mould) units;
c. Directional-solidification or single-crystal additive-manufacturing equipment, specially designed for manufacturing gas turbine engine blades, vanes or “tip shrouds”.

1-9.B.2. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, having all of the following:

a. Specially designed for the “development” of gas turbine engines, assemblies or components; **and**
b. Incorporating any of the “technologies” specified by 1-9.E.3.h. or 1-9.E.3.i.

1-9.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.

1-9.B.4. Tools, dies or fixtures, for the solid state joining of "superalloy", titanium or intermetallic airfoil-to-disk combinations described in 1-9.E.3.a.3. or 1-9.E.3.a.6. for gas turbines.

1-9.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:

a. Wind tunnels designed for speeds of Mach 1.2 or more;

***Note:***
*1-9.B.5.a. does not apply to wind tunnels specially designed for educational purposes and having a 'test section size' (measured laterally) of less than 250 mm.*

***Technical Note:***
*'Test section size' means 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 $25 \times 10^6$.

1-9.B.6. Acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 µPa) with a rated output of 4 kW or more at a test cell temperature exceeding 1,273 K (1,000° C), and specially designed quartz heaters therefor.

1-9.B.7. Equipment specially designed for inspecting the integrity of rocket motors and using Non-Destructive Test (NDT) techniques other than planar x-ray or basic physical or chemical analysis.

1-9.B.8. Direct measurement wall skin friction transducers specially designed to operate at a test flow total (stagnation) temperature exceeding 833 K (560° C).

1-9.B.9. Tooling specially designed for producing gas turbine engine powder metallurgy rotor components having all of the following:

a. Designed to operate at stress levels of 60% of Ultimate Tensile Strength (UTS) or more measured at a temperature of 873 K (600° C); **and**

b. Designed to operate at 873 K (600° C) or more.

***Note:***
*1-9.B.9. does not specify tooling for the production of powder.*

1-9.B.10. Equipment specially designed for the production of items specified by 1-9.A.12.

## 1-9.C. MATERIALS

None

## 1-9.D. SOFTWARE

1-9.D.1. "Software", not specified in 1-9.D.3. or 1-9.D.4., specially designed or modified for the "development" of equipment or "technology", specified by 1-9.A., 1-9.B. or 1-9.E.3.

1-9.D.2. "Software", not specified in 1-9.D.3. or 1-9.D.4., specially designed or modified for the "production" of equipment specified by 1-9.A. or 1-9.B.

1-9.D.3. "Software" incorporating "technology" specified by 1-9.E.3.h. and used in "FADEC Systems" for systems specified by 1-9.A. or equipment specified by 1-9.B.

1-9.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, having all of the following:

1. Specially designed for testing any of the following:

a. Aero gas turbine engines, assemblies or components, incorporating "technology" specified by 1-9.E.3.a., 1-9.E.3.h. or 1-9.E.3.i.; **or**

b. Multi-stage compressors providing either bypass or core flow, specially designed for aero gas turbine engines incorporating "technology" specified by 1-9.E.3.a. or 1-9.E.3.h.; **and**

2. Specially designed for all of the following:

a. Acquisition and processing of data, in real time; **and**

b. Feedback control of the test article or test conditions (e.g., temperature, pressure, flow rate) while the test is in progress;

***Note:***

*1-9.D.4.b. does not specify software for operation of the test facility or operator safety (e.g., overspeed shutdown, fire detection and suppression), or production, repair or maintenance acceptance-testing limited to determining if the item has been properly assembled or repaired.*

c. "Software" specially designed to control directional-solidification or single-crystal material growth in equipment specified by 1-9.B.1.a. or 1-9.B.1.c.;

d. Not used since 2011

e. "Software" specially designed or modified for the operation of items specified by 1-9.A.12.;

f. "Software" specially designed to design the internal cooling passages of aero gas turbine engine blades, vanes and "tip shrouds";

g. "Software" having all of the following:

1. Specially designed to predict aero thermal, aeromechanical and combustion conditions in aero gas turbine engines; **and**

2. Theoretical modelling predictions of the aero thermal, aeromechanical and combustion conditions, which have been validated with actual aero gas turbine engine (experimental or production) performance data.

1-9.D.5. "Software" specially designed or modified for the operation of items specified by 1-9.A.4.e. or 1-9.A.4.f.

## 1-9.E. TECHNOLOGY

***Note:***

*"Development" or "production" "technology" specified by 1-9.E. for gas turbine engines remains specified by 1-9.E. when used for repair or overhaul. Excluded from 1-9.E. 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.*

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

1-9.E.2. "Technology" according to the General Technology Note for the "production" of equipment specified by 1-9.A.1.b., 1-9.A.4. to 1-9.A.11. or 1-9.B.

***N.B.:***

*For "technology" for the repair of specified structures, laminates or materials, see 1-1.E.2.f.*

1-9.E.3. Other "technology" as follows:

1-9.E.3.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 and having (in the 001 Miller Index Direction) a stress-rupture life exceeding 400 hours at 1,273 K (1,000° C) at a stress of 200 MPa, based on the average property values;

***Technical Note:***

*For the purposes of 1-9.E.3.a.1., stress-rupture life testing is typically conducted on a test specimen.*

2. Combustors having any of the following:
   a. 'Thermally decoupled liners' designed to operate at 'combustor exit temperature' exceeding 1,883 K (1,610° C);
   b. Non-metallic liners;
   c. Non-metallic shells; **or**
   d. Liners designed to operate at 'combustor exit temperature' exceeding 1,883 K (1,610° C) and having holes that meet the parameters specified by 1-9.E.3.c.;

***Note:***

The "required" *"technology" for holes in 1-9.E.3.a.2. is limited to the derivation of the geometry and location of the holes.*

***Technical Notes:***

*1. 'Thermally decoupled liners' are liners that feature at least a support structure designed to carry mechanical loads and a combustion facing structure designed to protect the support structure from the heat of combustion. The combustion facing structure and support structure have independent thermal displacement (mechanical displacement due to thermal load) with respect to one another, i.e. they are thermally decoupled.*

*2. 'Combustor exit temperature' is the bulk average gas path total (stagnation) temperature between the combustor exit plane and the leading edge of the turbine inlet guide vane (i.e., measured at engine station T40 as defined in SAE ARP 755A) when the engine is running in a "steady state mode" of operation at the certificated maximum continuous operating temperature.*

***N.B.:***

*See 1-9.E.3.c. for "technology" "required" for manufacturing cooling holes.*

3. Components that are any of the following:
   a. Manufactured from organic "composite" materials designed to operate above 588 K (315° C);
   b. Manufactured from any of the following:
      1. Metal "matrix" "composites" reinforced by any of the following:
         a. Materials specified by 1-1.C.7.;
         b. "Fibrous or filamentary materials" specified by 1-1.C.10.; **or**
         c. Aluminides specified by 1-1.C.2.a.; **or**
      2. Ceramic "matrix" "composites" specified by 1-1.C.7.; **or**
   c. Stators, vanes, blades, tip seals (shrouds), rotating blings, rotating blisks, or 'splitter ducts', that are all of the following:
      1. Not specified in 1-9.E.3.a.3.a.;
      2. Designed for compressors or fans; **and**
      3. Manufactured from material specified by 1-1.C.10.e. with resins specified by 1-1.C.8.;

      ***Technical Note:***

      *A 'splitter duct' performs the initial separation of the air-mass flow between the bypass and core sections of the engine.*
4. Uncooled turbine blades, vanes or "tip-shrouds", designed to operate at a 'gas path temperature' of 1,373 K (1,100° C) or more;
5. Cooled turbine blades, vanes, "tip-shrouds" other than those described in 1-9.E.3.a.1., designed to operate at a 'gas path temperature' of 1,693 K (1,420° C) or more;

   ***Technical Note:***

   *'Gas path temperature' is the bulk average gas path total (stagnation) temperature at the leading edge plane of the turbine component when the engine is running in a "steady state mode" of operation at the certificated or specified maximum continuous operating temperature.*
6. Airfoil-to-disk blade combinations using solid state joining;
7. Not used since 2018
8. 'Damage tolerant' gas turbine engine rotor components using powder metallurgy materials specified by 1-1.C.2.b.; **or**

   ***Technical Note:***

   *'Damage tolerant' components are designed using methodology and substantiation to predict and limit crack growth.*
9. Not used since 2009

   ***N.B.:***

   *For "FADEC systems", see 1-9.E.3.h.*
10. Not used since 2010

    ***N.B.:***

    *For adjustable flow path geometry, see 1-9.E.3.i.*
11. Hollow fan blades;

1-9.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 prop fans, capable of absorbing more than 2,000 kW at flight speeds exceeding Mach 0.55;

1-9.E.3.c. "Technology" "required" for manufacturing cooling holes, in gas turbine engine components incorporating any of the "technologies" specified by 1-9.E.3.a.1., 1-9.E.3.a.2. or 1-9.E.3.a.5., and having any of the following:

1. Having all of the following:
   a. Minimum 'cross-sectional area' less than 0.45 $mm^2$;
   b. 'Hole shape ratio' greater than 4.52; **and**
   c. 'Incidence angle' equal to or less than 25°; **or**
2. Having all of the following:
   a. Minimum 'cross-sectional area' less than 0.12 $mm^2$;
   b. 'Hole shape ratio' greater than 5.65; **and**
   c. 'Incidence angle' more than 25°;

***Note:***

*1-9.E.3.c. does not apply to "technology" for manufacturing constant radius cylindrical holes that are straight through and enter and exit on the external surfaces of the component.*

***Technical Notes:***

1. *For the purposes of 1-9.E.3.c., the 'cross-sectional area' is the area of the hole in the plane perpendicular to the hole axis.*
2. *For the purposes of 1-9.E.3.c., 'hole shape ratio' is the nominal length of the axis of the hole divided by the square root of its minimum 'cross-sectional area'.*
3. *For the purposes of 1-9.E.3.c., 'incidence angle' is the acute angle measured between the plane tangential to the aerofoil surface and the hole axis at the point where the hole axis enters the aerofoil surface.*
4. *Methods for manufacturing holes in 1-9.E.3.c include "laser" beam machining, water jet machining, Electro-Chemical Machining (ECM) or Electrical Discharge Machining (EDM).*

1-9.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;

1-9.E.3.e. "Technology" for the "development" or "production" of reciprocating diesel engine ground vehicle propulsion systems having all of the following:

1. 'Box volume' of 1.2 $m^3$ or less;
2. An overall power output of more than 750 kW based on 80/1269/EEC, ISO 2534 or national equivalents; **and**
3. Power density of more than 700 $kW/m^3$ of 'box volume';

***Technical Note:***

*'Box volume' is the product of three perpendicular dimensions measured in the following way:*

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

*Width: The widest of any 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 any 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.*

1-9.E.3.f. "Technology" "required" for the "production" of specially designed components for high output diesel engines, as follows:

1. "Technology" "required" for the "production" of engine systems having all of the following components employing ceramics materials specified by 1-1.C.7.:
   a. Cylinder liners;
   b. Pistons;
   c. Cylinder heads; **and**
   d. One or more other components (including exhaust ports, turbochargers, valve guides, valve assemblies or insulated fuel injectors);
2. "Technology" "required" for the "production" of turbocharger systems with single-stage compressors and having all of the following:
   a. Operating at pressure ratios of 4:1 or higher;
   b. 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)) and having all of the following:
   a. Injection amount in excess of 230 $mm^3$ per injection per cylinder; **and**
   b. Electronic control features specially designed for switching governor characteristics automatically depending on fuel property to provide the same torque characteristics by using the appropriate sensors;

1-9.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 and 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' are 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.*

1-9.E.3.h. "Technology" for gas turbine engine "FADEC systems" as follows:

1. "Development" "technology" for deriving the functional requirements for the components necessary for the "FADEC system" to regulate engine thrust or shaft power (e.g., feedback sensor time constants and accuracies, fuel valve slew rate);
2. "Development" or "production" "technology" for control and diagnostic components unique to the "FADEC system" and used to regulate engine thrust or shaft power;
3. "Development" "technology" for the control law algorithms, including "source code", unique to the "FADEC system" and used to regulate engine thrust or shaft power;

***Note:***

*1-9.E.3.h. does not apply to technical data related to engine-"aircraft" integration required by civil aviation authorities of one or more Wassenaar Arrangement Participating States to be published for general airline use (e.g., installation manuals, operating instructions, instructions for continued airworthiness) or interface functions (e.g., input/output processing, airframe thrust or shaft power demand).*

1-9.E.3.i. "Technology" for adjustable flow path systems designed to maintain engine stability for gas generator turbines, fan or power turbines, or propelling nozzles, as follows:

1. "Development" "technology" for deriving the functional requirements for the components that maintain engine stability;
2. "Development" or "production" "technology" for components unique to the adjustable flow path system and that maintain engine stability;
3. "Development" "technology" for the control law algorithms, including "source code", unique to the adjustable flow path system and that maintain engine stability.

***Note:***

*1-9.E.3.i. does not apply to "technology" for any of the following:*

*a. Inlet guide vanes;*

*b. Variable pitch fans or prop-fans;*

*c. Variable compressor vanes;*

*d. Compressor bleed valves;* ***or***

*e. Adjustable flow path geometry for reverse thrust.*

1-9.E.3.j. "Technology" "required" for the "development" of wing-folding systems designed for fixed-wing "aircraft" powered by gas turbine engines.

***N.B.:***

*For "technology" "required" for the "development" of wing-folding systems designed for fixed-wing "aircraft" specified in 2-10., see 2-22.*

# GROUP 2 – MUNITIONS LIST

***Note 1:***

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

***Note 2:***

*In some instances chemicals are listed by name and CAS number. The list applies to chemicals of the same structural formula (including hydrates) regardless of name or CAS number. CAS numbers are shown to assist in identifying a particular chemical or mixture, irrespective of nomenclature. CAS numbers cannot be used as unique identifiers because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.*

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

*(All Destinations)*

a. Rifles and combination guns, handguns, machine, sub-machine and volley guns;

***Note:***

*2-1.a. does not apply to rifles or handguns, specially designed to discharge an inert projectile by compressed air or $CO_2$ at a muzzle velocity less than or equal to 152.4 m/s or at a muzzle energy less than or equal to 5.7 Joules.*

b. Smooth-bore weapons;

***Note:***

*2-1.b. does not apply to weapons specially designed to discharge an inert projectile by compressed air or $CO_2$ at a muzzle velocity less than or equal to 152.4 m/s or at a muzzle energy less than or equal to 5.7 Joules.*

c. Weapons using caseless ammunition;

d. Accessories designed for arms specified by 2-1.a., 2-1.b. or 2-1.c., as follows:

1. Detachable cartridge magazines;
2. Sound suppressors or moderators;
3. Special gun-mountings;
4. Flash suppressors;
5. Optical weapon-sights with electronic image processing;
6. Optical weapon-sights specially designed for military use.

e. Other firearms as defined by the Criminal Code, as follows:

1. Any firearm capable of discharging a dart or other object carrying an electrical current or substance, including the firearm of the design commonly known as the Taser Public Defender and any variant or modified version of it as set out in Part I of the Schedule to the *Regulations Prescribing Certain Firearms and other Weapons, Components and Parts of Weapons, Accessories, Cartridge Magazines, Ammunition and Projectiles as Prohibited or Restricted*;
2. Firearms, not specified by 2-1.a., 2-1.b., 2-1.c. or 2-1.e.1., designed to discharge a projectile at a muzzle velocity exceeding 152.4 m/s or at a muzzle energy exceeding 5.7 Joules.

***Note:***

*2-.1 does not control the following:*

1. *Firearms specially designed for dummy ammunition and which are incapable of discharging a projectile;*
2. *Firearms specially designed to launch tethered projectiles having no high explosive charge or communications link, to a range of less than or equal to 500 m.;*
3. *Weapons that are antique firearms, as defined in paragraph (a) and (b) of the definition antique firearms in subsection 84(1) of the Criminal Code.*
4. *Smooth-bore weapons or firearms defined by the Criminal Code specially designed for any of the following:*
   a. *Slaughtering of domestic animals*
   b. *Tranquilizing of animals*
   c. *Seismic testing;*
   d. *Firing of industrial projectiles; or*
   e. *Disrupting Improvised Explosive devices (IEDs).*

   ***N. B.:***

   *For disruptors, see 2-4. and 1-1.A.6. on the Dual-Use List.*
5. *"Deactivated firearms".*

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

a. Guns, howitzers, cannon, mortars, anti-tank weapons, projectile launchers, military flame throwers, rifles, recoilless rifles, smooth-bore weapons and signature reduction devices therefor;

*(All destinations)*

***Note 1:***

*2-2.a. includes injectors, metering devices, storage tanks and other specially designed components for use with liquid propelling charges for any of the equipment specified by 2-2.a.*

***Note 2:***

*2-2.a. does not control weapons that are antique firearms, as defined in paragraph (a) and (b) of the definition antique firearms in subsection 84(1) of the Criminal Code.*

***Note 3:***

*2-2.a. does not apply to weapons specially designed for any of the following:*

a. *Slaughtering of domestic animals;*
b. *Tranquilizing of animals;*
c. *Seismic testing;*
d. *Firing of industrial projectiles;* ***or***
e. *Disrupting Improvised Explosive Devices (IEDs);*

***N.B.:***

*For disruptors see 2-4. and 1-1.A.6. on the Dual-Use List.*

f. *Hand-held projectile launchers specially designed to launch tethered projectiles having no high explosive charge or communications link, to a range of less than or equal to 500 m.*

b. Smoke, gas and pyrotechnic projectors or generators, specially designed or modified for military use;

*(All destinations)*

***Note:***

*2-2.b. does not apply to signal pistols.*

c. Weapons sights and weapon sight mounts, having all of the following:
   1. Specially designed for military use; **and**
   2. Specially designed for weapons specified in 2-2.a.;

d. Mountings and detachable cartridge magazines, specially designed for the weapons specified in 2-2.a.

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

*(All Destinations)*

a. Ammunition for weapons specified by 2-1., 2-2. or 2-12.;

b. Fuze setting devices specially designed for ammunition specified by 2-3.a.

***Note 1:***

*Specially designed components specified by 2-3. 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, fuzes, sensors and initiation devices;*

*c. Power supplies with high one-time operational output;*

*d. Combustible cases for charges;*

*e. Submunitions including bomblets, minelets and terminally guided projectiles.*

***Note 2:***

*2-3.a. does not apply to any of the following:*

*a. Ammunition crimped without a projectile (blank star);*

*b. Dummy ammunition with a pierced powder chamber;*

*c. Other blank and dummy ammunition, not incorporating components designed for live ammunition;* ***or***

*d. Components specially designed for blank or dummy ammunition, specified in this Note 2.a., b. or c.*

***Note 3:***

*2-3.a. does not apply to cartridges specially designed for any of the following purposes:*

*a. Signalling;*

*b. Bird scaring;* ***or***

*c. Lighting of gas flares at oil wells.*

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

***N.B. 1:***

*For guidance and navigation equipment, see 2-11.*

***N.B. 2:***

*For Aircraft Missile Protection Systems (AMPS), see 2-4.c.*

a. Bombs, torpedoes, grenades, smoke canisters, rockets, mines, missiles, depth charges, demolition-charges, demolition-devices, demolition-kits, “pyrotechnic” devices, cartridges and simulators (i.e., equipment simulating the characteristics of any of these items), specially designed for military use;

   *(All destinations)*

***Note:***

*2-4.a. includes:*

*a. Smoke grenades, fire bombs, incendiary bombs and explosive devices;*

*b. Missile or rocket nozzles and re-entry vehicle nosetips.*

b. Equipment having all of the following:

1. Specially designed for military use; **and**
2. Specially designed for 'activities' relating to any of the following:
   a. Items specified by 2-4.a.; **or**
   b. Improvised Explosive Devices (IEDs).

***Technical Note:***

*For the purpose of 2-4.b.2. 'activities' applies to handling, launching, laying, controlling, discharging, detonating, activating, powering with one-time operational output, decoying, jamming, sweeping, detecting, disrupting or disposing.*

***Note 1:***

*2-4.b. includes:*

*a. Mobile gas liquefying equipment capable of producing 1,000 kg or more per day of gas in liquid form;*

*b. Buoyant electric conducting cable suitable for sweeping magnetic mines.*

***Note 2:***

*2-4.b. does not apply to hand-held devices limited by design solely to the detection of metal objects and incapable of distinguishing between mines and other metal objects.*

c. Aircraft Missile Protection Systems (AMPS).

***Note:***

*2-4.c. does not apply to AMPS having all of the following:*

*a. Any of the following missile warning sensors:*

*1. Passive sensors having peak response between 100-400 nm;* ***or***

*2. Active pulsed Doppler missile warning sensors;*

*b. Countermeasures dispensing systems;*

*c. Flares, which exhibit both a visible signature and an infrared signature, for decoying surface-to-air missiles;* ***and***

*d. Installed on "civil aircraft" and having all of the following:*

*1. The AMPS is only operable in a specific "civil aircraft" in which the specific AMPS is installed and for which any of the following has been issued:*

*a. A civil Type Certificate issued by civil aviation authorities of one or more Wassenaar Arrangement Participating States;* ***or***

*b. An equivalent document recognised by the International Civil Aviation Organisation (ICAO);*

*2. The AMPS employs protection to prevent unauthorised access to "software";* ***and***

*3. The AMPS incorporates an active mechanism that forces the system not to function when it is removed from the "civil aircraft" in which it was installed.*

2-5. Fire control, surveillance 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. Other fire control, surveillance and warning equipment, and related systems, as follows:
   1. Target acquisition, designation, range-finding, surveillance or tracking systems;
   2. Detection, recognition or identification equipment;
   3. Data fusion or sensor integration equipment;

c. Countermeasure equipment for items specified by 2-5.a. or 2-5.b.;

***Note:***
*For the purposes of 2-5.c., countermeasure equipment includes detection equipment.*

d. Field test or alignment equipment, specially designed for items specified by 2-5.a., 2-5.b. or 2-5.c.

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

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

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

***Note 1:***
*2-6.a. includes:*

*a. Tanks and other military armed vehicles and military vehicles fitted with mountings for arms or equipment for mine laying or the launching of munitions specified by 2-4.;*
*b. Armoured vehicles;*
*c. Amphibious and deep water fording vehicles;*
*d. Recovery vehicles and vehicles for towing or transporting ammunition or weapon systems and associated load handling equipment;*
*e. Trailers.*

***Note 2:***
*Modification of a ground vehicle for military use specified by 2-6.a. entails a structural, electrical or mechanical change involving one or more components that are specially designed for military use. Such components include:*

*a. Pneumatic tyre casings of a kind specially designed to be bullet-proof;*
*b. Armoured protection of vital parts (e.g., fuel tanks or vehicle cabs);*
*c. Special reinforcements or mountings for weapons;*
*d. Black-out lighting.*

b. Other ground vehicles and components, as follows:
   1. Vehicles having all of the following:
      a. Manufactured or fitted with materials or components to provide ballistic protection equal to or better than level III (NIJ 0108.01, September 1985, or comparable national standard);
      b. A transmission to provide drive to both front and rear wheels simultaneously, including those vehicles having additional wheels for load bearing purposes whether driven or not;
      c. Gross Vehicle Weight Rating (GVWR) greater than 4,500 kg; **and**
      d. Designed or modified for off-road use;
   2. Components having all of the following:
      a. Specially designed for vehicles specified in 2-6.b.1.; **and**

b. Providing ballistic protection equal to or better than level III (NIJ 0108.01, September 1985, or comparable national standard).

***N.B.:***

*See also 2-13.a.*

***Note 1:***

*2-6. does not apply to civil vehicles designed or modified for transporting money or valuables.*

***Note 2:***

*2-6. does not apply to vehicles that meet all of the following:*

*a. Were manufactured before 1946;*

*b. Do not have items specified by the Munitions List and manufactured after 1945, except for reproductions of original components or accessories for the vehicle;* ***and***

*c. Do not incorporate weapons specified in 2-1., 2-2. or 2-4. unless they are inoperable and incapable of discharging a projectile.*

2-7. Chemical agents, "biological agents", "riot control agents", radioactive materials, related equipment, components and materials, as follows:

a. "Biological agents" or radioactive materials selected or modified to increase their effectiveness in producing casualties in humans or animals, degrading equipment or damaging crops or the environment;

b. Chemical warfare (CW) agents, including:

1. CW nerve agents:

a. O-Alkyl (equal to or less than $C_{10}$, including cycloalkyl) alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) - phosphonofluoridates, such as:

Sarin (GB):O-Isopropyl methylphosphonofluoridate (CAS 107-44-8); **and**

Soman (GD):O-Pinacolyl methylphosphonofluoridate (CAS 96-64-0);

b. O-Alkyl (equal to or less than $C_{10}$, including cycloalkyl) N,N-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphoramidocyanidates, such as:

Tabun (GA):O-Ethyl N,N-dimethylphosphoramidocyanidate (CAS 77-81-6);

c. O-Alkyl (H or equal to or less than $C_{10}$, including cycloalkyl) S-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl)-aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonothiolates and corresponding alkylated and protonated salts, such as:

VX: O-Ethyl S-2-diisopropylaminoethyl methyl phosphonothiolate (CAS 50782-69-9);

2. CW vesicant agents:

a. Sulphur mustards, such as:

1. 2-Chloroethylchloromethylsulphide (CAS 2625-76-5);
2. Bis(2-chloroethyl) sulphide (CAS 505-60-2);
3. Bis(2-chloroethylthio) methane (CAS 63869-13-6);
4. 1,2-bis (2-chloroethylthio) ethane (CAS 3563-36-8);
5. 1,3-bis (2-chloroethylthio) -n-propane (CAS 63905-10-2);
6. 1,4-bis (2-chloroethylthio) -n-butane (CAS 142868-93-7);

7. 1,5-bis (2-chloroethylthio) -n-pentane (CAS 142868-94-8);
8. Bis (2-chloroethylthiomethyl) ether (CAS 63918-90-1);
9. Bis (2-chloroethylthioethyl) ether (CAS 63918-89-8);

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

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

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

4. CW defoliants, such as:
a. Butyl 2-chloro-4-fluorophenoxyacetate (LNF);
b. 2,4,5-trichlorophenoxyacetic acid (CAS 93-76-5) mixed with 2,4-dichlorophenoxyacetic acid (CAS 94-75-7) (Agent Orange (CAS 39277-47-9));

2-7.c. CW binary precursors and key precursors, as follows:

1. Alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) Phosphonyl Difluorides, such as:
DF: Methyl Phosphonyldifluoride (CAS 676-99-3);
2. O-Alkyl (H or equal to or less than $C_{10}$, including cycloalkyl) O-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl) aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonites and corresponding alkylated and protonated salts, such as:
QL: O-Ethyl O-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);

2-7.d. “Riot control agents”, active constituent chemicals and combinations thereof, including:

1. α-Bromobenzeneacetonitrile, (Bromobenzyl cyanide) (CA) (CAS 5798-79-8);
2. [(2-chlorophenyl) methylene] propanedinitrile, (o-Chlorobenzylidenemalononitrile) (CS) (CAS 2698-41-1);
3. 2-Chloro-1-phenylethanone, Phenylacyl chloride (ω-chloroacetophenone) (CN) (CAS 532-27-4);
4. Dibenz-(b,f)-1,4-oxazephine, (CR) (CAS 257-07-8);
5. 10-Chloro-5,10-dihydrophenarsazine, (Phenarsazine chloride), (Adamsite), (DM) (CAS 578-94-9);
6. N-Nonanoylmorpholine, (MPA) (CAS 5299-64-9);

***Note 1:***

*2-7.d. does not apply to “riot control agents” individually packaged for personal self-defence purposes.*

***Note 2:***

*2-7.d. does not apply to active constituent chemicals, and combinations thereof, identified and packaged for food production or medical purposes.*

2-7.e. Equipment, specially designed or modified for military use, designed or modified for the dissemination of any of the following, and specially designed components therefor:

1. Materials or agents specified by 2-7.a., 2-7.b. or 2-7.d.; **or**
2. CW agents made up of precursors specified by 2-7.c.;

2-7.f. Protective and decontamination equipment, specially designed or modified for military use, components and chemical mixtures, as follows:

1. Equipment designed or modified for defence against materials specified by 2-7.a., 2-7.b. or 2-7.d., and specially designed components therefor;
2. Equipment designed or modified for decontamination of objects contaminated with materials specified by 2-7.a. or 2-7.b., and specially designed components therefor;
3. Chemical mixtures specially developed or formulated for the decontamination of objects contaminated with materials specified by 2-7.a. or 2-7.b.;

***Note:***

*2-7.f.1. includes:*

*a. Air conditioning units specially designed or modified for nuclear, biological or chemical filtration;*

*b. Protective clothing.*

***N.B.:***

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

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

***Note:***

*2-7.g. does not apply to personal radiation monitoring dosimeters.*

***N.B.:***

*See also 1-1.A.4. on the Dual-Use List.*

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

2-7.i. “Biocatalysts” for the decontamination or degradation of CW agents, and biological systems therefor, as follows:

1. “Biocatalysts” specially designed for the decontamination or degradation of CW agents specified by 2-7.b., and resulting from directed laboratory selection or genetic manipulation of biological systems;
2. Biological systems containing the genetic information specific to the production of “biocatalysts” specified by 2-7.i.1., as follows:
   a. “Expression vectors”;
   b. Viruses;
   c. Cultures of cells.

***Note 1:***

*2-7.b. and 2-7.d. do not apply to the following:*

*a. Cyanogen chloride (CAS 506-77-4);*

*b. Hydrocyanic acid (CAS 74-90-8);*

*c. Chlorine (CAS 7782-50-5);*

*d. Carbonyl chloride (phosgene) (CAS 75-44-5);*

*e. Diphosgene (trichloromethyl-chloroformate) (CAS 503-38-8);*

*f. Not used since 2004*

*g. Xylyl bromide, ortho: (CAS 89-92-9), meta: (CAS 620-13-3), para: (CAS 104-81-4);*

*h. Benzyl bromide (CAS 100-39-0);*

*i. Benzyl iodide (CAS 620-05-3);*

*j. Bromo acetone (CAS 598-31-2);*

*k. Cyanogen bromide (CAS 506-68-3);*

*l. Bromo methylethylketone (CAS 816-40-0);*

*m. Chloro acetone (CAS 78-95-5);*

*n. Ethyl iodoacetate (CAS 623-48-3);*

*o. Iodo acetone (CAS 3019-04-3);*

*p. Chloropicrin (CAS 76-06-2).*

***Note 2:***

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

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

***N.B. 1:***

*See also 1-1.C.11. on the Dual-Use List.*

***N.B. 2:***

*For charges and devices, see 2-4. and 1-1.A.8. on the Dual-Use List.*

***Technical Notes:***

*1. For the purposes of 2-8., excluding 2-8.c.11. or 2-8.c.12., 'mixture' refers to a composition of two or more substances with at least one substance being listed in the 2-8. sub-items.*

*2. Any substance listed in the 2-8. sub-items is subject to this list, even when utilised in an application other than that indicated. (e.g., TAGN is predominantly used as an explosive but can also be used either as a fuel or an oxidizer.)*

*3. For the purposes of 2-8., particle size is the mean particle diameter on a weight or volume basis. International or equivalent national standards will be used in sampling and determining particle size.*

2-8.a. "Explosives" as follows, and 'mixtures' thereof:

1. ADNBF (aminodinitrobenzofuroxan or 7-amino-4,6-dinitrobenzofurazane-1-oxide) (CAS 97096-78-1);
2. BNCP (cis-bis (5-nitrotetrazolato) tetra amine-cobalt (III) perchlorate) (CAS 117412-28-9);
3. CL-14 (diamino dinitrobenzofuroxan or 5,7-diamino-4,6-dinitrobenzofurazane-1-oxide ) (CAS 117907-74-1);

4. CL-20 (HNIW or Hexanitrohexaazaisowurtzitane) (CAS 135285-90-4); chlathrates of CL-20 (see also 2-8.g.3. and 2-8.g.4. for its "precursors");
5. CP (2-(5-cyanotetrazolato) penta amine-cobalt (III) perchlorate) (CAS 70247-32-4);
6. DADE (1,1-diamino-2,2-dinitroethylene, FOX-7) (CAS 145250-81-3);
7. DATB (diaminotrinitrobenzene) (CAS 1630-08-6);
8. DDFP (1,4-dinitrodifurazanopiperazine);
9. DDPO (2,6-diamino-3,5-dinitropyrazine-1-oxide, PZO) (CAS 194486-77-6);
10. DIPAM (3,3′-diamino-2,2′,4,4′,6,6′-hexanitrobiphenyl or dipicramide) (CAS 17215-44-0);
11. DNGU (DINGU or dinitroglycoluril) (CAS 55510-04-8);
12. Furazans as follows:
    a. DAAOF (DAAF, DAAFox, or diaminoazoxyfurazan);
    b. DAAzF (diaminoazofurazan) (CAS 78644-90-3);
13. HMX and derivatives (see also 2-8.g.5. for its "precursors"), as follows:
    a. HMX (Cyclotetramethylenetetranitramine, octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazine, 1,3,5,7-tetranitro-1,3,5,7-tetraza-cyclooctane, octogen or octogene) (CAS 2691-41-0);
    b. difluoroaminated analogs of HMX;
    c. K-55 (2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo [3,3,0]-octanone-3, tetranitrosemiglycouril or keto-bicyclic HMX) (CAS 130256-72-3);
14. HNAD (hexanitroadamantane) (CAS 143850-71-9);
15. HNS (hexanitrostilbene) (CAS 20062-22-0);
16. Imidazoles as follows:
    a. BNNII (Octahydro-2,5-bis(nitroimino)imidazo [4,5-d]imidazole);
    b. DNI (2,4-dinitroimidazole) (CAS 5213-49-0);
    c. FDIA (1-fluoro-2,4-dinitroimidazole);
    d. NTDNIA (N-(2-nitrotriazolo)-2,4-dinitroimidazole);
    e. PTIA (1-picryl-2,4,5-trinitroimidazole);
17. NTNMH (1-(2-nitrotriazolo)-2-dinitromethylene hydrazine);
18. NTO (ONTA or 3-nitro-1,2,4-triazol-5-one) (CAS 932-64-9);
19. Polynitrocubanes with more than four nitro groups;
20. PYX (2,6-Bis(picrylamino)-3,5-dinitropyridine) (CAS 38082-89-2);
21. RDX and derivatives, as follows:
    a. RDX (cyclotrimethylenetrinitramine, cyclonite, T4, hexahydro-1,3,5-trinitro-1,3,5-triazine, 1,3,5-trinitro-1,3,5-triaza-cyclohexane, hexogen or hexogene) (CAS 121-82-4);
    b. Keto-RDX (K-6 or 2,4,6-trinitro-2,4,6-triazacyclohexanone) (CAS 115029-35-1);
22. TAGN (triaminoguanidinenitrate) (CAS 4000-16-2);
23. TATB (triaminotrinitrobenzene) (CAS 3058-38-6) (see also 2-8.g.7 for its "precursors");
24. TEDDZ (3,3,7,7-tetrabis(difluoroamine) octahydro-1,5-dinitro-1,5-diazocine);
25. Tetrazoles as follows:

a. NTAT (nitrotriazol aminotetrazole);
b. NTNT (1-N-(2-nitrotriazolo)-4-nitrotetrazole);

26. Tetryl (trinitrophenylmethylnitramine) (CAS 479-45-8);
27. TNAD (1,4,5,8-tetranitro-1,4,5,8-tetraazadecalin) (CAS 135877-16-6) (see also 2-8.g.6. for its "precursors");
28. TNAZ (1,3,3-trinitroazetidine) (CAS 97645-24-4) (see also 2-8.g.2. for its "precursors");
29. TNGU (SORGUYL or tetranitroglycoluril) (CAS 55510-03-7);
30. TNP (1,4,5,8-tetranitro-pyridazino[4,5-d]pyridazine) (CAS 229176-04-9);
31. Triazines as follows:
    a. DNAM (2-oxy-4,6-dinitroamino-s-triazine) (CAS 19899-80-0);
    b. NNHT (2-nitroimino-5-nitro-hexahydro-1,3,5-triazine) (CAS 130400-13-4);
32. Triazoles as follows:
    a. 5-azido-2-nitrotriazole;
    b. ADHTDN (4-amino-3,5-dihydrazino-1,2,4-triazole dinitramide) (CAS-1614-08-0);
    c. ADNT (1-amino-3,5-dinitro-1,2,4-triazole);
    d. BDNTA ((bis-dinitrotriazole)amine);
    e. DBT (3,3′-dinitro-5,5-bi-1,2,4-triazole) (CAS 30003-46-4);
    f. DNBT (dinitrobistriazole) (CAS 70890-46-9);
    g. Not used since 2010
    h. NTDNT (1-N-(2-nitrotriazolo) 3,5-dinitrotriazole);
    i. PDNT (1-picryl-3,5-dinitrotriazole);
    j. TACOT (tetranitrobenzotriazolobenzotriazole) (CAS 25243-36-1);
33. "Explosives" not listed elsewhere in 2-8.a. and having any of the following:
    a. Detonation velocity exceeding 8,700 m/s, at maximum density, **or**
    b. Detonation pressure exceeding 34 GPa (340 kbar);
34. Not used since 2013
35. DNAN (2,4-dinitroanisole) (CAS 119-27-7);
36. TEX (4,10-Dinitro-2,6,8,12-tetraoxa-4,10-diazaisowurtzitane);
37. GUDN (Guanylurea dinitramide) FOX-12 (CAS 217464-38-5);
38. Tetrazines as follows:
    a. BTAT (Bis(2,2,2-trinitroethyl)-3,6-diaminotetrazine);
    b. LAX-112 (3,6-diamino-1,2,4,5-tetrazine-1,4-dioxide);
39. Energetic ionic materials melting between 343 K (70° C) and 373 K (100° C) and with detonation velocity exceeding 6,800 m/s or detonation pressure exceeding 18 GPa (180 kbar);
40. BTNEN (Bis(2,2,2-trinitroethyl)-nitramine) (CAS 19836-28-3);
41. FTDO (5,6-(3',4'-furazano)- 1,2,3,4-tetrazine-1,3-dioxide);
42. EDNA (Ethylenedinitramine) (CAS 505-71-5);
43. TKX-50 (Dihydroxylammonium 5,5'-bistetrazole-1,1'-diolate);

***Note:***
*2-8.a. includes 'explosive co-crystals'.*

***Technical Note:***

*An 'explosive co-crystal' is a solid material consisting of an ordered three dimensional arrangement of two or more explosive molecules, where at least one is specified in 2-8.a.*

2-8.b. "Propellants" as follows:

1. Any solid "propellant" with a theoretical specific impulse (under standard conditions) of more than:
   a. 240 seconds for non-metallized, non-halogenized "propellant";
   b. 250 seconds for non-metallized, halogenized "propellant"; **or**
   c. 260 seconds for metallized "propellant";
2. Not used since 2013
3. "Propellants" having a force constant of more than 1,200 kJ/kg;
4. "Propellants" that can sustain a steady-state linear burning rate of more than 38 mm/s under standard conditions (as measured in the form of an inhibited single strand) of 6.89 MPa (68.9 bar) pressure and 294 K (21° C);
5. Elastomer Modified Cast Double Base (EMCDB) "propellants" with extensibility at maximum stress of more than 5% at 233 K (-40° C);
6. Any "propellant" containing substances specified by 2-8.a.;
7. "Propellants", not specified elsewhere in the Munitions List, specially designed for military use;

2-8.c. "Pyrotechnics", fuels and related substances, as follows, and 'mixtures' thereof:

1. "Aircraft" fuels specially formulated for military purposes;

***Note 1:***

*2-8.c.1. does not apply to the following "aircraft" fuels: JP-4, JP-5, and JP-8.*

***Note 2:***

*"Aircraft" fuels specified by 2-8.c.1. are finished products, not their constituents.*

2. Alane (aluminium hydride) (CAS 7784-21-6);
3. Boranes, as follows, and their derivatives:
   a. Carboranes;
   b. Borane homologues, as follows:
      1. Decaborane (14) (CAS 17702-41-9);
      2. Pentaborane (9) (CAS 19624-22-7);
      3. Pentaborane (11) (CAS 18433-84-6);
4. Hydrazine and derivatives, as follows (see also 2-8.d.8. and 2-8.d.9. for oxidising hydrazine derivatives):
   a. Hydrazine (CAS 302-01-2) in concentrations of 70% or more;
   b. Monomethyl hydrazine (CAS 60-34-4);
   c. Symmetrical dimethyl hydrazine (CAS 540-73-8);
   d. Unsymmetrical dimethyl hydrazine (CAS 57-14-7);

   ***Note :***

   *2-8.c.4.a. does not apply to hydrazine 'mixtures' specially formulated for corrosion control.*

5. Metal fuels, fuel 'mixtures' or "pyrotechnic" 'mixtures', in particle form whether spherical, atomized, spheroidal, flaked or ground, manufactured from material consisting of 99% or more of any of the following:
   a. Metals as follows and 'mixtures' thereof:

1. Beryllium (CAS 7440-41-7) in particle sizes of less than 60 µm;
2. Iron powder (CAS 7439-89-6) with particle size of 3 µm or less produced by reduction of iron oxide with hydrogen;

b. ‘Mixtures’ containing any of the following:
1. Zirconium (CAS 7440-67-7), magnesium (CAS 7439-95-4) or alloys of these in particle sizes of less than 60 µm; **or**
2. Boron (CAS 7440-42-8) or boron carbide (CAS 12069-32-8) fuels of 85% purity or higher and particle sizes of less than 60 µm;

***Note 1:***
*2-8.c.5 applies to “explosives” and fuels, whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium, or beryllium.*

***Note 2:***
*2-8.c.5.b. only applies to metal fuels in particle form when they are mixed with other substances to form a ‘mixture’ formulated for military purposes such as liquid “propellant” slurries, solid “propellants”, or “pyrotechnic” ‘mixtures’.*

***Note 3:***
*2-8.c.5.b.2. does not apply to boron and boron carbide enriched with boron-10 (20% or more of total boron-10 content.)*

6. Military materials, containing thickeners for hydrocarbon fuels, specially formulated for use in flame throwers or incendiary munitions, such as metal stearates (e.g., octal (CAS 637-12-7)) or palmitates;
7. Perchlorates, chlorates and chromates, composited with powdered metal or other high energy fuel components;
8. Spherical or spheroidal aluminium powder (CAS 7429-90-5) with a particle size of 60 µm or less and manufactured from material with an aluminium content of 99% or more;
9. Titanium subhydride ($TiH_n$) of stoichiometry equivalent to n = 0.65-1.68;
10. Liquid high energy density fuels not specified in 2-8.c.1., as follows:
    a. Mixed fuels, that incorporate both solid and liquid fuels (e.g., boron slurry), having a mass-based energy density of 40 MJ/kg or greater;
    b. Other high energy density fuels and fuel additives (e.g., cubane, ionic solutions, JP-7, JP-10), having a volume-based energy density of 37.5 GJ per cubic meter or greater, measured at 293 K (20° C) and one atmosphere (101.325 kPa) pressure;

    ***Note:***
    *2-8.c.10.b. does not apply to fossil refined fuels or biofuels, or fuels for engines certified for use in civil aviation.*
11. “Pyrotechnic” and pyrophoric materials as follows:
    a. “Pyrotechnic” or pyrophoric materials specifically formulated to enhance or control the production of radiated energy in any part of the IR spectrum;
    b. Mixtures of magnesium, polytetrafluoroethylene (PTFE) and a vinylidene difluoride-hexafluoropropylene copolymer (e.g., MTV);
12. Fuel mixtures, “pyrotechnic” mixtures or “energetic materials”, not specified elsewhere in 2-8, having all of the following:
    a. Containing greater than 0.5% of particles of any of the following:
        1. Aluminium;

2. Beryllium;
3. Boron;
4. Zirconium;
5. Magnesium; **or**
6. Titanium;

b. Particles specified by 2-8.c.12.a. with a size less than 200 nm in any direction; **and**

c. Particles specified by 2-8.c.12.a. with a metal content of 60% or greater;

***Note:***
*2-8.c.12. includes thermites.*

2-8.d. Oxidizers as follows, and ‘mixtures’ thereof:

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

   ***Note 1:***
   *2-8.d.3. does not apply to chlorine trifluoride (CAS 7790-91-2).*

   ***Note 2:***
   *2-8.d.3. does not apply to nitrogen trifluoride (CAS 7783-54-2) in its gaseous state.*
4. DNAD (1,3-dinitro-1,3-diazetidine) (CAS 78246-06-7);
5. HAN (hydroxylammonium nitrate) (CAS 13465-08-2);
6. HAP (hydroxylammonium perchlorate) (CAS 15588-62-2);
7. HNF (hydrazinium nitroformate) (CAS 20773-28-8);
8. Hydrazine nitrate (CAS 37836-27-4);
9. Hydrazine perchlorate (CAS 27978-54-7);
10. Liquid oxidisers comprised of or containing inhibited red fuming nitric acid (IRFNA) (CAS 8007-58-7);

    ***Note:***
    *2-8.d.10. does not apply to non-inhibited fuming nitric acid.*

2-8.e. Binders, plasticizers, monomers and polymers, as follows:

1. AMMO (azidomethylmethyloxetane and its polymers) (CAS 90683-29-7) (see also 2-8.g.1. for its “precursors”);
2. BAMO (3,3-bis(azidomethyl)oxetane and its polymers) (CAS 17607-20-4) (see also 2-8.g.1. for its “precursors”);
3. BDNPA (bis (2,2-dinitropropyl)acetal) (CAS 5108-69-0);
4. BDNPF (bis (2,2-dinitropropyl)formal) (CAS 5917-61-3);
5. BTTN (butanetrioltrinitrate) (CAS 6659-60-5) (see also 2-8.g.8. for its “precursors”);
6. Energetic monomers, plasticizers or polymers, specially formulated for military use and containing any of the following:
   a. Nitro groups;

b. Azido groups;
c. Nitrate groups;
d. Nitraza groups; **or**
e. Difluoroamino groups;

7. FAMAO (3-difluoroaminomethyl-3-azidomethyl oxetane) and its polymers;
8. FEFO (bis-(2-fluoro-2,2-dinitroethyl) formal) (CAS 17003-79-1);
9. FPF-1 (poly-2,2,3,3,4,4-hexafluoropentane-1,5-diol formal) (CAS 376-90-9);
10. FPF-3 (poly-2,4,4,5,5,6,6-heptafluoro-2-tri-fluoromethyl-3-oxaheptane-1, 7-diol formal);
11. GAP (glycidylazide polymer) (CAS 143178-24-9) and its derivatives;
12. HTPB (hydroxyl terminated polybutadiene) with a hydroxyl functionality equal to or greater than 2.2 and less than or equal to 2.4, a hydroxyl value of less than 0.77 meq/g, and a viscosity at 30° C of less than 47 poise (CAS 69102-90-5);
13. Alcohol functionalised poly(epichlorohydrin) with a molecular weight less than 10,000, as follows:
    a. Poly(epichlorohydrindiol);
    b. Poly(epichlorohydrintriol).
14. NENAs (nitratoethylnitramine compounds) (CAS 17096-47-8, 85068-73-1, 82486-83-7, 82486-82-6 and 85954-06-9);
15. PGN (poly-GLYN, polyglycidylnitrate or poly(nitratomethyl oxirane)) (CAS 27814-48-8);
16. Poly-NIMMO (poly (nitratomethylmethyloxetane), poly-NMMO or poly(3-Nitratomethyl-3-methyloxetane)) (CAS 84051-81-0);
17. Polynitroorthocarbonates;
18. TVOPA (1,2,3-tris[1,2-bis(difluoroamino)ethoxy] propane or tris vinoxy propane adduct) (CAS 53159-39-0);
19. 4,5 diazidomethyl-2-methyl-1,2,3-triazole (iso-DAMTR);
20. PNO (Poly(3-nitrato oxetane));
21. TMETN (Trimethylolethane trinitrate) (CAS 3032-55-1);

2-8.f. “Additives” as follows:

1. Basic copper salicylate (CAS 62320-94-9);
2. BHEGA (bis-(2-hydroxyethyl) glycolamide) (CAS 17409-41-5);
3. BNO (butadienenitrileoxide);
4. Ferrocene derivatives as follows:
    a. Butacene (CAS 125856-62-4);
    b. Catocene (2,2-bis-ethylferrocenyl propane) (CAS 37206-42-1);
    c. Ferrocene carboxylic acids and ferrocene carboxylic acid esters;
    d. n-butyl-ferrocene (CAS 31904-29-7);
    e. Other adducted polymer ferrocene derivatives not specified elsewhere in 2-8.f.4.;
    f. Ethyl ferrocene (CAS 1273-89-8);
    g. Propyl ferrocene;
    h. Pentyl ferrocene (CAS 1274-00-6);
    i. Dicyclopentyl ferrocene;

j. Dicyclohexyl ferrocene;
k. Diethyl ferrocene (CAS 1273-97-8);
l. Dipropyl ferrocene;
m. Dibutyl ferrocene (CAS 1274-08-4);
n. Dihexyl ferrocene (CAS 93894-59-8);
o. Acetyl ferrocene (CAS 1271-55-2)/1,1'-diacetyl ferrocene (CAS 1273-94-5);

5. Lead beta-resorcylate (CAS 20936-32-7) or copper beta-resorcylate (CAS 70983-44-7);
6. Lead citrate (CAS 14450-60-3);
7. Lead-copper chelates of beta-resorcylate or salicylates (CAS 68411-07-4);
8. Lead maleate (CAS 19136-34-6);
9. Lead salicylate (CAS 15748-73-9);
10. Lead stannate (CAS 12036-31-6);
11. MAPO (tris-1-(2-methyl)aziridinyl phosphine oxide) (CAS 57-39-6); BOBBA 8 (bis(2-methyl aziridinyl) 2-(2-hydroxypropanoxy) propylamino phosphine oxide); and other MAPO derivatives;
12. Methyl BAPO (bis(2-methyl aziridinyl) methylamino phosphine oxide) (CAS 85068-72-0);
13. N-methyl-p-nitroaniline (CAS 100-15-2);
14. 3-Nitraza-1,5-pentane diisocyanate (CAS 7406-61-9);
15. Organo-metallic coupling agents as follows:
    a. Neopentyl[diallyl]oxy, tri[dioctyl]phosphato-titanate (CAS 103850-22-2); also known as titanium IV, 2,2[bis 2-propenolato-methyl, butanolato, tris (dioctyl) phosphato] (CAS 110438-25-0); or LICA 12 (CAS 103850-22-2);
    b. Titanium IV, [(2-propenolato-1) methyl, n-propanolatomethyl] butanolato-1, tris[dioctyl] pyrophosphate or KR3538;
    c. Titanium IV, [(2-propenolato-1)methyl, n-propanolatomethyl] butanolato-1, tris(dioctyl)phosphate;
16. Polycyanodifluoroaminoethyleneoxide;
17. Bonding agents as follows:
    a. 1,1R,1S-trimesoyl-tris(2-ethylaziridine) (HX-868, BITA) (CAS 7722-73-8);
    b. Polyfunctional aziridine amides with isophthalic, trimesic, isocyanuric or trimethyladipic backbone also having a 2-methyl or 2-ethyl aziridine group;

    ***Note:***

    *Item 2-8.f.17.b. includes:*

    *a. 1,1H-Isophthaloyl-bis(2-methylaziridine)(HX-752) (CAS 7652-64-4);*
    *b. 2,4,6-tris(2-ethyl-1-aziridinyl)-1,3,5-triazine (HX-874) (CAS 18924-91-9);*
    *c. 1,1'-trimethyladipoyl-bis(2-ethylaziridine) (HX-877) (CAS 71463-62-2).*
18. Propyleneimine (2-methylaziridine) (CAS 75-55-8);
19. Superfine iron oxide ($Fe_2O_3$) (CAS 1317-60-8) with a specific surface area more than 250 $m^2/g$ and an average particle size of 3.0 nm or less;

20. TEPAN (tetraethylenepentaamineacrylonitrile) (CAS 68412-45-3); cyanoethylated polyamines and their salts;
21. TEPANOL (tetraethylenepentaamineacrylonitrileglycidol) (CAS 68412-46-4); cyanoethylated polyamines adducted with glycidol and their salts;
22. TPB (triphenyl bismuth) (CAS 603-33-8);
23. TEPB (Tris (ethoxyphenyl) bismuth) (CAS 90591-48-3);

2-8.g. "Precursors" as follows:

***N.B.:***

*In 2-8.g. the references are to specified "Energetic Materials" manufactured from these substances.*

1. BCMO (3,3-bis(chloromethyl)oxetane) (CAS 78-71-7) (see also 2-8.e.1. and 2-8.e.2.);
2. Dinitroazetidine-t-butyl salt (CAS 125735-38-8) (see also 2-8.a.28.);
3. Hexaazaisowurtzitane derivates including HBIW (hexabenzylhexaazaisowurtzitane) (CAS 124782-15-6) (see also 2-8.a.4.) and TAIW (tetraacetyldibenzylhexaazaisowurtzitane) (CAS 182763-60-6) (see also 2-8.a.4.);
4. Not used since 2013
5. TAT (1,3,5,7 tetraacetyl-1,3,5,7,-tetraaza cyclo-octane) (CAS 41378-98-7) (see also 2-8.a.13.);
6. 1,4,5,8-tetraazadecalin (CAS 5409-42-7) (see also 2-8.a.27.);
7. 1,3,5-trichlorobenzene (CAS 108-70-3) (see also 2-8.a.23.);
8. 1,2,4-trihydroxybutane (1,2,4-butanetriol) (CAS 3068-00-6) (see also 2-8.e.5.);
9. DADN (1,5-diacetyl-3,7-dinitro-1,3,5,7-tetraaza-cyclooctane) (see also 2-8.a.13).

2-8.h. 'Reactive material' powders and shapes, as follows:

1. Powders of any of the following materials, with a particle size less than 250 µm in any direction and not specified elsewhere by 2-8:
   a. Aluminium;
   b. Niobium;
   c. Boron;
   d. Zirconium;
   e. Magnesium;
   f. Titanium;
   g. Tantalum;
   h. Tungsten;
   i. Molybdenum; **or**
   j. Hafnium;
2. Shapes, not specified by 2-3, 2-4, 2-12 or 2-16, fabricated from powders specified by 2-8.h.1.

***Technical Notes:***

*1. 'Reactive materials' are designed to produce an exothermic reaction only at high shear rates and for use as liners or casings in warheads.*

2. *'Reactive material' powders are produced by, for example, a high energy ball milling process.*
3. *'Reactive material' shapes are produced by, for example, selective laser sintering.*

***Note 1:***

*2-8. does not apply to the following substances unless they are compounded or mixed with the "energetic material" specified by 2-8.a. or powdered metals specified by 2-8.c.:*

a. *Ammonium picrate (CAS 131-74-8);*
b. *Black powder;*
c. *Hexanitrodiphenylamine (CAS 131-73-7);*
d. *Difluoroamine (CAS 10405-27-3);*
e. *Nitrostarch (CAS 9056-38-6);*
f. *Potassium nitrate (CAS 7757-79-1);*
g. *Tetranitronaphthalene;*
h. *Trinitroanisol;*
i. *Trinitronaphthalene;*
j. *Trinitroxylene;*
k. *N-pyrrolidinone; 1-methyl-2-pyrrolidinone (CAS 872-50-4);*
l. *Dioctylmaleate (CAS 142-16-5);*
m. *Ethylhexylacrylate (CAS 103-11-7);*
n. *Triethylaluminium (TEA) (CAS 97-93-8), trimethylaluminium (TMA) (CAS 75-24-1), and other pyrophoric metal alkyls and aryls of lithium, sodium, magnesium, zinc or boron;*
o. *Nitrocellulose (CAS 9004-70-0);*
p. *Nitroglycerin (or glyceroltrinitrate, trinitroglycerine) (NG) (CAS 55-63-0);*
q. *2,4,6-trinitrotoluene (TNT) (CAS 118-96-7);*
r. *Ethylenediaminedinitrate (EDDN) (CAS 20829-66-7);*
s. *Pentaerythritoltetranitrate (PETN) (CAS 78-11-5);*
t. *Lead azide (CAS 13424-46-9), normal lead styphnate (CAS 15245-44-0) and basic lead styphnate (CAS 12403-82-6), and primary explosives or priming compositions containing azides or azide complexes;*
u. *Triethyleneglycoldinitrate (TEGDN) (CAS 111-22-8);*
v. *2,4,6-trinitroresorcinol (styphnic acid) (CAS 82-71-3);*
w. *Diethyldiphenylurea; (CAS 85-98-3); dimethyldiphenylurea;(CAS 611-92-7), methylethyldiphenylurea; [Centralites]*
x. *N,N-diphenylurea (unsymmetrical diphenylurea) (CAS 603-54-3);*
y. *Methyl-N,N-diphenylurea (methyl unsymmetrical diphenylurea) (CAS 13114-72-2);*
z. *Ethyl-N,N-diphenylurea (ethyl unsymmetrical diphenylurea) (CAS 64544-71-4);*
aa. *2-Nitrodiphenylamine (2-NDPA) (CAS 119-75-5);*
bb. *4-Nitrodiphenylamine (4-NDPA) (CAS 836-30-6);*
cc. *2,2-dinitropropanol (CAS 918-52-5);*
dd. *Nitroguanidine (CAS 556-88-7) (see 1-1.C.11.d. on the Dual-Use List).*

***Note 2:***

*2-8. does not apply to ammonium perchlorate (2-8.d.2.), NTO (2-8.a.18) or catocene (2-8.f.4.b.), and meeting all of the following:*

a. *Specially shaped and formulated for civil-use gas generation devices;*
b. *Compounded or mixed, with non-active thermoset binders or plasticizers, and having a mass of less than 250 g;*
c. *Having a maximum of 80% ammonium perchlorate (2-8.d.2.) in mass of active material;*
d. *Having less than or equal to 4 g of NTO (2-8.a.18);* ***and***

*e. Having less than or equal to 1 g of catocene (2-8.f.4.b.).*

2-9. Vessels of war (surface or underwater), special naval equipment, accessories, components and other surface vessels, as follows:

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

2-9.a. Vessels and components, as follows:

1. Vessels (surface or underwater) specially designed or modified for military use, regardless of current state of repair or operating condition, and whether or not they contain weapon delivery systems or armour, and hulls or parts of hulls for such vessels, and components therefor specially designed for military use;

   ***Note:***
   *2-9.a.1. includes vehicles specially designed or modified for the delivery of divers.*

2. Surface vessels, not specified in 2-9.a.1., having any of the following, fixed or integrated into the vessel:
   a. Automatic weapons specified in 2-1., or weapons specified in 2-2., 2-4., 2-12. or 2-19., or 'mountings' or hard points for weapons having a calibre of 12.7 mm or greater;

      ***Technical Note:***
      *'Mountings' refers to weapon mounts or structural strengthening for the purpose of installing weapons.*

   b. Fire control systems specified in 2-5.;
   c. Having all of the following:
      1. 'Chemical, Biological, Radiological and Nuclear (CBRN) protection'; **and**
      2. 'Pre-wet or wash down system' designed for decontamination purposes; **or**

         ***Technical Notes:***
         *1. 'CBRN protection' is a self-contained interior space containing features such as over-pressurization, isolation of ventilation systems, limited ventilation openings with CBRN filters and limited personnel access points incorporating air-locks.*
         *2. 'Pre-wet or wash down system' is a seawater spray system capable of simultaneously wetting the exterior superstructure and decks of a vessel.*

   d. Active weapon countermeasure systems specified in 2-4.b., 2-5.c. or 2-11.a. and having any of the following:
      1. 'CBRN protection';
      2. Hull and superstructure, specially designed to reduce the radar cross section;
      3. Thermal signature reduction devices, (e.g., an exhaust gas cooling system), excluding those specially designed to increase overall power plant efficiency or to reduce the environmental impact; **or**
      4. A degaussing system designed to reduce the magnetic signature of the whole vessel;

2-9.b. Engines and propulsion systems, as follows, specially designed for military use and components therefor specially designed for military use:

1. Diesel engines specially designed for submarines;
2. Electric motors specially designed for submarines and having all of the following:
   a. Power output of more than 0.75 MW (1,000 hp);
   b. Quick reversing;
   c. Liquid cooled; **and**
   d. Totally enclosed;
3. Diesel engines having all of the following:
   a. Power output of 37.3 kW (50 hp) or more; **and**
   b. 'Non-magnetic' content in excess of 75% of total mass;

   ***Technical Note:***
   *For the purposes of 2-9.b.3., 'non-magnetic' means relative the permeability is less than 2.*
4. 'Air Independent Propulsion' (AIP) systems specially designed for submarines;

   ***Technical Note:***
   *'Air Independent Propulsion' (AIP) allows a submerged submarine to operate its propulsion system, without access to atmospheric oxygen, for a longer time than the batteries would have otherwise allowed. For the purposes of 2-9.b.4., AIP does not include nuclear power.*

2-9.c. Underwater detection devices, specially designed for military use, controls therefor and components therefor specially designed for military use;

2-9.d. Anti-submarine nets and anti-torpedo nets, specially designed for military use;

2-9.e. Not used since 2003

2-9.f. Hull penetrators and connectors, specially designed for military use, that enable interaction with equipment external to a vessel, and components therefor specially designed for military use;

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

2-9.g. Silent bearings having any of the following, components therefor and equipment containing those bearings, specially designed for military use:
1. Gas or magnetic suspension;
2. Active signature controls; **or**
3. Vibration suppression controls.

2-9.h. Naval nuclear equipment and related equipment and components, as follows:
1. Nuclear power generating equipment or propulsion equipment, specially designed for vessels specified in 2-9.a. and components therefor specially designed or 'modified' for military use.

***Technical Note:***

*For the purpose of 2-9.h.1., 'modified' means any structural, electrical, mechanical, or other change that provides a non-military item with military capabilities equivalent to an item which is specially designed for military use.*

***Note:***

*2-9.h.1. includes "nuclear reactors".*

2-10. "Aircraft", "lighter-than-air vehicles", "Unmanned Aerial Vehicles" ("UAVs"), aero-engines and "aircraft" equipment, related equipment, and components, as follows, specially designed or modified for military use:

***N.B.:***

*For guidance and navigation equipment, see 2-11.*

a. Manned "aircraft" and "lighter-than-air vehicles", and specially designed components therefor;

b. Not used since 2011;

c. Unmanned "aircraft" and "lighter-than-air vehicles", and related equipment, as follows, and specially designed components therefor:

   1. "UAVs", Remotely Piloted Air Vehicles (RPVs), autonomous programmable vehicles and unmanned "lighter-than-air vehicles";
   2. Launchers, recovery equipment and ground support equipment;
   3. Equipment designed for command or control;

d. Propulsion aero-engines and specially designed components therefor;

e. Airborne refuelling equipment specially designed or modified for any of the following, and specially designed components therefor:

   1. "Aircraft" specified by 2-10.a.; **or**
   2. Unmanned "aircraft" specified by 2-10.c.;

f. 'Ground equipment' specially designed for "aircraft" specified by 2-10.a. or aero-engines specified by 2-10.d.;

***Technical Note:***

*'Ground equipment' includes pressure refuelling equipment and equipment designed to facilitate operations in confined areas.*

g. Aircrew life support equipment, aircrew safety equipment and other devices for emergency escape, not specified in 2-10.a., designed for "aircraft" specified by 2-10.a.;

***Note:***

*2-10.g. does not control aircrew helmets that do not incorporate, or have mountings or fittings for, equipment specified in the Munitions List.*

***N.B.:***

*For helmets see also 2-13.c.*

h. Parachutes, paragliders and related equipment, as follows, and specially designed components therefor:

   1. Parachutes not specified elsewhere in the Munitions List;
   2. Paragliders;
   3. Equipment specially designed for high altitude parachutists (e.g., suits, special helmets, breathing systems, navigation equipment);

i. Controlled opening equipment or automatic piloting systems, designed for parachuted loads.

***Note 1:***

*2-10.a. does not apply to "aircraft" and "lighter-than-air vehicles" or variants of those "aircraft", specially designed for military use and which are all of the following:*

*a. Not a combat "aircraft";*

*b. Not configured for military use and not fitted with equipment or attachments specially designed or modified for military use;* ***and***

*c. Certified for civil use by civil aviation authorities of one or more Wassenaar Arrangement Participating States.*

***Note 2:***

*2-10.d. does not apply to:*

*a. Aero-engines designed or modified for military use which have been certified by civil aviation authorities of one or more Wassenaar Arrangement Participating States for use in "civil aircraft", or specially designed components therefor;*

*b. Reciprocating engines or specially designed components therefor, except those specially designed for "UAVs".*

***Note 3:***

*For the purposes of 2-10.a. and 2-10.d., specially designed components and related equipment for non-military "aircraft" or aero-engines modified for military use applies only to those military components and to military related equipment required for the modification to military use.*

***Note 4:***

*For the purposes of 2-10.a., military use includes: combat, military reconnaissance, assault, military training, logistics support, and transporting and airdropping troops or military equipment.*

***Note 5:***

*2-10.a. does not apply to "aircraft" or "lighter-than-air vehicles" that meet all of the following:*

*a. Were first manufactured before 1946;*

*b. Do not incorporate items specified by the Munitions List, unless the items are required to meet safety or airworthiness standards of civil aviation authorities of one or more Wassenaar Arrangement Participating States;* ***and***

*c. Do not incorporate weapons specified by the Munitions List, unless inoperable and incapable of being returned to operation.*

***Note 6:***

*2-10.d. does not apply to propulsion aero-engines that were first manufactured before 1946.*

2-11. Electronic equipment, "spacecraft" and components, not specified elsewhere on the Munitions List, as follows:

a. Electronic equipment specially designed for military use and specially designed components therefor;

***Note:***

*2-11.a. includes:*

*a. Electronic countermeasure and electronic counter-countermeasure equipment (i.e., equipment designed to introduce extraneous or erroneous signals into radar or radio communication receivers or otherwise hinder the reception, operation or effectiveness of adversary electronic receivers including their countermeasure equipment), including jamming and counter-jamming equipment;*

*b. Frequency agile tubes;*

*c. Electronic systems or equipment, designed either for surveillance and monitoring of the electro-magnetic spectrum for military intelligence or security purposes or for counteracting such surveillance and monitoring;*

*d. Underwater countermeasures, including acoustic and magnetic jamming and decoy, equipment designed to introduce extraneous or erroneous signals into sonar receivers;*

*e. Data processing security equipment, data security equipment and transmission and signalling line security equipment, using ciphering processes;*

*f. Identification, authentification and keyloader equipment and key management, manufacturing and distribution equipment;*

*g. Guidance and navigation equipment;*

*h. Digital troposcatter-radio communications transmission equipment;*

*i. Digital demodulators specially designed for signals intelligence;*

*j. "Automated Command and Control Systems".*

***N.B.:***

*For "software" associated with military "Software" Defined Radio (SDR), see 2-21.*

b. "Satellite navigation system" jamming equipment and specially designed components therefor;

c. "Spacecraft" specially designed or modified for military use, and "spacecraft" components specially designed for military use.

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

a. Kinetic energy weapon systems specially designed for destruction or effecting mission-abort of a target;

b. Specially designed test and evaluation facilities and test models, including diagnostic instrumentation and targets, for dynamic testing of kinetic energy projectiles and systems.

***N.B.:***

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

***Note 1:***

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

*a. Launch propulsion systems capable of accelerating masses larger than 0.1 g to velocities in excess of 1.6 km/s, in single or rapid fire modes;*

*b. Prime power generation, electric armour, energy storage (e.g., high energy storage capacitors), thermal management, conditioning, switching or fuel-handling equipment; and electrical interfaces between power supply, gun and other turret electric drive functions;*

***N.B.:***

*See also 1-3.A.1.e.2. on the Dual-Use List for high energy storage capacitors.*

*c. Target acquisition, tracking, fire control or damage assessment systems;*

*d. Homing seeker, guidance or divert propulsion (lateral acceleration) systems for projectiles.*

***Note 2:***

*2-12. applies to weapon systems using any of the following methods of propulsion:*

*a. Electromagnetic;*

*b. Electrothermal;*

*c. Plasma;*

*d. Light gas;* ***or***

*e. Chemical (when used in combination with any of the above).*

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

a. Metallic or non-metallic armoured plate, having any of the following:

1. Manufactured to comply with a military standard or specification; **or**
2. Suitable for military use;

***N.B.:***

*For body armour plates, see 2-13.d.2.*

b. Constructions of metallic or non-metallic materials, or combinations thereof, specially designed to provide ballistic protection for military systems, and specially designed components therefor;

c. Helmets manufactured according to military standards or specifications, or comparable national standards, and specially designed helmet shells, liners, or comfort pads, therefor;

***N.B.:***

*For other military helmet components or accessories, see the relevant ML entry.*

d. Body armour or protective garments, and components therefor, as follows:

1. Soft body armour or protective garments, manufactured to military standards or specifications, or to their equivalents, and specially designed components therefor;

***Note:***

*For the purposes of 2-13.d.1., military standards or specifications include, at a minimum, specifications for fragmentation protection.*

2. Hard body armour plates providing ballistic protection equal to or greater than level III (NIJ 0101.06, July 2008) or national equivalents.

***Note 1:***

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

***Note 2:***

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

***Note 3:***

*2-13.c. and 2-13.d. do not apply to helmets, body armour or protective garments, when accompanying their user for the user's own personal protection.*

***Note 4:***

*The only helmets specially designed for bomb disposal personnel that are specified by 2-13.c. are those specially designed for military use.*

***N.B. 1:***

*See also entry 1-1.A.5. on the Dual-Use List.*

***N.B. 2:***

*For "fibrous or filamentary materials" used in the manufacture of body armour and helmets, see entry 1-1.C.10. on the Dual-Use List.*

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

***Technical Note:***

*The term ‘specialised equipment for military training’ includes military types of attack trainers, operational flight trainers, radar target trainers, radar target generators, gunnery training devices, anti-submarine warfare trainers, flight simulators (including human-rated centrifuges for pilot/astronaut training), radar trainers, instrument flight trainers, navigation trainers, missile launch trainers, target equipment, drone “aircraft”, armament trainers, pilotless “aircraft” trainers, mobile training units and training equipment for ground military operations.*

***Note 1:***

*2-14. includes image generating and interactive environment systems for simulators, when specially designed or modified for military use.*

***Note 2:***

*2-14. does not apply to equipment specially designed for training in the use of hunting or sporting weapons.*

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

a. Recorders and image processing equipment;
b. Cameras, photographic equipment and film processing equipment;
c. Image intensifier equipment;
d. Infrared or thermal imaging equipment;
e. Imaging radar sensor equipment;
f. Countermeasure or counter-countermeasure equipment, for the equipment specified by 2-15.a. to 2-15.e.

***Note:***

*2-15.f. includes equipment designed to degrade the operation or effectiveness of military imaging systems or to minimise such degrading effects.*

***Note:***

*2-15. does not apply to “first generation image intensifier tubes” or equipment specially designed to incorporate “first generation image intensifier tubes”.*

***N.B.:***

*For the classification of weapons sights incorporating “first generation image intensifier tubes” see 2-1., 2-2. and 2-5.a.*

***N.B.:***

*See also 1-6.A.2.a.2. and 1-6.A.2.b. on the Dual-Use List.*

2-16. Forgings, castings and other unfinished products, specially designed for items specified by 2-1. to 2-4., 2-6., 2-9., 2-10., 2-12. or 2-19.

***Note:***

*2-16. applies to unfinished products when they are identifiable by material composition, geometry or function.*

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

a. Diving and underwater swimming apparatus, specially designed or modified for military use, as follows:
   1. Self-contained diving rebreathers, closed or semi-closed circuit;
   2. Underwater swimming apparatus specially designed for use with the diving apparatus specified in 2-17.a.1.;

   ***N.B.:***
   *See also 1-8.A.2.q. on the Dual-Use List.*

b. Construction equipment specially designed for military use;
c. Fittings, coatings and treatments, for signature suppression, specially designed for military use;
d. Field engineer equipment specially designed for use in a combat zone;
e. "Robots", "robot" controllers and "robot" "end-effectors", having any of the following characteristics:
   1. Specially designed for military use;
   2. Incorporating means of protecting hydraulic lines against externally induced punctures caused by ballistic fragments (e.g., incorporating self-sealing lines) and designed to use hydraulic fluids with flash points higher than 839 K (566° C); **or**
   3. Specially designed or rated for operating in an electro-magnetic pulse (EMP) environment;

      ***Technical Note:***
      *Electro-magnetic pulse does not refer to unintentional interference caused by electromagnetic radiation from nearby equipment (e.g., machinery, appliances or electronics) or lightning.*

f. "Libraries" specially designed or modified for military use with systems, equipment or components, specified by the Munitions List;
g. Nuclear power generating equipment or propulsion equipment, not specified elsewhere, specially designed for military use and components therefor specially designed or 'modified' for military use;

   ***Note:***
   *2-17.g. includes "nuclear reactors".*

h. Equipment and material, coated or treated for signature suppression, specially designed for military use, other than those specified elsewhere in the Munitions List;
i. Simulators specially designed for military "nuclear reactors";
j. Mobile repair shops specially designed or 'modified' to service military equipment;
k. Field generators specially designed or 'modified' for military use;
l. ISO intermodal containers or demountable vehicle bodies (i.e., swap bodies), specially designed or 'modified' for military use;
m. Ferries, not specified elsewhere in the Munitions List, bridges and pontoons, specially designed for military use;
n. Test models specially designed for the "development" of items specified by 2-4., 2-6., 2-9. or 2-10.;
o. "Laser" protection equipment (e.g., eye or sensor protection) specially designed for military use;

p. "Fuel cells", not specified elsewhere in the Munitions List, specially designed or 'modified' for military use.

***Technical Note:***

*1. Not used since 2014*

*2. For the purpose of 2-17., 'modified' means any structural, electrical, mechanical, or other change that provides a non-military item with military capabilities equivalent to an item which is specially designed for military use.*

2-18. 'Production' equipment and components, as follows:

a. Specially designed or modified 'production' equipment for the 'production' of products specified by the Munitions List, and specially designed components therefor;

b. Specially designed environmental test facilities and specially designed equipment therefor, for the certification, qualification or testing of products specified by the Munitions List.

***Technical Note:***

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

***Note:***

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

*a. Continuous nitrators;*

*b. Centrifugal testing apparatus or equipment, having any of the following:*

*1. Driven by a motor or motors having a total rated horsepower of more than 298 kW (400 hp);*

*2. Capable of carrying a payload of 113 kg or more;* ***or***

*3. Capable of exerting a centrifugal acceleration of 8 g or more on a payload of 91 kg or more;*

*c. Dehydration presses;*

*d. Screw extruders specially designed or modified for military "explosive" extrusion;*

*e. Cutting machines for the sizing of extruded "propellants";*

*f. Sweetie barrels (tumblers) 1.85 m or more in diameter and having over 227 kg product capacity;*

*g. Continuous mixers for solid "propellants";*

*h. Fluid energy mills for grinding or milling the ingredients of military "explosives";*

*i. Equipment to achieve both sphericity and uniform particle size in metal powder listed in 2-8.c.8.;*

*j. Convection current converters for the conversion of materials listed in 2-8.c.3.*

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

a. "Laser" systems specially designed for destruction or effecting mission-abort of a target;

b. Particle beam systems capable of destruction or effecting mission-abort of a target;

c. High power Radio-Frequency (RF) systems capable of destruction or effecting mission-abort of a target;

d. Equipment specially designed for the detection or identification of, or defence against, systems specified by 2-19.a. to 2-19.c.;

e. Physical test models for the systems, equipment and components, specified by 2-19.;

f. "Laser" systems specially designed to cause permanent blindness to unenhanced vision, i.e., to the naked eye or to the eye with corrective eyesight devices.

***Note 1:***

*DEW systems specified by 2-19. include systems whose capability is derived from the controlled application of:*

*a. "Lasers" of sufficient power to effect destruction similar to the manner of conventional ammunition;*

*b. Particle accelerators which project a charged or neutral particle beam with destructive power;*

*c. High pulsed power or high average power radio frequency beam transmitters, which produce fields sufficiently intense to disable electronic circuitry at a distant target.*

***Note 2:***

*2-19. includes the following when specially designed for DEW systems:*

*a. Prime power generation, energy storage, switching, power conditioning or fuel-handling equipment;*

*b. Target acquisition or tracking systems;*

*c. Systems capable of assessing target damage, destruction or mission-abort;*

*d. Beam-handling, propagation or pointing equipment;*

*e. Equipment with rapid beam slew capability for rapid multiple target operations;*

*f. Adaptive optics and phase conjugators;*

*g. Current injectors for negative hydrogen ion beams;*

*h. "Space-qualified" accelerator components;*

*i. Negative ion beam funnelling equipment;*

*j. Equipment for controlling and slewing a high energy ion beam;*

*k. "Space-qualified" foils for neutralising negative hydrogen isotope beams.*

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

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

***Note:***

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

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

***Note:***

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

2-21. "Software" as follows:

a. "Software" specially designed or modified for any of the following:

1. "Development", "production", operation or maintenance of equipment specified by the Munitions List;
2. "Development" or "production" of materials specified by the Munitions List; **or**
3. "Development", "production", operation or maintenance of "software" specified by the Munitions List.

b. Specific "software", other than that specified by 2-21.a., as follows:
1. "Software" specially designed for military use and specially designed for modelling, simulating or evaluating military weapon systems;
2. "Software" specially designed for military use and specially designed for modelling or simulating military operational scenarios;
3. "Software" for determining the effects of conventional, nuclear, chemical or biological weapons;
4. "Software" specially designed for military use and specially designed for Command, Communications, Control and Intelligence ($C^3I$) or Command, Communications, Control, Computer and Intelligence ($C^4I$) applications;

c. "Software", not specified by 2-21.a. or 2-21.b., specially designed or modified to enable equipment not specified by the Munitions List to perform the military functions of equipment specified by the Munitions List.

2-22. "Technology" as follows:

a. "Technology", other than specified in 2-22.b., which is "required" for the "development", "production", operation, installation, maintenance (checking), repair, overhaul or refurbishing of items specified by the Munitions List;

b. "Technology" as follows:
1. "Technology" "required" for the design of, the assembly of components into, and the operation, maintenance and repair of, complete production installations for items specified by the Munitions List, even if the components of such production installations are not specified;
2. "Technology" "required" for the "development" and "production" of small arms, even if used to produce reproductions of antique small arms;
3. Not used since 2013

***N.B.:***
*See 2-22.a. for "technology" previously specified by 2-22.b.3.*

4. Not used since 2013

***N.B.:***
*See 2-22.a. for "technology" previously specified by 2-22.b.4.*

5. "Technology" "required" exclusively for the incorporation of "biocatalysts", specified by 2-7.i.1., into military carrier substances or military material.

***Note 1:***
*"Technology" "required" for the "development", "production", operation, installation, maintenance (checking), repair, overhaul or refurbishing of items specified by the Munitions List remains under control even when applicable to any item not specified by the Munitions List.*

***Note 2:***
*2-22. does not apply to:*

a. *"Technology" that is the minimum necessary for the installation, operation, maintenance (checking) or repair, of those items which are not controlled or whose export has been authorised;*

b. *"Technology" that is "in the public domain", "basic scientific research" or the minimum necessary information for patent applications;*

c. *"Technology" for magnetic induction for continuous propulsion of civil transport devices.*

## DEFINITIONS OF TERMS USED IN GROUPS 1 AND 2

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

*Note 1:* *Definitions apply throughout Groups 1 and 2. The references are purely advisory and have no effect on the universal application of defined terms throughout Groups 1 and 2.*

*Note 2:* *Words and terms contained in the List of Definitions only take the defined meaning where this is indicated by their being enclosed in quotations marks (“ ”). Elsewhere, words and terms take their commonly accepted (dictionary) meanings, unless a local definition for a particular control is given.*

“Accuracy” - Cat 2, cat 3, cat 6, cat 7, cat 8

(Usually measured in terms of inaccuracy) is the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

“Active flight control systems” - Cat 7

Function to prevent undesirable “aircraft” and missile motions or structural loads by autonomously processing outputs from multiple sensors and then providing necessary preventive commands to effect automatic control.

“Active pixel” - Cat 6

A minimum (single) element of the solid state array which has a photoelectric transfer function when exposed to light (electromagnetic) radiation.

“Additives” - 2-8

Substances used in explosive formulations to improve their properties.

“Aircraft” - Cat 1, cat 6, cat 7, cat 9, 2-8, 2-10, 2-14

A fixed wing, swivel wing, rotary wing (helicopter), tilt rotor or tilt-wing airborne vehicle.

“Airship” - Cat 9

A power-driven airborne vehicle that is kept buoyant by a body of gas (usually helium, formerly hydrogen) which is lighter than air.

“All compensations available” - Cat 2

“All compensations available” means after all feasible measures available to the manufacturer to minimise all systematic positioning errors for the particular machine-tool model or measuring errors for the particular coordinate measuring machine are considered.

“Allocated by the ITU” - Cat 3, cat 5P1

The allocation of frequency bands according to the current edition of the ITU Radio Regulations for primary, permitted and secondary services.

*N.B.:* *Additional and alternative allocations are not included.*

“Angle random walk” - Cat 7

The angular error build up with time that is due to white noise in angular rate. (IEEE STD 528-2001)

“Asymmetric algorithm” - Cat 5P2

A cryptographic algorithm using different, mathematically-related keys for encryption and decryption.

*Technical Note:*

*A common use of "asymmetric algorithms" is key management.*

"Authentication" - Cat 5P2

Verifying the identity of a user, process or device, often as a prerequisite to allowing access to resources in an information system. This includes verifying the origin or content of a message or other information, and 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 unauthorized access.

"Automated Command and Control Systems" - 2-11

Electronic systems, through which information essential to the effective operation of the grouping, major formation, tactical formation, unit, ship, subunit or weapons under command is entered, processed and transmitted. This is achieved by the use of computer and other specialised hardware designed to support the functions of a military command and control organisation. The main functions of an automated command and control system are: the efficient automated collection, accumulation, storage and processing of information; the display of the situation and the circumstances affecting the preparation and conduct of combat operations; operational and tactical calculations for the allocation of resources among force groupings or elements of the operational order of battle or battle deployment according to the mission or stage of the operation; the preparation of data for appreciation of the situation and decision-making at any point during operation or battle; computer simulation of operations.

"Average output power" - Cat 6

The total "laser" output energy, in joules, divided by the period over which a series of consecutive pulses is emitted, in seconds. For a series of uniformly-spaced pulses it is equal to the total "laser" output energy in a single pulse, in joules, multiplied by the pulse frequency of the "laser", in Hertz.

"Basic gate propagation delay time" - Cat 3

The propagation delay time value corresponding to the basic gate used in a "monolithic integrated circuit". For a 'family' of "monolithic integrated circuits", this may be specified either as the propagation delay time per typical gate within the given 'family' or as the typical propagation delay time per gate within the given 'family'.

*Technical Notes:*

1. *"Basic gate propagation delay time" is not to be confused with the input/output delay time of a complex "monolithic integrated circuit".*
2. *'Family' consists of all integrated circuits to which all of the following are applied as their manufacturing methodology and specifications except their respective functions:*
   a. *The common hardware and software architecture;*
   b. *The common design and process technology;* ***and***
   c. *The common basic characteristics.*

"Basic scientific research" - General Technology Note, 2-22

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

"Bias" (accelerometer) - Cat 7

The average over a specified time of accelerometer output, measured at specified operating conditions, that has no correlation with input acceleration or rotation. "Bias" is expressed in g or in metres per second$^2$ (g or m/s$^2$). (IEEE Std 528-2001) (Micro g equals 1 x $10^{-6}$ g).

"Bias" (gyro) - Cat 7

The average over a specified time of gyro output measured at specified operating conditions that has no correlation with input rotation or acceleration. "Bias" is typically expressed in degrees per hour (deg/hr). (IEEE Std 528-2001).

"Biocatalysts" - 2-7, 2-22

'Enzymes' for specific chemical or biochemical reactions or other biological compounds which bind to and accelerate the degradation of CW agents.

*Technical Note:*

*'Enzymes' means "biocatalysts" for specific chemical or biochemical reactions.*

"Biological agents" - Cat 1, 2-7

Pathogens or toxins, selected or modified (such as altering purity, shelf life, virulence, dissemination characteristics, or resistance to UV radiation) to produce casualties in humans or animals, degrade equipment or damage crops or the environment.

"Biopolymers" - 2-7

Biological macromolecules as follows:

a. Enzymes for specific chemical or biochemical reactions;
b. 'Anti-idiotypic', 'monoclonal' or 'polyclonal' 'antibodies';
c. Specially designed or specially processed 'receptors';

*Technical Notes:*

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

"Camming" (axial displacement) - Cat 2

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

"Chemical Laser" - Cat 6

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

"Circuit element" - Definitions

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

"Circular Error Probable" ("CEP") - Cat 7

In a circular normal distribution, the radius of the circle containing 50% of the individual measurements being made, or the radius of the circle within which there is a 50% probability of being located.

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

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

"Civil aircraft" - Cat 1, cat 3, cat 4, cat 7, 2-4, 2-10

Those "aircraft" listed by designation in published airworthiness certification lists by civil aviation authorities of one or more Wassenaar Arrangement Participating States to fly commercial civil internal and external routes or for legitimate civil, private or business use.

"Communications channel controller" - Cat 4

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

"Compensation systems" - Cat 6

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

"Composite" - Cat 1, cat 2, cat 6, cat 8, cat 9

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

"III/V compounds" - Cat 3, cat 6

Polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev's periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).

"Contouring control" - Cat 2

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

"Critical temperature" - Cat 1, cat 3, cat 5P1

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

"Cryptographic activation" - Cat 5P2

Any technique that specifically activates or enables cryptographic capability of an item, by means of a mechanism implemented by the manufacturer of the item, where this mechanism is uniquely bound to any of the following:

1. A single instance of the item; **or**
2. One customer, for multiple instances of the item.

*Technical Notes:*

1. *"Cryptographic activation" techniques and mechanisms may be implemented as hardware, "software" or "technology".*
2. *Mechanisms for "cryptographic activation" can, for example, be serial number-based licence keys or authentication instruments such as digitally signed certificates.*

"Cryptography" - Cat 5P2

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

*Notes:*

1. *"Cryptography" does not include 'fixed' data compression or coding techniques.*
2. *"Cryptography" includes decryption.*

*Technical Notes:*

1. *'Secret parameter': a constant or key kept from the knowledge of others or shared only within a group.*
2. *'Fixed': the coding or compression algorithm cannot accept externally supplied parameters (e.g., cryptographic or key variables) and cannot be modified by the user.*

"CW Laser" - Cat 6

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

"Data-Based Referenced Navigation" ("DBRN") Systems - Cat 7

Systems which use various sources of previously measured geo-mapping data integrated to provide accurate navigation information under dynamic conditions. Data sources include bathymetric maps, stellar maps, gravity maps, magnetic maps or 3-D digital terrain maps.

"Deactivated firearm" - 2-1

A firearm that has been made incapable of firing any projectile by processes defined by the Wassenaar Arrangement Participating State's national authority.

These processes permanently modify the essential elements of the firearm.

According to national laws and regulations, deactivation of the firearm may be attested by a certificate delivered by a competent authority and may be marked on the firearm by a stamp on an essential part.

"Development" - General Technology Note, Both Lists

Is related to all stages prior to serial production, such as: design, design research, design analyses, design concepts, assembly and testing of prototypes, pilot production schemes, design data, process of transforming design data into a product, configuration design, integration design, layouts.

"Diffusion bonding" - Cat 1, cat 2, cat 9

A solid state joining of at least two separate pieces of metals into a single piece with a joint strength equivalent to that of the weakest material, wherein the principal mechanism is interdiffusion of atoms across the interface.

"Digital computer" - Cat 4, cat 5P1

Equipment which can, in the form of one or more discrete variables, perform all of the following:

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

*Technical Note:*

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

"Digital transfer rate" - Definitions

The total bit rate of the information that is directly transferred on any type of medium. (See also "total digital transfer rate").

"Discrete component" - Definitions

A separately packaged "circuit element" with its own external connections.

"Electronic assembly" - Cat 2, cat 3, cat 4

A number of electronic components (i.e., "circuit elements", "discrete components", integrated circuits, etc.) connected together to perform (a) specific function(s), replaceable as an entity and normally capable of being disassembled.

"End-effectors" - Cat 2, 2-17

Grippers, 'active tooling units' and any other tooling that is attached to the baseplate on the end of a "robot" manipulator arm.

*Technical Note:*

*'Active tooling units' are devices for applying motive power, process energy or sensing to a workpiece.*

"Energetic materials" - Cat 1, 2-8

Substances or mixtures that react chemically to release energy required for their intended application. "Explosives", "pyrotechnics" and "propellants" are subclasses of energetic materials.

"Equivalent Density" - Cat 6

The mass of an optic per unit optical area projected onto the optical surface.

"Explosives" - Cat 1, 2-8, 2-18,

Solid, liquid or gaseous substances or mixtures of substances which, in their application as primary, booster, or main charges in warheads, demolition and other applications, are required to detonate.

"Expression Vectors" - 2-7

Carriers (e.g., plasmid or virus) used to introduce genetic material into host cells.

"FADEC Systems" - Cat 9

Full Authority Digital Engine Control Systems – A digital electronic control system for a gas turbine engine that is able to autonomously control the engine throughout its whole operating range from demanded engine start until demanded engine shut-down, in both normal and fault conditions.

"Fibrous or filamentary materials" - Cat 1, cat 8, cat 9, 2-13

Include:

a. Continuous monofilaments;
b. Continuous yarns and rovings;
c. Tapes, fabrics, random mats and braids;
d. Chopped fibres, staple fibres and coherent fibre blankets;
e. Whiskers, either monocrystalline or polycrystalline, of any length;
f. Aromatic polyamide pulp.

"Film type integrated circuit" - Cat 3

An array of "circuit elements" and metallic interconnections formed by deposition of a thick or thin film on an insulating "substrate".

"First generation image intensifier tubes" - 2-15

Electrostatically focused tubes, employing input and output fibre optic or glass face plates, multi-alkali photocathodes (S-20 or S-25), but not microchannel plate amplifiers.

"Fly-by-light system" - Cat 7

A primary digital flight control system employing feedback to control the "aircraft" during flight, where the commands to the effectors/actuators are optical signals.

"Fly-by-wire system" - Cat 7

A primary digital flight control system employing feedback to control the "aircraft" during flight, where the commands to the effectors/actuators are electrical signals.

"Focal plane array" - Cat 6, cat 8

A linear or two-dimensional planar layer, or combination of planar layers, of individual detector elements, with or without readout electronics, which work in the focal plane.

*Note:* *This definition does not include a stack of single detector elements or any two, three or four element detectors provided time delay and integration is not performed within the element.*

"Fractional bandwidth" - Cat 3, cat 5P1, cat 5P2

The "instantaneous bandwidth" divided by the centre frequency, expressed as a percentage.

"Frequency hopping" - Cat 5P1, cat 5P2, cat 6

A form of "spread spectrum" in which the transmission frequency of a single communication channel is made to change by a random or pseudo-random sequence of discrete steps.

"Frequency switching time" - Cat 3

The time (i.e., delay) taken by a signal when switched from an initial specified output frequency, to arrive at or within any of the following:

a. ±100 Hz of a final specified output frequency of less than 1 GHz; **or**
b. ±0.1 part per million of a final specified output frequency equal to or greater than 1 GHz.

"Fuel cell" - Cat 8, 2-17

An electrochemical device that converts chemical energy directly into Direct Current (DC) electricity by consuming fuel from an external source.

"Fusible" - Cat 1

Capable of being cross-linked or polymerized further (cured) by the use of heat, radiation, catalysts, etc., or that can be melted without pyrolysis (charring).

"Hybrid integrated circuit" - Cat 3

Any combination of integrated circuit(s), or integrated circuit with "circuit elements" or "discrete components" connected together to perform (a) specific function(s), and having all of the following characteristics:

a. Containing at least one unencapsulated device;
b. Connected together using typical IC production methods;
c. Replaceable as an entity; **and**
d. Not normally capable of being disassembled.

"Image enhancement" - Cat 4

The processing of externally derived information-bearing images by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform). This does not include algorithms using only linear or rotational transformation of a single image, such as translation, feature extraction, registration or false coloration.

"In the public domain" - General Technology Note, General Software Note, 2-22

This means "technology" or "software" which has been made available without restrictions upon its further dissemination.

*Note:* *Copyright restrictions do not remove "technology" or "software" from being "in the public domain".*

"Information security" - General Software Note, General Information Security Note, Cat 5P2

All the means and functions ensuring the accessibility, confidentiality or integrity of information or communications, excluding the means and functions intended to safeguard against malfunctions. This includes "cryptography", "cryptographic activation", 'cryptanalysis', protection against compromising emanations and computer security.

*Technical Note:*

*'Cryptanalysis': the analysis of a cryptographic system or its inputs and outputs to derive confidential variables or sensitive data, including clear text. (ISO 7498-2-1988 (E), paragraph 3.3.18).*

"Instantaneous bandwidth" - Cat 3, cat 5P1

The bandwidth over which output power remains constant within 3 dB without adjustment of other operating parameters.

"Instrumented range" - Cat 6

The specified unambiguous display range of a radar.

"Interleaved Analogue-to-Digital Converter (ADC)" – Cat 3

Devices that have multiple ADC units that sample the same analogue input at different times such that when the outputs are aggregated, the analogue input has been effectively sampled and converted at a higher sampling rate.

"Intrinsic magnetic gradiometer" - Cat 6

A single magnetic field gradient sensing element and associated electronics the output of which is a measure of magnetic field gradient.

"Intrusion software" - Cat 4

"Software" specially designed or modified to avoid detection by 'monitoring tools', or to defeat 'protective countermeasures', of a computer or network-capable device, and performing any of the following:

a. The extraction of data or information, from a computer or network-capable device, or the modification of system or user data; **or**
b. The modification of the standard execution path of a program or process in order to allow the execution of externally provided instructions.

*Notes:*

1. *"Intrusion software" does not include any of the following:*
   a. *Hypervisors, debuggers or Software Reverse Engineering (SRE) tools;*
   b. *Digital Rights Management (DRM) "software";* ***or***
   c. *"Software" designed to be installed by manufacturers, administrators or users, for the purposes of asset tracking or recovery.*
2. *Network-capable devices include mobile devices and smart meters.*

*Technical Notes:*

1. *'Monitoring tools': "software" or hardware devices, that monitor system behaviours or processes running on a device. This includes antivirus (AV) products, end point security products, Personal Security Products (PSP), Intrusion Detection Systems (IDS), Intrusion Prevention Systems (IPS) or firewalls.*
2. *'Protective countermeasures': techniques designed to ensure the safe execution of code, such as Data Execution Prevention (DEP), Address Space Layout Randomisation (ASLR) or sandboxing.*

"Isostatic presses" - Cat 2

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

"Laser" - Cat 1, cat 2, cat 3, cat 5P1, cat 6, cat 7, cat 8, cat 9, 2-9, 2-19

An item that produces spatially and temporally coherent light through amplification by stimulated emission of radiation.

"Library" (parametric technical database) - Cat 1, 2-17

A collection of technical information, reference to which may enhance the performance of relevant systems, equipment or components.

"Lighter-than-air vehicles" - 2-10

Balloons and "airships" that rely on hot air or on lighter-than-air gases such as helium or hydrogen for their lift.

"Local area network" - Cat 4, cat 5P1

A data communication system having all of the following characteristics:

a. Allows an arbitrary number of independent 'data devices' to communicate directly with each other; **and**
b. Is confined to a geographical area of moderate size (e.g., office building, plant, campus, warehouse).

*Technical Note:*

*'Data device' means equipment capable of transmitting or receiving sequences of digital information.*

"Magnetic gradiometers" - Cat 6

Are designed to detect the spatial variation of magnetic fields from sources external to the instrument. They consist of multiple "magnetometers" and associated electronics the output of which is a measure of magnetic field gradient. (See also "Intrinsic Magnetic Gradiometer")

"Magnetometers" - Cat 6

Are designed to detect magnetic fields from sources external to the instrument. They consist of a single magnetic field sensing element and associated electronics the output of which is a measure of the magnetic field.

"Matrix" - Cat 1, cat 2, cat 8, cat 9

A substantially continuous phase that fills the space between particles, whiskers or fibres.

"Measurement uncertainty" - Cat 2

The characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95%. It includes the uncorrected systematic deviations, the uncorrected backlash and the random deviations (Reference: ISO 10360-2).

"Microcomputer microcircuit" - Cat 3

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing general purpose instructions from an internal storage, on data contained in the internal storage.

*Technical Note:*

*The internal storage may be augmented by an external storage.*

"Microprocessor microcircuit" - Cat 3

A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing a series of general purpose instructions from an external storage.

*Technical Note:*

*The "microprocessor microcircuit" normally does not contain integral user-accessible storage, although storage present on-the-chip may be used in performing its logic function.*

*Note:* *This definition includes chip sets which are designed to operate together to provide the function of a "microprocessor microcircuit".*

"Microprogram" - Definitions

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

"Monolithic integrated circuit" - Cat 3

A combination of passive or active "circuit elements" or both which:

a. Are formed by means of diffusion processes, implantation processes or deposition processes in or on a single semiconducting piece of material, a so-called 'chip';
b. Can be considered as indivisibly associated; **and**

c. Perform the function(s) of a circuit.

"Monolithic Microwave Integrated Circuit" ("MMIC") - Cat 3, cat 5P1

A "monolithic integrated circuit" that operates at microwave or millimeter wave frequencies.

"Monospectral imaging sensors" - Cat 6

Are capable of acquisition of imaging data from one discrete spectral band.

"Multichip integrated circuit" - Cat 3

Two or more "monolithic integrated circuits" bonded to a common "substrate".

"Multiple channel Analogue-to-Digital Converter (ADC)" – Cat 3

Devices that integrate more than one ADC, designed so that each ADC has a separate analogue input.

"Multispectral imaging sensors" - Cat 6

Are capable of simultaneous or serial acquisition of imaging data from two or more discrete spectral bands. Sensors having more than twenty discrete spectral bands are sometimes referred to as hyperspectral imaging sensors.

"Network access controller" - Cat 4

A physical interface to a distributed switching network. It uses a common medium which operates throughout at the same "digital transfer rate" using arbitration (e.g., token or carrier sense) for transmission. Independently from any other, it selects data packets or data groups (e.g., IEEE 802) addressed to it. It is an assembly that can be integrated into computer or telecommunications equipment to provide communications access.

"Nuclear reactor" - 2-17

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

"Numerical control" - Cat 2

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

"Object code" - General Software Note

An equipment executable form of a convenient expression of one or more processes ("source code" (or source language)) which has been compiled by a programming system.

"Operations, Administration or Maintenance" ("OAM") - Cat 5P2

Means performing one or more of the following tasks:

a. Establishing or managing any of the following:
    1. Accounts or privileges of users or administrators;
    2. Settings of an item; **or**
    3. Authentication data in support of the tasks described in paragraphs a.1. or a.2.;
b. Monitoring or managing the operating condition or performance of an item; **or**
c. Managing logs or audit data in support of any of the tasks described in paragraphs a. or b.

*<u>Note:</u> "OAM" does not include any of the following tasks or their associated key management functions:*

*a. Provisioning or upgrading any cryptographic functionality that is not directly related to establishing or managing authentication data in support of the tasks described in paragraphs a.1. or a.2. above;* ***or***

*b. Performing any cryptographic functionality on the forwarding or data plane of an item.*

"Optical integrated circuit" - Cat 3

A "monolithic integrated circuit" or a "hybrid integrated circuit", containing one or more parts designed to function as a photosensor or photoemitter or to perform (an) optical or (an) electro-optical function(s).

"Optical switching" - Cat 5P1

The routing of or switching of signals in optical form without conversion to electrical signals.

"Overall current density" - Cat 3

The total number of ampere-turns in the coil (i.e., the sum of the number of turns multiplied by the maximum current carried by each turn) divided by the total cross-section of the coil (comprising the superconducting filaments, the metallic matrix in which the superconducting filaments are embedded, the encapsulating material, any cooling channels, etc.).

"Peak power" - Cat 6

The highest power attained in the "pulse duration".

"Personal area network" - Cat 5P2

A data communication system having all of the following characteristics:

a. Allows an arbitrary number of independent or interconnected 'data devices' to communicate directly with each other; **and**

b. Is confined to the communication between devices within the immediate vicinity of an individual person or device controller (e.g., single room, office, or automobile, and their nearby surrounding spaces).

*<u>Technical Note:</u>*

*'Data device' means equipment capable of transmitting or receiving sequences of digital information.*

"Precursors" - 2-8

Speciality chemicals used in the manufacture of explosives.

"Principal element" - Cat 4

An element is a "principal element" when its replacement value is more than 35% of the total value of the system of which it is an element. Element value is the price paid for the element by the manufacturer of the system, or by the system integrator. Total value is the normal international selling price to unrelated parties at the point of manufacture or consolidation of shipment.

"Production" - General Technology Note, Both Lists

Means all production stages, such as: product engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

“Program” - Cat 2, cat 6

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

“Propellants” - 2-8

Substances or mixtures that react chemically to produce large volumes of hot gases at controlled rates to perform mechanical work.

“Pulse compression” - Cat 6

The coding and processing of a radar signal pulse of long time duration to one of short time duration, while maintaining the benefits of high pulse energy.

“Pulse duration” - Cat 6

Duration of a “laser” pulse is the time between the half-power points on the leading edge and trailing edge of an individual pulse.

“Pulsed laser” - Cat 6

A “laser” having a “pulse duration” that is less than or equal to 0.25 seconds.

“Pyrotechnic(s)” - 2-4, 2-8

Mixtures of solid or liquid fuels and oxidizers which, when ignited, undergo an energetic chemical reaction at a controlled rate intended to produce specific time delays, or quantities of heat, noise, smoke, visible light or infrared radiation. Pyrophorics are a subclass of pyrotechnics, which contain no oxidizers but ignite spontaneously on contact with air.

“Quantum cryptography” - Cat 5P2

A family of techniques for the establishment of a shared key for “cryptography” by measuring the quantum-mechanical properties of a physical system (including those physical properties explicitly governed by quantum optics, quantum field theory, or quantum electrodynamics).

“Radar frequency agility” - Cat 6

Any technique which changes, in a pseudo-random sequence, the carrier frequency of a pulsed radar transmitter between pulses or between groups of pulses by an amount equal to or larger than the pulse bandwidth.

“Radar spread spectrum” - Cat 6

Any modulation technique for spreading energy originating from a signal with a relatively narrow frequency band, over a much wider band of frequencies, by using random or pseudo-random coding.

“Radiant sensitivity” - Cat 6

Radiant sensitivity (mA/W) = 0.807 x (wavelength in nm) x Quantum Efficiency (QE).

*Technical Note:*

*QE is usually expressed as a percentage; however, for the purposes of this formula QE is expressed as a decimal number less than one, e.g., 78% is 0.78.*

“Real-time processing” - Cat 6

The processing of data by a computer system providing a required level of service, as a function of available resources, within a guaranteed response time, regardless of the load of the system, when stimulated by an external event.

“Repeatability” - Cat 7

The closeness of agreement among repeated measurements of the same variable under the same operating conditions when changes in conditions or non-operating periods occur between measurements. (Reference: IEEE STD 528-2001 (one sigma standard deviation))

"Required" - Cat 5P1, cat 6, cat 7, cat 9, General Technology Note, 2-22

As applied to "technology", refers to only that portion of "technology" which is peculiarly responsible for achieving or exceeding the controlled performance levels, characteristics or functions. Such "required" "technology" may be shared by different products.

"Resolution" - Cat 2

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

"Riot control agents" - Cat 1, 2-7

Substances which, under the expected conditions of use for riot control purposes, produce rapidly in humans sensory irritation or disabling physical effects which disappear within a short time following termination of exposure. (Tear gases are a subset of "riot control agents".)

"Robot" - Cat 2, cat 8, 2-17

A manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use sensors, and has all the following characteristics:

a. Is multifunctional;
b. Is capable of positioning or orienting material, parts, tools or special devices through variable movements in three dimensional space;
c. Incorporates three or more closed or open loop servo-devices which may include stepping motors; **and**
d. Has "user-accessible programmability" by means of the teach/playback method or by means of an electronic computer which may be a programmable logic controller, i.e., without mechanical intervention.

*Note:* *The above definition does not include the following devices:*

1. *Manipulation mechanisms which are only manually/tele-operator controllable;*
2. *Fixed sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic or electrical means;*
3. *Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is mechanically limited by fixed, but adjustable stops, such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed programme pattern. Variations or modifications of the programme pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;*

4. *Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;*
5. *Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.*

"Run-out" (out-of-true running) - Cat 2

Radial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle axis at a point on the external or internal revolving surface to be tested (Reference: ISO 230/1-1986, paragraph 5.61).

"Sample rate" - Cat 3

For an Analogue-to-Digital Converter (ADC) the maximum number of samples that are measured at the analogue input over a period of one second, except for oversampling ADCs. For oversampling ADCs the "sample rate" is taken to be its output word rate. "Sample rate" may also be referred to as sampling rate, usually specified in Mega Samples Per Second (MSPS) or Giga Samples Per Second (GSPS), or conversion rate, usually specified in Hertz (Hz).

"Satellite navigation system" - Cat 7

A system consisting of ground stations, a constellation of satellites, and receivers, that enables receiver locations to be calculated on the basis of signals received from the satellites. It includes Global Navigation Satellite Systems (GNSS) and Regional Navigation Satellite Systems (RNSS).

"Scale factor" (gyro or accelerometer) - Cat 7

The ratio of change in output to a change in the input intended to be measured. Scale factor is generally evaluated as the slope of the straight line that can be fitted by the method of least squares to input-output data obtained by varying the input cyclically over the input range.

"Settling time" - Cat 3

The time required for the output to come within one-half bit of the final value when switching between any two levels of the converter.

"Signal analysers" - Cat 3

Apparatus capable of measuring and displaying basic properties of the single-frequency components of multi-frequency signals.

"Signal processing" - Cat 3, cat 4, cat 5P1, cat 6

The processing of externally derived information-bearing signals by algorithms such as time compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform).

"Software" - Both Lists

A collection of one or more "programs" or "microprograms" fixed in any tangible medium of expression.

"Source code" - Cat 6, cat 7, cat 9

A convenient expression of one or more processes which may be turned by a programming system into equipment executable form ("object code" (or object language)).

"Spacecraft" - Cat 9, 2-11

Active and passive satellites and space probes.

"Spacecraft bus" - Cat 9

Equipment that provides the support infrastructure of the "spacecraft" and location for the "spacecraft payload".

"Spacecraft payload" - Cat 9

Equipment, attached to the "spacecraft bus", designed to perform a mission in space (e.g., communications, observation, science).

"Space-qualified" - Cat 3, cat 6, cat 7, 2-19

Designed, manufactured, or qualified through successful testing, for operation at altitudes greater than 100 km above the surface of the Earth.

*Note:* *A determination that a specific item is "space-qualified" by virtue of testing does not mean that other items in the same production run or model series are "space-qualified" if not individually tested.*

"Specific modulus" - Cat 1

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

"Specific tensile strength" - Cat 1

Ultimate tensile strength in pascals, equivalent to $N/m^2$, divided by specific weight in $N/m^3$, measured at a temperature of 296 ± 2 K (23 ± 2° C) and a relative humidity of (50 ± 5)%.

"Spinning mass gyros" - Cat 7

"Spinning mass gyros" are gyros which use a continually rotating mass to sense angular motion.

"Spread spectrum" - Cat 5P1, cat 5P2

The technique whereby energy in a relatively narrow-band communication channel is spread over a much wider energy spectrum.

"Spread spectrum" radar - see "Radar spread spectrum" - Cat 6

"Stability" - Cat 7

Standard deviation (1 sigma) of the variation of a particular parameter from its calibrated value measured under stable temperature conditions. This can be expressed as a function of time.

*Statement of Understanding*

*For gyroscopes and accelerometers, "stability" can be estimated by determining the Allan variance noise-analysis value at the integration period (i.e., sample time) consistent with the stated measurement period, which may include extrapolating the Allan variance noise analysis beyond the instability point into the rate/acceleration–random walk or rate/acceleration ramp regions to an integration period consistent*

*with the stated measurement period (Reference: IEEE Std 952-1997 [R2008]) or IEEE Std 1293-1998 [R2008]).*

"Steady State Mode" - Cat 9

The term "steady state mode" defines engine operation conditions, where the engine parameters, such as thrust/power, rpm and others, have no appreciable fluctuations, when the ambient air temperature and pressure at the engine inlet are constant.

"Substrate" - Cat 3

A sheet of base material with or without an interconnection pattern and on which or within which "discrete components" or integrated circuits or both can be located.

"Substrate blanks" - Cat 6

Monolithic compounds with dimensions suitable for the production of optical elements such as mirrors or optical windows.

"Superalloy" - Cat 2, cat 9

Nickel-, cobalt- or iron-base alloys having strengths superior to any alloys in the AISI 300 series at temperatures over 922 K (649° C) under severe environmental and operating conditions.

"Superconductive" - Cat 1, cat 3, cat 5P1, cat 6, cat 8, 2-20

Refers to materials, (i.e., metals, alloys or compounds) which can lose all electrical resistance (i.e., which can attain infinite electrical conductivity and carry very large electrical currents without Joule heating).

*Technical Note:*

*The "superconductive" state of a material is individually characterised by a "critical temperature", a critical magnetic field, which is a function of temperature, and a critical current density which is, however, a function of both magnetic field and temperature.*

"Super High Power Laser" ("SHPL") - Cat 6

A "laser" capable of delivering (the total or any portion of) the output energy exceeding 1 kJ within 50 ms or having an average or CW power exceeding 20 kW.

"Superplastic forming" - Cat 1, cat 2

A deformation process using heat for metals that are normally characterised by low values of elongation (less than 20%) at the breaking point as determined at room temperature by conventional tensile strength testing, in order to achieve elongations during processing which are at least 2 times those values.

"Symmetric algorithm" - Cat 5P2

A cryptographic algorithm using an identical key for both encryption and decryption.

*Technical Note:*

*A common use of "symmetric algorithms" is confidentiality of data.*

"Technology" - General Technology Note, Both Lists

Specific information necessary for the "development", "production" or "use" of a product. The information takes the form of 'technical data' or 'technical assistance'. Specified "technology" for the Dual-Use List is defined in the General Technology Note and in the Dual-Use List. Specified "technology" for the Munitions List is defined in 2-22.

*Technical Notes:*

1. *'Technical data' may take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.*
2. *'Technical assistance' may take forms such as instruction, skills, training, working knowledge, consulting services. 'Technical assistance' may involve transfer of 'technical data'.*

"Three dimensional integrated circuit" - Cat 3

A collection of semiconductor dies or active device layers, integrated together, and having through semiconductor via connections passing completely through an interposer, substrate, die or layer to establish interconnections between the device layers. An interposer is an interface that enables electrical connections.

"Tilting spindle" - Cat 2

A tool-holding spindle which alters, during the machining process, the angular position of its centre line with respect to any other axis.

"Time constant" - Cat 6

The time taken from the application of a light stimulus for the current increment to reach a value of 1-1/e times the final value (i.e., 63% of the final value).

"Tip shroud" - Cat 9

A stationary ring component (solid or segmented) attached to the inner surface of the engine turbine casing or a feature at the outer tip of the turbine blade, which primarily provides a gas seal between the stationary and rotating components.

"Total control of flight" - Cat 7

Automated control of "aircraft" state variables and flight path to meet mission objectives responding to real time changes in data regarding objectives, hazards or other "aircraft".

"Total digital transfer rate" - Cat 5P1

The number of bits, including line coding, overhead and so forth per unit time passing between corresponding equipment in a digital transmission system. (See also "digital transfer rate")

"Tunable" - Cat 6

The ability of a "laser" to produce a continuous output at all wavelengths over a range of several "laser" transitions. A line selectable "laser" produces discrete wavelengths within one "laser" transition and is not considered "tunable".

"Unidirectional positioning repeatability" - Cat 2

The smaller of values R↑ and R↓ (forward and backward), as defined by 3.21 of ISO 230-2:2014 or national equivalents, of an individual machine tool axis.

"Unmanned aerial vehicle" ("UAV") - Cat 9, 2-10

Any "aircraft" capable of initiating flight and sustaining controlled flight and navigation without any human presence on board.

"Use" - General Technology Note, Dual-Use List

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

"User-accessible programmability" - Cat 4, cat 5, cat 6

The facility allowing a user to insert, modify or replace "programs" by means other than:

a. A physical change in wiring or interconnections; **or**

b. The setting of function controls including entry of parameters.

"Vacuum electronic devices" - Cat 3

Electronic devices based on the interaction of an electron beam with an electromagnetic wave propagating in a vacuum circuit or interacting with radio-frequency vacuum cavity resonators. "Vacuum electronic devices" include klystrons, travelling-wave tubes, and their derivatives.

## ACRONYMS AND ABBREVIATIONS USED IN GROUPS 1 AND 2

An acronym or abbreviation, when used as a defined term, will be found in 'Definitions of Terms used in Groups 1 and 2'.

| | |
|---|---|
| ADC | Analogue-to-Digital Converter |
| AGMA | American Gear Manufacturers' Association |
| AHRS | Attitude and Heading Reference Systems |
| AISI | American Iron and Steel Institute |
| ALE | Atomic Layer Epitaxy |
| ALU | Arithmetic Logic Unit |
| ANSI | American National Standards Institute |
| APP | Adjusted Peak Performance |
| APU | Auxiliary Power Unit |
| ASTM | American Society for Testing and Materials |
| ATC | Air Traffic Control |
| BJT | Bipolar Junction Transistors |
| BPP | Beam Parameter Product |
| BSC | Base Station Controller |
| C3I | Command, Communications, Control & Intelligence |
| CAD | Computer-Aided-Design |
| CAS | Chemical Abstracts Service |
| CCD | Charge Coupled Device |
| CDU | Control and Display Unit |
| CEP | Circular Error Probable |
| CMM | Coordinate Measuring Machine |
| CMOS | Complementary Metal Oxide Semiconductor |
| CNTD | Controlled Nucleation Thermal Deposition |
| CPLD | Complex Programmable Logic Device |
| CPU | Central Processing Unit |
| CVD | Chemical Vapour Deposition |
| CW | Chemical Warfare |
| CW | (for lasers) Continuous Wave |
| DAC | Digital-to-Analogue Converter |
| DANL | Displayed Average Noise Level |
| DBRN | Data-Base Referenced Navigation |
| DDS | Direct Digital Synthesizer |
| DEW | Directed Energy Weapon |
| DMA | Dynamic Mechanical Analysis |

| | |
|---|---|
| DME | Distance Measuring Equipment |
| DMOSFET | Diffused Metal Oxide Semiconductor Field Effect Transistor |
| DS | Directionally Solidified |
| EB | Exploding Bridge |
| EB-PVD | Electron Beam-Physical Vapour Deposition |
| EBW | Exploding bridge wire |
| ECM | electro-chemical machining |
| EDM | Electrical Discharge Machines |
| EEPROM | Electrically Erasable Programmable Read Only Memory |
| EFI | Exploding Foil Initiators |
| EIRP | Effective Isotropic Radiated Power |
| EMCDB | Elastomer Modified Cast Double Based Propellants |
| ENOB | Effective Number of Bits |
| ERF | Electrorheological Finishing |
| ERP | Effective Radiated Power |
| ETO | Emitter Turn-Off Thyristor |
| ETT | Electrical Triggering Thyristor |
| EUV | Extreme Ultraviolet |
| FADEC | Full Authority Digital Engine Control |
| FFT | Fast Fourier Transform |
| FPGA | Field Programmable Gate Array |
| FPIC | Field Programmable Interconnect |
| FPLA | Field Programmable Logic Array |
| FPO | Floating Point Operation |
| FWHM | Full-Width Half-Maximum |
| GSM | Global System for Mobile Communications |
| GTO | Gate Turn-off Thyristor |
| GVWR | Gross Vehicle Weight Rating |
| HBT | Hetero-Bipolar Transistors |
| HEMT | High Electron Mobility Transistor |
| ICAO | International Civil Aviation Organisation |
| IEC | International Electro-technical Commission |
| IED | Improvised Explosive Device |
| IEEE | Institute of Electrical and Electronic Engineers |
| IFOV | Instantaneous-Field-of-View |
| IGBT | Insulated Gate Bipolar Transistor |
| IGCT | Integrated Gate Commutated Thyristor |
| IHO | International Hydrographic Organization |

| | |
|---|---|
| ILS | Instrument Landing System |
| IMU | Inertial Measurement Unit |
| INS | Inertial Navigation System |
| IP | Internet Protocol |
| IRS | Inertial Reference System |
| IRU | Inertial Reference Unit |
| ISA | International Standard Atmosphere |
| ISAR | Inverse Synthetic Aperture Radar |
| ISO | International Organization for Standardization |
| ITU | International Telecommunication Union |
| JT | Joule-Thomson |
| LIDAR | Light Detection and Ranging |
| LIDT | Laser Induced Damage Threshold |
| LOA | Length Overall |
| LRU | Line Replaceable Unit |
| LTT | Light Triggering Thyristor |
| LVDT | Linear Variable Differential Transformer |
| MLS | Microwave Landing Systems |
| MMIC | Monolithic Microwave Integrated Circuit |
| MOCVD | Metal Organic Chemical Vapour Deposition |
| MOSFET | Metal-Oxide-Semiconductor Field Effect Transistor |
| MPM | Microwave Power Module |
| MRAM | Magnetic Random Access Memory |
| MRF | Magnetorheological Finishing |
| MRF | Minimum Resolvable Feature size |
| MRI | Magnetic Resonance Imaging |
| MTBF | Mean-Time-Between-Failures |
| MTTF | Mean-Time-To-Failure |
| NA | Numerical Aperture |
| NDT | Non-Destructive Test |
| NEQ | Net Explosive Quantity |
| OAM | Operations, Administration or Maintenance |
| OSI | Open Systems Interconnection |
| PAI | Polyamide-imides |
| PAR | Precision Approach Radar |
| PCL | Passive Coherent Location |
| PDK | Process Design Kit |
| PIN | Personal Identification Number |

| | |
|---|---|
| PMR | Private Mobile Radio |
| PVD | Physical Vapour Deposition |
| QAM | Quadrature-Amplitude-Modulation |
| QE | Quantum Efficiency |
| RAP | Reactive Atom Plasmas |
| RF | Radio Frequency |
| RNC | Radio Network Controller |
| ROIC | Read-out Integrated Circuit |
| RPV | Remotely Piloted Air Vehicles |
| S-FIL | Step and Flash Imprint Lithography |
| SAR | Synthetic Aperture Radar |
| SAS | Synthetic Aperture Sonar |
| SC | Single Crystal |
| SCR | Silicon Controlled Rectifier |
| SFDR | Spurious Free Dynamic Range |
| SHPL | Super High Powered Laser |
| SLAR | Sidelooking Airborne Radar |
| SOI | Silicon-on-Insulator |
| SPLD | Simple Programmable Logic Device |
| SQUID | Superconducting Quantum Interference Device |
| SRA | Shop Replaceable Assembly |
| SRAM | Static Random Access Memory |
| SSB | Single Sideband |
| SSR | Secondary Surveillance Radar |
| SSS | Side Scan Sonar |
| TE-PVD | Thermal Evaporation-Physical Vapour Deposition |
| TIR | Total Indicated Reading |
| TVR | Transmitting Voltage Response |
| UPR | Unidirectional Positioning Repeatability |
| UTS | Ultimate Tensile Strength |
| VJFET | Vertical Junction Field Effect Transistor |
| VOR | Very High Frequency Omni-directional Range |
| WLAN | Wireless Local Area Network |

# GROUP 3 – NUCLEAR NON-PROLIFERATION LIST

*(All destinations. All destinations applies to all Group 3 Items.)*

***Note:***

*Terms in 'single quotations' are usually defined within each entry of the list.*

*Terms in "double quotations" are defined at the end of Group 4.*

***CANADIAN NUCLEAR SAFETY COMMISSION (CNSC) NOTE:***

*The export of nuclear and nuclear-related items is also controlled by the CNSC under the Nuclear Safety and Control Act (NSCA) and Regulations. Therefore, the export of nuclear and nuclear-related items, not listed in Group 3 or which meet the specific Group 3 decontrol notes may still require a license from the CNSC. Information on export licensing requirements under the NSCA may be obtained by contacting the CNSC.*

***NUCLEAR TECHNOLOGY NOTE:***

*The "technology" directly associated with any items controlled in Group 3 is controlled according to the provisions of Group 3.*

*"Technology" for the "development", "production" or "use" of items under control remains under control even when applicable to non-controlled items.*

*The approval of items for export also authorizes the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance and repair of the items.*

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

***GENERAL SOFTWARE NOTE:***

*Group 3 does not control "software" which is either:*

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

## 3-1. SOURCE AND SPECIAL FISSIONABLE MATERIALS

### 3-1.1. Source materials

Source materials in the form of metal, alloy, chemical compound, concentrate, or that are incorporated in any material or substance and in which the concentration of source material is greater than 0.05 weight %, as follows:

1. Natural uranium (i.e. containing the mixture of isotopes occurring in nature);
2. Depleted uranium (i.e. depleted in the isotope 235 below that occurring in nature); **and**
3. Thorium.

***Note:***

*3-1.1. does not control the following:*

*a. Four grams or less of natural uranium or depleted uranium when contained in a sensing component in instruments;*

*b. Alloys containing less than 5% thorium;*

*c. Ceramic products containing thorium, which have been manufactured for non-nuclear use;*

*d. Medicinal substances;*

*e. Trace amounts found on contaminated items such as clothing, shielding or packaging;* ***and***

*f. Source material which the Government is satisfied is to be used only in civil non-nuclear applications, such as shielding, packaging, ballasts, counter-weights or the production of alloys and ceramics (For the purpose of export control, Global Affairs Canada will determine whether or not the exports of source material meeting the above specifications are for non-nuclear applications).*

3-1.2. Special fissionable materials

1. Plutonium of all isotopes and any alloy, compound or material containing plutonium;
2. Uranium-233; uranium enriched in the isotopes 233 or 235; or any alloy, compound or material containing one or more of the foregoing;

***Note:***

*3-1.2. does not control the following:*

*a. Four 'effective grams' or less of special fissionable material when contained in a sensing component in instruments;*

*b. Trace amounts found on contaminated items such as clothing, shielding or packaging;* ***and***

*c. Plutonium 238 that is contained in heart pacemakers.*

***Technical Note:***

*'Effective gram' means:*

*a. For plutonium isotopes and uranium-233, the isotope weight in grams;*

*b. For uranium enriched 1 percent or greater in the isotope uranium-235, the element weight in grams multiplied by the square of its enrichment expressed as a decimal weight fraction;* ***and***

*c. For uranium enriched below 1 percent in the isotope uranium-235, the element weight in grams multiplied by 0.0001.*

## 3-2. EQUIPMENT AND NON-NUCLEAR MATERIALS

3-2.1. Nuclear reactors and especially designed or prepared equipment and components therefor, including:

***Introductory Note:***

*Various types of nuclear reactors may be characterized by the moderator used (e.g., graphite, heavy water, light water, none), the spectrum of neutrons therein (e.g., thermal, fast), the type of coolant used (e.g., water, liquid metal, molten salt, gas), or by their function or type (e.g., power reactors, research reactors, test reactors). It is intended that all of these types of nuclear reactors are within scope of this entry and all of its subentries where applicable. This entry does not control fusion reactors.*

1. Complete nuclear reactors

   Nuclear reactors capable of operation so as to maintain a controlled self-sustaining fission chain reaction.

***Explanatory Note:***

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

2. Nuclear reactor vessels

   Metal vessels, or major shop-fabricated parts therefor, especially designed or prepared to contain the core of a nuclear reactor as defined in item 3-2.1.1. above, as well as relevant reactor internals as defined in item 3-2.1.8. below.

   ***Explanatory Note:***

   *Item 3-2.1.2 covers nuclear reactor vessels regardless of pressure rating and includes reactor pressure vessels and calandrias. The reactor vessel head is covered by item 3-2.1.2. as a major shop-fabricated part of a reactor vessel.*

3. Nuclear reactor fuel charging and discharging machines

   Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor as defined in item 3-2.1.1. above.

   ***Explanatory Note:***

   *The items noted above are capable of on-load operation or at employing technically sophisticated positioning or alignment features to allow complex off-load fuelling operations such as those in which direct viewing of or access to the fuel is not normally available.*

4. Nuclear reactor control rods and equipment

   Especially designed or prepared rods, support or suspension structures therefor, rod drive mechanisms or rod guide tubes to control the fission process in a nuclear reactor as defined in item 3-2.1.1. above.

5. Nuclear reactor pressure tubes

   Tubes which are especially designed or prepared to contain both fuel elements and the primary coolant in a reactor as defined in item 3-2.1.1. above.

   ***Explanatory Note:***

   *Pressure tubes are parts of fuel channels designed to operate at elevated pressure, sometimes in excess of 5 MPa.*

6. Nuclear Fuel Cladding

   Zirconium metal tubes or zirconium alloy tubes (or assemblies of tubes), especially designed or prepared for use as fuel cladding in a reactor as defined in item 3-2.1.1. above, and in quantities exceeding 10 kg.

   ***N.B.:***

   *For zirconium pressure tubes see 3-2.1.5. For calandria tubes see 3-2.1.8.*

   ***Explanatory Note:***

   *Zirconium metal tubes or zirconium alloy tubes for use in a nuclear reactor consist of zirconium in which the relation of hafnium to zirconium is typically less than 1:500 parts by weight.*

7. Primary coolant pumps or circulators

   Pumps or circulators especially designed or prepared for circulating the primary coolant for nuclear reactors as defined in item 3-2.1.1. above.

   ***Explanatory Note:***

   *Especially designed or prepared pumps or circulators include pumps for water-cooled reactors, circulators for gas-cooled reactors, and electromagnetic and mechanical*

*pumps for liquid-metal-cooled reactors. This equipment may include pumps with elaborate sealed or multi-sealed systems to prevent leakage of primary coolant, canned-driven pumps, and pumps with inertial mass systems. This definition encompasses pumps certified to Section III, Division I, Subsection NB (Class 1 components) of the American Society of Mechanical Engineers (ASME) Code, or equivalent standards.*

8. Nuclear reactor internals

   Nuclear reactor internals especially designed or prepared for use in a nuclear reactor as defined in item 3-2.1.1. above. This includes for example, support columns for the core, fuel channels, calandria tubes, thermal shields, baffles, core grid plates, and diffuser plates.

   ***Explanatory Note:***

   *Nuclear reactor internals are major structures within a reactor vessel which have one or more functions such as supporting the core, maintaining fuel alignment, directing primary coolant flow, providing radiation shields for the reactor vessel, and guiding in-core instrumentation.*

9. Heat exchangers
   a. Steam generators especially designed or prepared for the primary or intermediate coolant circuit of a nuclear reactor as defined in item 3-2.1.1. above.
   b. Other heat exchangers especially designed or prepared for use in the primary coolant circuit of a nuclear reactor as defined in item 3-2.1.1. above.

   ***Explanatory Note:***

   *Steam generators are especially designed or prepared to transfer the heat generated in the reactor to the feed water for steam generation. In the case of a fast reactor for which an intermediate coolant loop is also present, the steam generator is in the intermediate circuit. In a gas-cooled reactor, a heat exchanger may be utilised to transfer heat to a secondary gas loop that drives a gas turbine. The scope of control for this entry does not include heat exchangers for the supporting systems of the reactor e.g., the emergency cooling system or the decay heat cooling system.*

10. Neutron Detectors

    Especially designed or prepared neutron detectors for determining neutron flux levels within the core of a reactor as defined in item 3-2.1.1. above.

    ***Explanatory Note:***

    *The scope of this entry encompasses in-core and ex-core detectors which measure flux levels in a wide range, typically from $10^4$ neutrons per $cm^2$ per second or more. Ex-core refers to those instruments outside the core of a reactor as defined in item 3-2.1.1. above, but located within the biological shielding.*

11. External thermal shields

    External thermal shields especially designed or prepared for use in a nuclear reactor as defined in paragraph 3-2.1.1. for reduction of heat loss and also for containment vessel protection.

    ***Explanatory Note:***

    *External thermal shields are major structures placed over the reactor vessel which reduce heat loss from the reactor and reduce temperature within the containment vessel.*

3-2.2. Non-nuclear materials for reactors

1. Deuterium and heavy water

Deuterium, heavy water (deuterium oxide) and any other deuterium compound in which the ratio of deuterium to hydrogen atoms exceeds 1:5,000 for use in a nuclear reactor as defined in item 3-2.1.1. above.

***Explanatory Note:***

*For the purpose of export control, Global Affairs Canada will determine whether or not the exports of deuterium and deuterium compounds meeting the above specifications are for nuclear reactor use.*

2. Nuclear grade graphite

Graphite having a purity level better than 5 ppm (parts per million) boron equivalent and with a density greater than 1.50 g/cm$^3$ for use in a nuclear reactor as defined in paragraph 3-2.1.1. above, in quantities exceeding 1 kg.

***Explanatory Note:***

*For the purpose of export control, Global Affairs Canada will determine whether or not the exports of graphite meeting the above specifications are for nuclear reactor use.*

*Graphite having a purity level better than 5 ppm (parts per million) boron equivalent and with a density greater than 1.50 g/cm3 not for use in a nuclear reactor as defined in paragraph 3-2.1.1. above is not covered by this paragraph.*

*Boron Equivalent (BE) may be determined experimentally or is calculated as the sum of $BE_Z$ for impurities (excluding $BE_{carbon}$ since carbon is not considered an impurity) including boron, where:*

*$BE_Z$ ppm = CF x concentration of element Z (in ppm);*

*CF is the conversion factor: ($\sigma_Z$ x $A_B$) divided by ($\sigma_B$ x $A_Z$);*

*$\sigma_B$ and $\sigma_Z$ are the thermal neutron capture cross sections (in barns) for naturally occurring boron and element Z respectively;* ***and***

*$A_B$ and $A_Z$ are the atomic masses of naturally occurring boron and element Z respectively.*

3-2.3. Plants for the reprocessing of irradiated fuel elements, and equipment especially designed or prepared therefor

***Introductory Note:***

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

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

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

*These processes, including the complete systems for plutonium conversion and plutonium metal production, may be identified by the measures taken to avoid criticality (e.g., by*

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

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

1. Irradiated fuel element decladding equipment and chopping machines

   Remotely operated equipment especially designed or prepared for use in a reprocessing plant as identified above and intended to expose or prepare the irradiated nuclear material in fuel assemblies, bundles or rods for processing.

   ***Explanatory Note:***

   *This equipment cuts, chops, shears or otherwise breaches the cladding of the fuel to expose the irradiated nuclear material for processing or prepares the fuel for processing. Especially designed cutting shears are most commonly employed, although advanced equipment, such as lasers, peeling machines, or other techniques, may be used. Decladding involves removing the cladding of the irradiated nuclear fuel prior to its dissolution.*

2. Dissolvers

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

   ***Explanatory Note:***

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

3. Solvent extractors and solvent extraction equipment

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

   ***Explanatory Note:***

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

4. Chemical Holding or Storage Vessels

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

1. Walls or internal structures with a boron equivalent of at least 2%, **or**
2. A maximum diameter of 175 mm for cylindrical vessels, **or**
3. A maximum width of 75 mm for either a slab or annular vessel.

***Explanatory Note:***

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

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

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

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

5. Neutron measurement systems for process control

Neutron measurement systems especially designed or prepared for integration and use with automated process control systems in a plant for the reprocessing of irradiated fuel elements.

***Explanatory Note:***

*These systems involve the capability of active and passive neutron measurement and discrimination in order to determine the fissile material quantity and composition. The complete system is composed of a neutron generator, a neutron detector, amplifiers, and signal processing electronics. The scope of this entry does not include neutron detection and measurement instruments that are designed for nuclear material accountancy and safeguarding or any other application not related to integration and use with automated process control systems in a plant for the reprocessing of irradiated fuel elements.*

3-2.4. Plants for the fabrication of nuclear reactor fuel elements, and equipment especially designed or prepared therefor

***Introductory Note:***

*Nuclear fuel elements are manufactured from one or more of the source or special fissionable materials mentioned in Item 3-1. For oxide fuels, the most common type of fuel, equipment for pressing pellets, sintering, grinding and grading will be present. Mixed oxide fuels are handled in glove boxes (or equivalent containment) until they are sealed in the cladding. In all cases, the fuel is hermetically sealed inside a suitable cladding which is designed to be the primary envelope encasing the fuel so as to provide suitable performance and safety during reactor operation. Also, in all cases, precise control of processes, procedures and equipment to extremely high standards is necessary in order to ensure predictable and safe fuel performance.*

***Explanatory Note:***

*Items of equipment that are considered to fall within the meaning of the phrase 'and equipment especially designed or prepared' for the fabrication of fuel elements include equipment which:*

*a. normally comes in direct contact with, or directly processes, or controls, the production flow of nuclear material;*

*b. seals the nuclear material within the cladding;*

*c. checks the integrity of the cladding or the seal;*

*d. checks the finish treatment of the sealed fuel;* ***or***

*e. is used for assembling reactor fuel elements.*

*Such equipment or systems of equipment may include, for example:*

1. *Fully automatic pellet inspection stations especially designed or prepared for checking final dimensions and surface defects of the fuel pellets;*
2. *Automatic welding machines especially designed or prepared for welding end caps onto the fuel pins (or rods);*
3. *Automatic test and inspection stations especially designed or prepared for checking the integrity of completed fuel pins (or rods).*

   *Item 3 typically includes equipment for:*

   a) *X-ray examination of pin (or rod) end cap welds;*
   b) *Helium leak detection from pressurized pins (or rods);*
   c) *Gamma-ray scanning of the pins (or rods) to check for correct loading of the fuel pellets inside.*
4. *Systems especially designed or prepared to manufacture nuclear fuel cladding.*

3-2.5. Plants for the separation of isotopes of natural uranium, depleted uranium or special fissionable material and equipment, other than analytical instruments, especially designed or prepared therefor

***Introductory Note:***

*Plants, equipment and technology for the separation of uranium isotopes have, in many instances, a close relationship to plants, equipment and technology for isotope separation of "other elements". In particular cases, the controls under Section 3-2.5. also apply to plants and equipment that are intended for isotope separation of "other elements". These controls of plants and equipment for isotope separation of "other elements" are complementary to controls on plants and equipment especially designed or prepared for the processing, use or production of special fissionable material covered by the Group 3. These complementary Section 3-2.5. controls for uses involving "other elements" do not apply to the electromagnetic isotope separation process, which is addressed under Group 4 of the Export Control List.*

*Processes for which the controls in Section 3-2.5. equally apply whether the intended use is uranium isotope separation or isotope separation of "other elements" are: gas centrifuge, gaseous diffusion, the plasma separation process, and aerodynamic processes.*

*For some processes, the relationship to uranium isotope separation depends on the element being separated. These processes are: laser-based processes (e.g. molecular laser isotope separation and atomic vapour laser isotope separation), chemical exchange, and ion exchange. Suppliers must therefore evaluate these processes on a case-by-case basis to apply Section 3-2.5. controls for uses involving "other elements" accordingly.*

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

3-2.5.1. Gas centrifuges and assemblies and components especially designed or prepared for use in gas centrifuges.

***Introductory Note:***

*The gas centrifuge normally consists of a thin-walled cylinder of between 75 mm and 650 mm diameter contained in a vacuum environment and spun at high peripheral speed of the order of 300 m/s or more with its central axis vertical. In order to achieve high speed the materials of construction for the rotating components have to be of a high strength to density ratio and the rotor assembly, and hence its individual components, have to be manufactured to very close tolerances in order to minimise the unbalance. In contrast to other centrifuges, the gas centrifuge for uranium enrichment is characterised by having within the rotor chamber a rotating disc-shaped baffle (or baffles) and a stationary tube arrangement for feeding and extracting the uranium hexafluoride ($UF_6$) gas and featuring at least three separate channels, of which two are connected to scoops extending from the rotor axis towards the periphery of the rotor chamber. Also*

*contained within the vacuum environment are a number of critical items which do not rotate and which although they are especially designed are not difficult to fabricate nor are they fabricated out of unique materials. A centrifuge facility however requires a large number of these components, so that quantities can provide an important indication of end use.*

1. Rotating components
   a. Complete rotor assemblies:

      Thin-walled cylinders, or a number of interconnected thin-walled cylinders, manufactured from one or more of the high strength to density ratio materials described in the Explanatory Note to this Section. If interconnected, the cylinders are joined together by flexible bellows or rings as described in section 3-2.5.1.1.c. following. The rotor is fitted with an internal baffle (or baffles) and end caps, as described in section 3-2.5.1.1.d. and 3-2.5.1.1.e. following, if in final form. However the complete assembly may be delivered only partly assembled.

   b. Rotor tubes:

      Especially designed or prepared thin-walled cylinders with thickness of 12 mm or less, a diameter of between 75 mm and 650 mm, and manufactured from one or more of the high strength to density ratio materials described in the Explanatory Note to this Section.

   c. Rings or Bellows:

      Components especially designed or prepared to give localised support to the rotor tube or to join together a number of rotor tubes. The bellows is a short cylinder of wall thickness 3 mm or less, a diameter of between 75 mm and 650 mm, having a convolute, and manufactured from one of the high strength to density ratio materials described in the Explanatory Note to this Section.

   d. Baffles:

      Disc-shaped components of between 75 mm and 650 mm diameter especially designed or prepared to be mounted inside the centrifuge rotor tube, in order to isolate the take-off chamber from the main separation chamber and, in some cases, to assist the $UF_6$ gas circulation within the main separation chamber of the rotor tube, and manufactured from one of the high strength to density ratio materials described in the Explanatory Note to this Section.

   e. Top caps/Bottom caps:

      Disc-shaped components of between 75 mm and 650 mm diameter especially designed or prepared to fit to the ends of the rotor tube, and so contain the $UF_6$ within the rotor tube, and in some cases to support, retain or contain as an integrated part an element of the upper bearing (top cap) or to carry the rotating elements of the motor and lower bearing (bottom cap), and manufactured from one of the high strength to density ratio materials described in the Explanatory Note to this Section.

***Explanatory Note:***

*The materials used for centrifuge rotating components include the following:*

*a. Maraging steel capable of an ultimate tensile strength of 1.95 GPa or more;*

*b. Aluminium alloys capable of an ultimate tensile strength of 0.46 GPa or more;*

c. *Filamentary materials suitable for use in composite structures and having a specific modulus of $3.18 \times 10^6$ m or greater and a 'specific ultimate tensile strength' of $7.62 \times 10^4$ m or greater ('Specific Modulus' is the Young's Modulus in $N/m^2$ divided by the specific weight in $N/m^3$; 'Specific Ultimate Tensile Strength' is the ultimate tensile strength in $N/m^2$ divided by the specific weight in $N/m^3$).*

2. Static components

a. Magnetic suspension bearings:

1. Especially designed or prepared bearing assemblies consisting of an annular magnet suspended within a housing containing a damping medium. The housing will be manufactured from a $UF_6$-resistant material (see Explanatory Note to Section 3-2.5.2.). The magnet couples with a pole piece or a second magnet fitted to the top cap described in Section 3-2.5.1.1.e. The magnet may be ring-shaped with a relation between outer and inner diameter smaller or equal to 1.6:1. The magnet may be in a form having an initial permeability of 0.15 H/m or more, or a remanence of 98.5% or more, or an energy product of greater than 80 $kJ/m^3$. In addition to the usual material properties, it is a prerequisite that the deviation of the magnetic axes from the geometrical axes is limited to very small tolerances (lower than 0.1 mm) or that homogeneity of the material of the magnet is specially called for.
2. Active magnetic bearings especially designed or prepared for use in gas centrifuges.

***Explanatory Note:***

*These bearings usually have the following characteristics:*

- *Designed to keep centred a rotor spinning at 600 Hz or more,* ***and***
- *Associated to a reliable electrical power supply and/or to an uninterruptible power supply UPS) unit in order to function for more than one hour.*

b. Bearings/Dampers:

Especially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper. The pivot is normally a hardened steel shaft with a hemisphere at one end with a means of attachment to the bottom cap described in section 3-2.5.1.1.e. at the other. The shaft may however have a hydrodynamic bearing attached. The cup is pellet-shaped with a hemispherical indentation in one surface. These components are often supplied separately to the damper.

c. Molecular pumps:

Especially designed or prepared cylinders having internally machined or extruded helical grooves and internally machined bores. Typical dimensions are as follows: 75 mm to 650 mm internal diameter, 10 mm or more wall thickness, with the length equal to or greater than the diameter. The grooves are typically rectangular in cross section and 2 mm or more in depth.

d. Motor stators:

Especially designed or prepared ring-shaped stators for high speed multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuum at a frequency of 600 Hz or greater and a

power of 40 VA or greater. The stators may consist of multi-phase windings on a laminated low loss iron core comprised of thin layers typically 2 mm thick or less.

e. Centrifuge housing/recipients:

Components especially designed or prepared to contain the rotor tube assembly of a gas centrifuge. The housing consists of a rigid cylinder of wall thickness up to 30 mm with precision machined ends to locate the bearings and with one or more flanges for mounting. The machined ends are parallel to each other and perpendicular to the cylinder's longitudinal axis to within 0.05° or less. The housing may also be a honeycomb type structure to accommodate several rotor assemblies.

f. Scoops:

Especially designed or prepared tubes for the extraction of $UF_6$ gas from within the rotor tube by a Pitot tube action (that is, with an aperture facing into the circumferential gas flow within the rotor tube, for example by bending the end of a radially disposed tube) and capable of being fixed to the central gas extraction system.

3-2.5.2. Especially designed or prepared auxiliary systems, equipment and components for gas centrifuge enrichment plants.

***Introductory Note:***

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

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

***Explanatory Note:***

*Some of the items listed below either come into direct contact with the $UF_6$ process gas or directly control the centrifuges and the passage of the gas from centrifuge to centrifuge and cascade to cascade. Materials resistant to corrosion by $UF_6$ include copper, copper alloys, stainless steel, aluminium, aluminium oxide, aluminium alloys, nickel or alloys containing 60% by weight or more nickel and fluorinated hydrocarbon polymers.*

1. Feed systems/'product' and 'tails' withdrawal systems

Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$ including:

a. Feed autoclaves, ovens or systems, used for passing $UF_6$ to the enrichment process;

b. Desublimers, cold traps or pumps used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating;

c. Solidification or liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form;

d. 'Product' and 'tails' stations used for transferring $UF_6$ into containers.

2. Machine header piping systems

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

3. Special shut-off and control valves

a. Shut-off valves especially designed or prepared to act on the feed, 'product' or 'tails' $UF_6$ gas streams of an individual gas centrifuge.

b. Bellows-sealed valves, manual or automated, shut-off or control, made of or protected by materials resistant to corrosion by $UF_6$, with an inside diameter of 10 to 160 mm, specially designed or prepared for use in main or auxiliary systems of gas centrifuge enrichment plants.

***Explanatory Note:***

*Typical especially designed or prepared valves include bellow-sealed valves, fast acting closure-types, fast acting valves and others.*

4. $UF_6$ mass spectrometers/ion sources

Especially designed or prepared mass spectrometers capable of taking on-line samples from $UF_6$ gas streams and having all of the following characteristics:

1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320;
2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% by weight or more, or nickel-chrome alloys;
3. Electron bombardment ionization sources; **and**
4. Having a collector system suitable for isotopic analysis.

5. Frequency changers

Frequency changers (also known as converters or invertors) especially designed or prepared to supply motor stators as defined under 3-2.5.1.2.d., or parts, components and sub-assemblies of such frequency changers having both of the following characteristics:

1. A multiphase frequency output of 600 Hz or greater; **and**
2. High stability (with frequency control better than 0.2%);

3-2.5.3. Especially designed or prepared assemblies and components for use in gaseous diffusion enrichment.

***Introductory Note:***

*In the gaseous diffusion method of uranium isotope separation, the main technological assembly is a special porous gaseous diffusion barrier, heat exchanger for cooling the gas (which is heated by the process of compression), seal valves and control valves, and pipelines. In as much as gaseous diffusion technology uses $UF_6$, all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of*

*materials that remain stable in contact with $UF_6$. A gaseous diffusion facility requires a number of these assemblies, so that quantities can provide an important indication of end use.*

1. Gaseous diffusion barriers and barrier materials
   a. Especially designed or prepared thin, porous filters, with a pore size of 10-100 nm, a thickness of 5 mm or less, and for tubular forms, a diameter of 25 mm or less, made of metallic, polymer or ceramic materials resistant to corrosion by $UF_6$ (see Explanatory Note to section 3-2.5.4.).
   b. Especially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60% by weight or more nickel, aluminium oxide, or $UF_6$-resistant fully fluorinated hydrocarbon polymers having a purity of 99.9% by weight or more, a particle size less than 10 µm, and a high degree of particle size uniformity, which are especially prepared for the manufacture of gaseous diffusion barriers.
2. Diffuser housings

   Especially designed or prepared hermetically sealed vessels for containing the gaseous diffusion barrier, made of or protected by $UF_6$-resistant materials (see Explanatory Note to section 3-2.5.4.).
3. Compressors and gas blowers

   Especially designed or prepared compressors, or gas blowers with a suction volume capacity of 1 $m^3$ per minute or more of $UF_6$, with a discharge pressure of up to 500 kPa, and designed for long-term operation in the $UF_6$ environment, as well as separate assemblies of such compressors and gas blowers. These compressors and gas blowers have a pressure ratio of 10:1 or less and are made of, or protected by, materials resistant to $UF_6$ (see Explanatory Note to section 3-2.5.4.).
4. Rotary shaft seals

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

   Especially designed or prepared heat exchangers made of or protected by $UF_6$-resistant materials (see Explanatory Note to section 3-2.5.4.), and intended for a leakage pressure change rate of less than 10 Pa per hour under a pressure difference of 100 kPa.

3-2.5.4. Especially designed or prepared auxiliary systems, equipment and components for use in gaseous diffusion enrichment.

***Introductory Note:***

*The auxiliary systems, equipment and components for gaseous diffusion enrichment plants are the systems of plant needed to feed $UF_6$ to the gaseous diffusion assembly, to link the individual assemblies to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the 'product' and 'tails' $UF_6$ from the diffusion cascades. Because of the high inertial properties of diffusion cascades, any interruption in their operation, and especially their shut-down, leads to serious*

*consequences. Therefore, a strict and constant maintenance of vacuum in all technological systems, automatic protection from accidents, and precise automated regulation of the gas flow is of importance in a gaseous diffusion plant. All this leads to a need to equip the plant with a large number of special measuring, regulating and controlling systems.*

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

***Explanatory Note:***

*The items listed below either come into direct contact with the $UF_6$ process gas or directly control the flow within the cascade. Materials resistant to corrosion by $UF_6$ include copper, copper alloys, stainless steel, aluminium, aluminium oxide, aluminium alloys, nickel or alloys containing 60% by weight or more nickel and fluorinated hydrocarbon polymers.*

1. Feed systems/'product' and 'tails' withdrawal systems

   Especially designed or prepared process systems, or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$ including:

   a. Feed autoclaves, ovens, or systems, used for passing $UF_6$ to the enrichment process;
   b. Desublimers, cold traps or pumps used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating;
   c. Solidification or Liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form;
   d. 'Product' or 'tails' stations used for transferring $UF_6$ into containers.

2. Header piping systems

   Especially designed or prepared piping systems and header systems for handling $UF_6$ within the gaseous diffusion cascades.

   ***Explanatory Note:***

   *This piping network is normally of the 'double' header system with each cell connected to each of the headers.*

3. Vacuum systems

   a. Especially designed or prepared vacuum manifolds, vacuum headers and vacuum pumps having a suction capacity of 5 $m^3$/min or more.
   b. Vacuum pumps especially designed for service in $UF_6$-bearing atmospheres made of, or protected by, materials resistant to corrosion by $UF_6$ (see Explanatory Note to this section). These pumps may be either rotary or positive, may have displacement and fluorocarbon seals, and may have special working fluids present.

4. Special shut-off and control valves

Especially designed or prepared bellows-sealed valves, manual or automated shut-off or control, made of or protected by materials resistant to corrosion by $UF_6$, for installation in main and auxiliary systems of gaseous diffusion enrichment plants.

5. $UF_6$ mass spectrometers/ion sources

   Especially designed or prepared mass spectrometers capable of taking "on-line samples" from $UF_6$ gas streams and having all of the following:

   1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320;
   2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% by weight or more, or nickel-chrome alloys;
   3. Electron bombardment ionisation sources; **and**
   4. Having a collector system suitable for isotopic analysis.

3-2.5.5. Especially designed or prepared systems, equipment and components for use in aerodynamic enrichment plants.

***Introductory Note:***

*In aerodynamic enrichment processes, a mixture of gaseous $UF_6$ and light gas (hydrogen or helium) is compressed and then passed through separating elements wherein isotopic separation is accomplished by the generation of high centrifugal forces over a curved-wall geometry. Two processes of this type have been successfully developed: the separation nozzle process and the vortex tube process. For both processes the main components of a separation stage include cylindrical vessels housing the special separation elements (nozzles or vortex tubes), gas compressors and heat exchangers to remove the heat of compression. An aerodynamic plant requires a number of these stages, so that quantities can provide an important indication of end use. Since aerodynamic processes use $UF_6$, all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of, or protected by materials that remain stable in contact with $UF_6$.*

***Explanatory Note:***

*The items listed in this section either come into direct contact with the $UF_6$ process gas or directly control the flow within the cascade. All surfaces which come into contact with the process gas are wholly made of or protected by $UF_6$-resistant materials. For the purposes of the section relating to aerodynamic enrichment items, the materials resistant to corrosion by $UF_6$ include copper, copper alloys, stainless steel, aluminium, aluminium oxide, aluminium alloys, nickel or alloys containing 60% by weight or more nickel and fluorinated hydrocarbon polymers.*

1. Separation nozzles

   Especially designed or prepared separation nozzles and assemblies thereof. The separation nozzles consist of slit-shaped, curved channels having a radius of curvature less than 1 mm, resistant to corrosion by $UF_6$ and having a knife-edge within the nozzle that separates the gas flowing through the nozzle into two fractions.

2. Vortex tubes

   Especially designed or prepared vortex tubes and assemblies thereof. The vortex tubes are cylindrical or tapered, made of or protected by materials resistant to corrosion by $UF_6$, and with one or more tangential inlets. The tubes may be equipped with nozzle-type appendages at either or both ends.

   ***Explanatory Note:***

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

3. Compressors and gas blowers

   Especially designed or prepared compressors or gas blowers made of or protected by materials resistant to corrosion by the $UF_6$/carrier gas (hydrogen or helium) mixture.

4. Rotary shaft seals

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

5. Heat exchangers for gas cooling

   Especially designed or prepared heat exchangers made of or protected by materials resistant to corrosion by $UF_6$.

6. Separation element housings

   Especially designed or prepared separation element housings, made of or protected by materials resistant to corrosion by $UF_6$, for containing vortex tubes or separation nozzles.

7. Feed systems/'product' and 'tails' withdrawal systems

   Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$, including:

   a. Feed autoclaves, ovens, or systems used for passing $UF_6$ to the enrichment process;
   b. Desublimers (or cold traps) used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating;
   c. Solidification or liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form;
   d. 'Product' or 'tails' stations used for transferring $UF_6$ into containers.

8. Header piping systems

   Especially designed or prepared header piping systems, made of or protected by materials resistant to corrosion by $UF_6$, for handling $UF_6$ within the aerodynamic cascades. This piping network is normally of the 'double' header design with each stage or group of stages connected to each of the headers.

9. Vacuum systems and pumps

   a. Especially designed or prepared vacuum systems consisting of vacuum manifolds, vacuum headers and vacuum pumps, and designed for service in $UF_6$-bearing atmospheres;
   b. Vacuum pumps especially designed or prepared for service in $UF_6$-bearing atmospheres and made of or protected by materials resistant to corrosion by $UF_6$. These pumps may use fluorocarbon seals and special working fluids.

10. Special shut-off and control valves

    Especially designed or prepared bellows-sealed valves, manual or automated shut-off or control made of or protected by materials resistant to corrosion by $UF_6$ with a diameter of 40 mm or greater for installation in main and auxiliary systems of aerodynamic enrichment plants.

11. $UF_6$ mass spectrometers/Ion sources

    Especially designed or prepared mass spectrometers capable of taking on-line samples from $UF_6$ gas streams and having all of the following:

    1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320;
    2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% by weight or more, or nickel-chrome alloys;
    3. Electron bombardment ionization sources; **and**
    4. Having a collector system suitable for isotopic analysis.

12. $UF_6$/carrier gas separation systems

    Especially designed or prepared process systems for separating $UF_6$ from carrier gas (hydrogen or helium).

    ***Explanatory Note:***

    *These systems are designed to reduce the $UF_6$ content in the carrier gas to 1 ppm or less and may incorporate equipment such as:*

    *a. Cryogenic heat exchangers and cryoseparators capable of temperatures of 153 K (-120 °C) or less;*

    *b. Cryogenic refrigeration units capable of temperatures of 153 K (-120 °C) or less;*

    *c. Separation nozzle or vortex tube units for the separation of $UF_6$ from carrier gas;* ***or***

    *d. $UF_6$ cold traps capable of freezing out $UF_6$.*

3-2.5.6. Especially designed or prepared systems, equipment and components for use in chemical exchange or ion exchange enrichment plants.

***Introductory Note:***

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

*In the liquid-liquid chemical exchange process, immiscible liquid phases (aqueous and organic) are counter currently contacted to give the cascading effect of thousands of separation stages. The aqueous phase consists of uranium chloride in hydrochloric acid solution; the organic phase consists of an extractant containing uranium chloride in an organic solvent. The contactors employed in the separation cascade can be liquid-liquid exchange columns (such as pulsed columns with sieve plates) or liquid centrifugal contactors. Chemical conversions (oxidation and reduction) are required at both ends of the separation cascade in order to provide for the reflux requirements at each end. A major design concern is to avoid contamination of the process streams with certain metal ions. Plastic, plastic-lined (including use of fluorocarbon polymers) and/or glass-lined columns and piping are therefore used.*

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

1. Liquid-liquid exchange columns (Chemical exchange)

   Countercurrent liquid-liquid exchange columns having mechanical power input, especially designed or prepared for uranium enrichment using the chemical exchange process. For corrosion resistance to concentrated hydrochloric acid solutions, these columns, and their internals are normally made of or protected by suitable plastic materials (such as fluorinated hydrocarbon polymers) or glass. The stage residence time of the columns is normally designed to be 30 s or less.

2. Liquid-liquid centrifugal contactors (Chemical exchange)

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

3. Uranium reduction systems and equipment (Chemical exchange)

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

      ***Explanatory Note:***

      *The cell cathodic compartment must be designed to prevent re-oxidation of uranium to its higher valence state. To keep the uranium in the cathodic compartment, the cell may have an impervious diaphragm membrane constructed of special cation exchange material. The cathode consists of a suitable solid conductor such as graphite.*

   b. Especially designed or prepared systems at the product end of the cascade for taking the $U^{+4}$ out of the organic stream, adjusting the acid concentration and feeding to the electrochemical reduction cells.

      ***Explanatory Note:***

      *These systems consist of solvent extraction equipment for stripping the $U^{+4}$ from the organic stream into an aqueous solution, evaporation and/or other equipment to accomplish solution pH adjustment and control, and pumps or other transfer devices for feeding to the electrochemical reduction cells. A major design concern is to avoid contamination of the aqueous stream with certain metal ions. Consequently, for those parts in contact with the process stream, the system is constructed of equipment made of or protected by*

*suitable materials (such as glass, fluorocarbon polymers, polyphenyl sulphate, polyether sulphone, and resin-impregnated graphite).*

4. Feed preparation systems (Chemical exchange)

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

   ***Explanatory Note:***

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

5. Uranium oxidation systems (Chemical exchange)

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

   ***Explanatory Note:***

   *These systems may incorporate equipment such as:*

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

   *b. Equipment that separates water from hydrochloric acid so that the water and the concentrated hydrochloric acid may be reintroduced to the process at the proper locations.*

6. Fast-reacting ion exchange resins/adsorbents (Ion exchange)

   Fast-reacting ion exchange resins or adsorbents especially designed or prepared for uranium enrichment using the ion exchange process, including porous macroreticular resins, and/or pellicular structures in which the active chemical exchange groups are limited to a coating on the surface of an inactive porous support structure, and other composite structures in any suitable form including particles or fibres. These ion exchange resins/adsorbents have diameters of 0.2 mm or less and must be chemically resistant to concentrated hydrochloric acid solutions as well as physically strong enough so as not to degrade in the exchange columns. The resins/adsorbents are especially designed to achieve very fast uranium isotope exchange kinetics (exchange rate half-time of less than 10 s) and are capable of operating at a temperature in the range of 373 K (100 °C) to 473 K (200 °C).

7. Ion exchange columns (Ion exchange)

   Cylindrical columns greater than 1,000 mm in diameter for containing and supporting packed beds of ion exchange resin/adsorbent, especially designed or prepared for uranium enrichment using the ion exchange process. These columns are made of or protected by materials (such as titanium or fluorocarbon plastics) resistant to corrosion by concentrated hydrochloric acid solutions and are capable of operating at a temperature in

the range of 373 K (100 °C) to 473 K (200 °C) and pressures above 0.7 MPa.

8. Ion exchange reflux systems (Ion exchange)
   a. Especially designed or prepared chemical or electrochemical reduction systems for regeneration of the chemical reducing agent used in ion exchange uranium enrichment cascades.
   b. Especially designed or prepared chemical or electrochemical oxidation systems for regeneration of the chemical oxidising agent (agents) used in ion exchange uranium enrichment cascades.

***Explanatory Note:***

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

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

3-2.5.7. Especially designed or prepared systems, equipment and components for use in laser-based enrichment plants.

***Introductory Note:***

*Present systems for enrichment processes using lasers fall into two categories: those in which the process medium is atomic uranium vapour and those in which the process medium is the vapour of a uranium compound sometimes mixed with another gas or gases. Common nomenclature for such processes include:*

- *first category - atomic vapour laser isotope separation;*
- *second category - molecular laser isotope separation, including chemical reaction by isotope selective laser activation.*

*The systems, equipment and components for laser enrichment plants include:*

*a. Devices to feed uranium-metal vapour (for selective photo-ionisation) or devices to feed the vapour of a uranium compound (for selective photo-dissociation or selective excitation/activation);*

*b. Devices to collect enriched and depleted uranium metal as 'product' and 'tails' in the first category, and devices to collect enriched and depleted uranium compounds as 'product' and 'tails' in the second category;*

*c. Process laser systems to selectively excite the uranium-235 ($^{235}U$) species;*

*d. Feed preparation and product conversion equipment.*

*The complexity of the spectroscopy of uranium atoms and compounds may require incorporation of any of a number of available laser and laser optics technologies.*

***Explanatory Note:***

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

1. Uranium vaporisation systems (atomic vapour based methods)

   Especially designed or prepared uranium metal vaporisation systems for use in laser enrichment.

***Explanatory Note:***

*These systems may contain electron beam guns and are designed to achieve a delivered power (1kW or greater) on the target sufficient to generate uranium metal vapour at a rate required for the laser enrichment function.*

2. Liquid or vapour uranium metal handling systems and components (atomic vapour based methods)

   Especially designed or prepared systems for handling molten uranium, molten uranium alloys, or uranium metal vapour for use in laser enrichment or especially designed or prepared components therefor.

   ***Explanatory Note:***

   *The liquid uranium metal handling systems may consist of crucibles and cooling equipment for the crucibles.*

   *The crucibles and other parts of this system that come into contact with molten uranium, molten uranium alloys or uranium metal vapour are made of or protected by materials of suitable corrosion and heat resistance. Suitable materials may include tantalum, yttria-coated graphite, graphite coated with other rare earth oxides (see Group 4) or mixtures thereof.*

3. Uranium metal ‘product’ and ‘tails’ collector assemblies (atomic vapour based methods)

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

   ***Explanatory Note:***

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

4. Separator module housings (atomic vapour based methods)

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

   ***Explanatory Note:***

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

5. Supersonic expansion nozzles (molecular based methods)

   Especially designed or prepared supersonic expansion nozzles for cooling mixtures of $UF_6$ and carrier gas to 150 K (-123 °C) or less and which are corrosion resistant to $UF_6$.

6. ‘Product’ or ‘Tails’ collectors (molecular based methods)

   Especially designed or prepared components or devices for collecting uranium ‘product’ material or uranium ‘tails’ material following illumination with laser light.

   ***Explanatory Note:***

   *In one example of molecular laser isotope separation, the product collectors serve to collect enriched uranium pentafluoride ($UF_5$) solid material. The product collectors may consist of filter, impact, or cyclone-type collectors, or combinations thereof, and must be corrosion resistant to the $UF_5$ /$UF_6$ environment.*

7. $UF_6$/carrier gas compressors (molecular based methods)

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

8. Rotary shaft seals (molecular based methods)

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

9. Fluorination systems (molecular based methods)

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

   ***Explanatory Note:***

   *These systems are designed to fluorinate the collected $UF_5$ powder to $UF_6$ for subsequent collection in product containers or for transfer as feed for additional enrichment. In one approach, the fluorination reaction may be accomplished within the isotope separation system to react and recover directly off the product collectors. In another approach, the $UF_5$ powder may be removed/transferred from the product collectors into a suitable reaction vessel (e.g., fluidised-bed reactor, screw reactor or flame tower) for fluorination. In both approaches, equipment for storage and transfer of fluorine (or other suitable fluorinating agents) and for collection and transfer of $UF_6$ are used.*

10. $UF_6$ mass spectrometers/ion sources (molecular based methods)

    Especially designed or prepared mass spectrometers capable of taking on-line samples from $UF_6$ gas streams and having all of the following:

    1. Capable of measuring ions of 320 atomic mass units or greater and having a resolution of better than 1 part in 320;
    2. Ion sources constructed of or protected by nickel, nickel-copper alloys with a nickel content of 60% by weight or more, or nickel-chrome alloys;
    3. Electron bombardment ionisation sources; **and**
    4. Having a collector system suitable for isotopic analysis.

11. Feed systems/'product' and 'tails' withdrawal systems (molecular based methods)

    Especially designed or prepared process systems or equipment for enrichment plants made of or protected by materials resistant to corrosion by $UF_6$, including:

    a. Feed autoclaves, ovens, or systems used for passing $UF_6$ to the enrichment process;
    b. Desublimers (or cold traps) used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating;
    c. Solidification or liquefaction stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form;
    d. 'Product' or 'tails' stations used for transferring $UF_6$ into containers.

12. $UF_6$/carrier gas separation systems (molecular based methods)

Especially designed or prepared process systems for separating $UF_6$ from carrier gas.

***Explanatory Note:***

*These systems may incorporate equipment such as:*

*a. Cryogenic heat exchangers or cryoseparators capable of temperatures of 153 K (-120 °C) or less;*

*b. Cryogenic refrigeration units capable of temperatures of 153 K (-120 °C) or less;*

*c. $UF_6$ cold traps capable of freezing out $UF_6$.*

*The carrier gas may be nitrogen, argon, or other gas.*

13. Laser systems

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

***Explanatory Note:***

*The lasers and laser components of importance in laser-based enrichment processes include those identified in Group 4. The laser system typically contains both optical and electronic components for the management of the laser beam (or beams) and the transmission to the isotope separation chamber. The laser system for atomic vapour based methods usually consists of tunable dye lasers pumped by another type of laser (e.g. copper vapour laser or certain solid-state lasers). The laser system for molecular based methods may consist of carbon dioxide lasers or excimer laser and a multi-pass optical cell. Lasers or laser systems for both methods require a spectrum frequency stabilisation for operation over extended periods of time.*

3-2.5.8. Especially designed or prepared systems, equipment and components for use in plasma separation enrichment plants

***Introductory Note:***

*In the plasma separation process, a plasma of uranium ions passes through an electric field tuned to the $^{235}U$ ion resonance frequency so that they preferentially absorb energy and increase the diameter of their corkscrew-like orbits. Ions with a large diameter path are trapped to produce a product enriched in $^{235}U$. The plasma, which is made by ionising uranium vapor, is contained in a vacuum chamber with a high-strength magnetic field produced by a superconducting magnet. The main technological systems of the process include the uranium plasma generation system, the separator module with superconducting magnet (see Group 4), and metal removal systems for the collection of 'product' and 'tails'.*

1. Microwave power sources and antennae

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

2. Ion excitation coils

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

3. Uranium plasma generation systems

Especially designed or prepared systems for the generation of uranium plasma, for use in plasma separation plants.

4. Not used since 2013

5. Uranium metal ‘product’ and ‘tails’ collector assemblies

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

6. Separator module housings

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

   ***Explanatory Note:***

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

3-2.5.9. Especially designed or prepared systems, equipment and components for use in electromagnetic enrichment plants

***Introductory Note:***

*In the electromagnetic process, uranium metal ions produced by ionization of a salt feed material (typically uranium tetrachloride ($UCI_4$)) are accelerated and passed through a magnetic field that has the effect of causing the ions of different isotopes to follow different paths. The major components of an electromagnetic isotope separator include: a magnetic field for ion-beam diversion/separation of the isotopes, an ion source with its acceleration system, and a collection system for the separated ions. Auxiliary systems for the process include the magnet power supply system, the ion source high-voltage power supply system, the vacuum system, and extensive chemical handling systems for recovery of product and cleaning/recycling of components.*

1. Electromagnetic isotope separators

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

   a. Ion sources

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

   b. Ion collectors

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

   c. Vacuum housings

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

***Explanatory Note:***

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

d. Magnet pole pieces

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

2. High voltage power supplies

Especially designed or prepared high-voltage power supplies for ion sources, having both of the following characteristics:

1. Capable of continuous operation, output voltage of 20,000 V or greater, output current of 1 A or greater; **and**
2. Voltage regulation of better than 0.01% over a time period of 8 h.

3. Magnet power supplies

Especially designed or prepared high-power, direct current magnet power supplies having both of the following characteristics:

1. Capable of continuously producing a current output of 500 A or greater at a voltage of 100 V or greater; **and**
2. Current or voltage regulation better than 0.01% over a period of 8 h.

3-2.6 Plants for the production or concentration of heavy water, deuterium and deuterium compounds and equipment especially designed or prepared therefor;

***Introductory Note:***

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

*The GS process is based upon the exchange of hydrogen and deuterium between water and hydrogen sulphide within a series of towers which are operated with the top section cold and the bottom section hot. Water flows down the towers while the hydrogen sulphide gas circulates from the bottom to the top of the towers. A series of perforated trays are used to promote mixing between the gas and the water. Deuterium migrates to the water at low temperatures and to the hydrogen sulphide at high temperatures. Gas or water, enriched in deuterium, is removed from the first stage towers at the junction of the hot and cold sections and the process is repeated in subsequent, stage towers. The product of the last stage, water enriched up to 30% by weight in deuterium, is sent to a distillation unit to, produce reactor grade heavy water; i.e., 99.75% by weight deuterium oxide ($D_2O$).*

*The ammonia-hydrogen exchange process can extract deuterium from synthesis gas through contact with liquid ammonia ($NH_3$) in the presence of a catalyst. The synthesis gas is fed into exchange towers and to an ammonia converter. Inside the towers the gas flows from the bottom to the top while the liquid ammonia $NH_3$ flows from the top to the bottom. The deuterium is stripped from the hydrogen in the synthesis gas and concentrated in the $NH_3$. The $NH_3$ then flows into an ammonia cracker at the bottom of the tower while the gas flows into an ammonia converter at the top. Further enrichment takes place in subsequent stages and reactor grade heavy water is produced through final distillation. The synthesis gas feed can be provided by an ammonia plant that, in turn, can be constructed in association with a heavy water ammonia-hydrogen exchange plant. The ammonia-hydrogen exchange process can also use ordinary water as a feed source of deuterium.*

*Many of the key equipment items for heavy water production plants using GS or the ammonia-hydrogen exchange processes are common to several segments of the chemical and petroleum industries. This is particularly so for small plants using the GS process. However, few of the items are available off-the-shelf. The GS and ammonia hydrogen processes require the handling of large quantities of flammable, corrosive and toxic fluids at elevated pressures.*

*Accordingly, in establishing the design and operating standards for plants and equipment using these processes, careful attention to the materials selection and specifications is required to ensure long service life with high safety and reliability factors. The choice of scale is primarily a function of economics and need. Thus, most of the equipment items would be prepared according to the requirements of the customer.*

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

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

1. Water-hydrogen sulphide exchange towers

   Exchange towers with diameters of 1.5 m or greater and capable of operating at pressures greater than or equal to 2 MPa, especially designed or prepared for heavy water production utilising the water-hydrogen sulphide exchange process.

2. Blowers and compressors

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

3. Ammonia-hydrogen exchange towers

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

4. Tower internals and stage pumps

   Tower internals and stage pumps especially designed or prepared for towers for heavy water production utilising the ammonia-hydrogen exchange process. Tower internals include especially designed stage contactors which promote intimate gas/liquid contact. Stage pumps include especially designed submersible pumps for circulation of liquid $NH_3$ within a contacting stage internal to the stage towers.

5. $NH_3$ Crackers

   $NH_3$ crackers with operating pressures greater than or equal to 3 MPa especially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process.

6. Infrared absorption analyzers

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

7. Catalytic burners

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

8. Complete heavy water upgrade systems or columns therefor

   Complete heavy water upgrade systems, or columns therefor, especially designed or prepared for the upgrade of heavy water to reactor-grade deuterium concentration.

   ***Explanatory Note:***

   *These systems, which usually employ water distillation to separate heavy water from light water, are especially designed or prepared to produce reactor-grade heavy water (i.e., typically 99.75% by weight $D_2O$ deuterium oxide) from heavy water feedstock of lesser concentration.*

9. $NH_3$ synthesis converters or synthesis units

   $NH_3$ synthesis converters or synthesis units especially designed or prepared for heavy water production utilising the ammonia-hydrogen exchange process.

   ***Explanatory Note:***

   *These converters or units take synthesis gas (nitrogen and hydrogen) from an $NH_3$/hydrogen high-pressure exchange column (or columns), and the synthesized $NH_3$ is returned to the exchange column (or columns).*

3-2.7. Plants for the conversion of uranium and plutonium for use in the fabrication of fuel elements and the separation of uranium isotopes as defined in Items 3-2.4. and 3-2.5. respectively, and equipment especially designed or prepared therefor;

3-2.7.1. Plants for the conversion of uranium and equipment especially designed or prepared therefor

***Introductory Note:***

*Uranium conversion plants and systems may perform one or more transformations from one uranium chemical species to another, including: conversion of uranium ore concentrates to uranium trioxide ($UO_3$), conversion of $UO_3$ to uranium dioxide ($UO_2$), conversion of uranium oxides to uranium tetrafluoride ($UF_4$), $UF_6$, or $UCl_4$, conversion of $UF_4$ to $UF_6$, conversion of $UF_6$ to $UF_4$, conversion of $UF_4$ to uranium metal, and conversion of uranium fluorides to $UO_2$.*

*Many of the key equipment items for uranium conversion plants are common to several segments of the chemical process industry. For example, the types of equipment employed in these processes may include: furnaces, rotary kilns, fluidized bed reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. However, few of the items are available 'off-the-shelf', most would be prepared according to the requirements and specifications of the customer. In some instances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled hydrogen fluoride (HF), fluorine ($F_2$),chlorine trifluoride ($CIF_3$), and uranium fluorides) as well as nuclear criticality concerns. Finally, it should be noted that, in all of the uranium conversion processes, items of equipment which individually are not especially designed or prepared for uranium conversion can be assembled into systems which are especially designed or prepared for use in uranium conversion.*

1. Especially designed or prepared systems for the conversion of uranium ore concentrates to $UO_3$

   ***Explanatory Note:***

   *Conversion of uranium ore concentrates to $UO_3$ can be performed by first dissolving the ore in nitric acid and extracting purified uranyl nitrate ($UO_2(NO_3)_2$) using a solvent such as tributyl phosphate (TBP). Next, the uranyl nitrate is converted to $UO_3$ either by concentration and denitration or by neutralization with gaseous $NH_3$ to produce ammonium diuranate with subsequent filtering, drying, and calcining.*

2. Especially designed or prepared systems for the conversion of $UO_3$ to $UF_6$

   ***Explanatory Note:***

   *Conversion of $UO_3$ to $UF_6$ can be performed directly by fluorination. The process requires a source of $F_2$ or $CLF_3$ chlorine trifluoride.*

3. Especially designed or prepared systems for the conversion of $UO_3$ to $UO_2$

   ***Explanatory Note:***

   *Conversion of $UO_3$ to $UO_2$ can be performed through reduction of $UO_3$ with cracked gaseous $NH_3$ or hydrogen.*

4. Especially designed or prepared systems for the conversion of $UO_2$ to $UF_4$

   ***Explanatory Note:***

   *Conversion of $UO_2$ to $UF_4$ can be performed by reacting $UO_2$ with gaseous HF at 573-773 K (300-500 °C).*

5. Especially designed or prepared systems for the conversion of $UF_4$ to $UF_6$

   ***Explanatory Note:***

   *Conversion of $UF_4$ to $UF_6$ is performed by exothermic reaction with fluorine in a tower reactor. $UF_6$ is condensed from the hot effluent gases by passing the effluent stream through a cold trap cooled to 263 K (-10 °C). The process requires a source of gaseous $F_2$.*

6. Especially designed or prepared systems for the conversion of $UF_4$ to uranium metal

   ***Explanatory Note:***

   *Conversion of $UF_4$ to uranium metal is performed by reduction with magnesium (large batches) or calcium (small batches). The reaction is carried out at temperatures above the melting point of uranium (1,403 K (1,130 °C)).*

7. Especially designed or prepared systems for the conversion of $UF_6$ to $UO_2$

   ***Explanatory Note:***

   *Conversion of $UF_6$ to $UO_2$ can be performed by one of three processes. In the first, $UF_6$ is reduced and hydrolyzed to $UO_2$ using hydrogen and steam. In the second, $UF_6$ is hydrolyzed by solution in water, $NH_3$ is added to precipitate ammonium diuranate, and the diuranate is reduced to $UO_2$ with hydrogen at 1,093 K (820 °C). In the third process, gaseous $UF_6$, $CO_2$, and $NH_3$ are combined in water, precipitating ammonium uranyl carbonate. The ammonium uranyl carbonate is combined with steam and hydrogen at 773-873 K (500-600 °C) to yield $UO_2$. $UF_6$ to $UO_2$ conversion is often performed as the first stage of a fuel fabrication plant.*

8. Especially designed or prepared systems for the conversion of $UF_6$ to $UF_4$

   ***Explanatory Note:***

   *Conversion of $UF_6$ to $UF_4$ is performed by reduction with hydrogen.*

9. Especially designed or prepared systems for the conversion of $UO_2$ to $UCl_4$

***Explanatory Note:***

*Conversion of $UO_2$ to $UCl_4$ can be performed by one of two processes. In the first, $UO_2$ is reacted with carbon tetrachloride ($CCl_4$) at approximately 673 K (400 °C). In the second, $UO_2$ is reacted at approximately 973 K (700 °C) in the presence of carbon black (CAS 1333-86-4), carbon monoxide, and chlorine to yield $UCl_4$.*

3-2.7.2. Plants for the conversion of plutonium and equipment especially designed or prepared therefor

***Introductory Note:***

*Plutonium conversion plants and systems perform one or more transformations from one plutonium chemical species to another, including: conversion of plutonium nitrate (PuN) to plutonium dioxide ($PuO_2$), conversion of $PuO_2$ to plutonium tetrafluoride ($PuF_4$), and conversion of $PuF_4$ to plutonium metal. Plutonium conversion plants are usually associated with reprocessing facilities, but may also be associated with plutonium fuel fabrication facilities. Many of the key equipment items for plutonium conversion plants are common to several segments of the chemical process industry. For example, the types of equipment employed in these processes may include: furnaces, rotary kilns, fluidised bed reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. Hot cells, glove boxes and remote manipulators may also be required. However, few of the items are available off-the-shelf; most would be prepared according to the requirements and specifications of the customer. Particular care in designing for the special radiological, toxicity and criticality hazards associated with plutonium is essential.*

*In some instances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (e.g., HF). Finally, it should be noted that, for all plutonium conversion processes, items of equipment which individually are not especially designed or prepared for plutonium conversion can be assembled into systems which are especially designed or prepared for use in plutonium conversion.*

1. Especially designed or prepared systems for the conversion of plutonium nitrate to oxide

***Explanatory Note:***

*The main functions involved in this process are: process feed storage and adjustment, precipitation and solid/liquor separation, calcination, product handling, ventilation, waste management, and process control. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. In most reprocessing facilities, this process involves the conversion of PuN to $PuO_2$. Other processes can involve the precipitation of plutonium oxalate or plutonium peroxide.*

2. Especially designed or prepared systems for plutonium metal production

***Explanatory Note:***

*This process usually involves the fluorination of $PuO_2$, normally with highly corrosive HF, to produce plutonium fluoride which is subsequently reduced using high purity calcium metal to produce metallic plutonium and a calcium fluoride slag. The main functions involved in this process are fluorination (e.g., involving equipment fabricated or lined with a precious metal), metal reduction (e.g., employing ceramic crucibles), slag recovery, product handling, ventilation, waste management and process control. The process systems are, particularly adapted so as to avoid criticality and radiation effects and to minimise toxicity hazards. Other, processes include the fluorination of plutonium oxalate or plutonium peroxide followed by a reduction to metal.*

## 3-3. SOFTWARE

"Software" especially designed or modified for the "development", "production", or "use" of items specified in Group 3.

## 3-4. TECHNOLOGY

"Technology" according to the Nuclear Technology Note for the "development", "production", or "use" of items specified in Group 3.

# GROUP 4 – NUCLEAR-RELATED DUAL-USE LIST

*(All destinations. All destinations applies to all Group 4 Items.)*

***Note:***

*Terms in 'single quotations' are usually defined within each entry of the list.*

*Terms in "double quotations" are defined at the end of Group 4.*

***CANADIAN NUCLEAR SAFETY COMMISSION (CNSC) NOTE:***

*The export of nuclear and nuclear-related items is also controlled by the CNSC under the Nuclear Safety and Control Act (NSCA) and Regulations. Therefore, the export of nuclear and nuclear-related items, not listed in Group 4 or which meet the specific Group 4 decontrol notes may still require a license from the CNSC. Information on export licensing requirements under the NSCA may be obtained by contacting the CNSC.*

***GENERAL TECHNOLOGY NOTE:***

*The export of "technology" required for the "development", "production" or "use" of items controlled in Group 4, is controlled according to the provisions of Group 4. This "technology" remains under control even when applicable to non-controlled items.*

*The approval of items for export also authorizes the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance and repair of the items.*

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

***GENERAL SOFTWARE NOTE:***

*The transfer of "software" is controlled according to Group 4. The approval of any Group 4 item for export also authorises the export, or transfer, to the same end user of the minimum "software", excluding source code, required for the installation, operation, maintenance or repair of the item.*

***Note:***

*The General Software Note also authorises export of "software", excluding source code, intended to only correct defects (bug fixes) in a previously legally exported item, provided that the capability and/or performance of the item are not otherwise enhanced.*

***Note:***

*Controls on "software" transfers do not apply to "software" as follows:*

1. *Generally available to the public by being:*
   a. *Sold from stock at retail selling points, without restriction;* ***and***
   b. *Designed for installation by the user without further substantial support by the supplier;* ***or***
2. *"In the public domain".*

***PRINCIPAL ELEMENT GENERAL NOTE***

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

***Note:***

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

## 4-1. INDUSTRIAL EQUIPMENT

### 4-1.A Equipment, Assemblies and Components

1. High-density (lead glass or other) radiation shielding windows, having all of the following characteristics, and specially designed frames therefor:
   a. A 'cold area' greater than 0.09 $m^2$;
   b. A density greater than 3 $g/cm^3$; **and**
   c. A thickness of 100 mm or greater.

   ***Technical Note:***
   *In Item 4-1.A.1.a. the term 'cold area' means the viewing area of the window exposed to the lowest level of radiation in the design application.*

2. Radiation-hardened TV cameras, or lenses therefor, specially designed or rated as radiation hardened to withstand a total radiation dose greater than $5 \times 10^4$ Gy (silicon) without operational degradation.

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

3. 'Robots', 'end-effectors' and control units as follows:
   a. 'Robots' or 'end-effectors' having either of the following characteristics:
      1. Specially designed to comply with national safety standards applicable to handling high explosives (for example, meeting electrical code ratings for high explosives); **or**
      2. Specially designed or rated as radiation hardened to withstand a total radiation dose greater than $5 \times 10^4$ Gy (silicon) without operational degradation;

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

   b. Control units specially designed for any of the 'robots' or 'end-effectors' specified in Item 4-1.A.3.a.

   ***Note:***
   *Item 4-1.A.3. does not control 'robots' specially designed for non-nuclear industrial applications such as automobile paint-spraying booths.*

   ***Technical Notes:***
   *1. 'Robots'*
   *In Item 4-1.A.3. 'robot' means a manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use 'sensors', and has all of the following characteristics:*
   *a. is multifunctional;*
   *b. is capable of positioning or orienting material, parts, tools, or special devices through variable movements in three-dimensional space;*
   *c. incorporates three or more closed or open loop servo-devices which may include stepping motors;* ***and***
   *d. has 'user-accessible programmability' by means of teach/playback method or by means of an electronic computer which may be a programmable logic controller, i.e., without mechanical intervention.*

***N.B. 1:***

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

***N.B. 2:***

*In the above definition 'user-accessible programmability' means the facility allowing a user to insert, modify or replace "programs" by means other than:*

*a. a physical change in wiring or interconnections; or*

*b. the setting of function controls including entry of parameters.*

***N.B. 3:***

*The above definition does not include the following devices:*

*a. Manipulation mechanisms which are only manually/teleoperator controllable;*

*b. Fixed sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic, or electrical means;*

*c. Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by fixed, but adjustable, stops such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed "program" pattern. Variations or modifications of the "program" pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;*

*d. Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The "program" is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;*

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

*2. 'End-effectors'*

*In Item 4-1.A.3. 'end-effectors' are grippers, 'active tooling units', and any other tooling that is attached to the baseplate on the end of a 'robot' manipulator arm.*

***N.B.:***

*In the above definition 'active tooling units' is a device for applying motive power, process energy or sensing to the workpiece.*

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

   a. A capability of penetrating 0.6 m or more of hot cell wall (through-the-wall operation); **or**

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

***Technical Note:***

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

4-1.B. Test and Production Equipment

4-1.B.1. Flow-forming machines, spin-forming machines capable of flow-forming functions, and mandrels, as follows:

a. Machines having both of the following characteristics:

1. Three or more rollers (active or guiding); **and**
2. Which, according to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control;

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

***Note:***

*Item 4-1.B.1. includes machines which have only a single roller designed to deform metal plus two auxiliary rollers which support the mandrel, but do not participate directly in the deformation process.*

4-1.B.2. Machine tools, as follows, and any combination thereof, for removing or cutting metals, ceramics, or composites, which, according to the manufacturer's technical specifications, can be equipped with electronic devices for simultaneous "contouring control" in two or more axes:

***N.B.:***

*For "numerical control" units controlled by their associated "software", see Item 4-1.D.3.*

a. Machine tools for turning, that have "positioning accuracies" with all compensations available better (less) than 6 µm according to ISO 230/2 (1988) along any linear axis (overall positioning) for machines capable of machining diameters greater than 35 mm;

***Note:***

*Item 4-1.B.2.a. does not control bar machines (Swissturn), limited to machining only bar feed thru, if maximum bar diameter is equal to or less than 42 mm and there is no capability of mounting chucks. Machines may have drilling and/or milling capabilities for machining parts with diameters less than 42 mm.*

b. Machine tools for milling, having any of the following characteristics:

1. "Positioning accuracies" with all compensations available better (less) than 6 µm according to ISO 230/2 (1988) along any linear axis (overall positioning);
2. Two or more contouring rotary axes; **or**
3. Five or more axes which can be coordinated simultaneously for "contouring control".

***Note:***

*Item 4-1.B.2.b. does not control milling machines having both of the following characteristics:*

1. *X-axis travel greater than 2 m;* ***and***
2. *Overall "positioning accuracy" on the x-axis worse (more) than 30 µm according to ISO 230/2 (1988).*

c. Machine tools for grinding, having any of the following characteristics:

1. "Positioning accuracies" with all compensations available better (less) than 4 µm according to ISO 230/2 (1988) along any linear axis (overall positioning);
2. Two or more contouring rotary axes; **or**
3. Five or more axes which can be coordinated simultaneously for "contouring control".

***Note:***

*Item 4-1.B.2.c. does not control grinding machines as follows:*

1. *Cylindrical external, internal, and external-internal grinding machines having all the following characteristics:*
   a. *Limited to a maximum workpiece capacity of 150 mm outside diameter or length;* ***and***
   b. *Axes limited to x, z, and c.*
2. *Jig grinders that do not have a z-axis or a w-axis with an overall "positioning accuracy" less (better) than 4 µm according to ISO 230/2 (1988).*

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

***Notes:***

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

   *Stated "positioning accuracy" are to be derived as follows:*

   a. *Select five machines of a model to be evaluated;*
   b. *Measure the linear axis accuracies according to ISO 230/2 (1988);*
   c. *Determine the accuracy values (A) for each axis of each machine. The method of calculating the accuracy value is described in the ISO 230/2 (1988) standard;*
   d. *Determine the average accuracy value of each axis. This average value becomes the stated "positioning accuracy" of each axis for the model (Âx, Ây...);*
   e. *Since Item 4-1.B.2. refers to each linear axis, there will be as many stated "positioning accuracy" values as there are linear axes;*
   f. *If any axis of a machine tool not controlled by Items 4-1.B.2.a., 4-1.B.2.b., or 4-1.B.2.c. has a stated "positioning accuracy" of 6 µm or better (less) for grinding machines, and 8 µm or better (less) for milling and turning machines, both according to ISO 230/2 (1988), then the builder should be required to reaffirm the accuracy level once every eighteen months.*
2. *Item 4-1.B.2. does not control special purpose machine tools limited to the manufacture of any of the following parts;*
   a. *Gears;*
   b. *Crankshafts or cam shafts;*
   c. *Tools or cutters;*
   d. *Extruder worms.*

***Technical Notes:***

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

2. *Not counted in the total number of contouring axes are secondary parallel contouring axes (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centerline of which is parallel to the primary rotary axis).*
3. *Rotary axes do not necessarily have to rotate over 360 degrees. A rotary axis can be driven by a linear device, e.g., a screw or a rack-and-pinion.*
4. *For the purposes of 4-1.B.2. the number of axes which can be coordinated simultaneously for "contouring control" is the number of axes along or around which, during processing of the workpiece, simultaneous and interrelated motions are performed between the workpiece and a tool. This does not include any additional axes along or around which other relative motions within the machine are performed, such as:*
   a. *Wheel-dressing systems in grinding machines;*
   b. *Parallel rotary axes designed for mounting of separate workpieces;*
   c. *Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.*
5. *A machine tool having at least 2 of the 3 turning, milling, or grinding capabilities (e.g., a turning machine with milling capability) must be evaluated against each applicable entry, 4-1.B.2.a., 4-1.B.2.b. and 4-1.B.2.c.*
6. *Items 4-1.B.2.b.3. and 4-1.B.2.c.3. include machines based on a parallel linear kinematic design (e.g., hexapods) that have 5 or more axes none of which is a rotary axis.*

4-1.B.3. Dimensional inspection machines, instruments, or systems, as follows:

a. Computer controlled or numerically controlled coordinate measuring machines (CMM) having either of the following characteristics:
   1. Having only two axes, and having a maximum permissible error of length measurement along any axis (one dimensional), identified as any combination of $E_{0X\ MPE}$, $E_{0Y\ MPE}$ or $E_{0Z\ MPE}$, equal to or less (better) than (1.25 + L/1,000) µm (where L is the measured length in mm) at any point within the operating range of the machine (i.e., within the length of the axis), according to ISO 10360-2(2009); **or**
   2. Three or more axes and having a three dimensional (volumetric) maximum permissible error of length measurement ($E_{0,\ MPE}$ equal to or less (better) than (1.7 + L/800) µm (where L is the measured length in mm) at any point within the operating range of the machine (i.e., within the length of the axis), according to ISO 10360-2(2009).

      ***Technical Note:***

      *The $E_{0,\ MPE}$ of the most accurate configuration of the CMM specified according to ISO 10360-2(2009) by the manufacturer (e.g. best of the following: probe, stylus length, motion parameters, environment) and with all compensations available shall be compared to the 1.7 + L/800 µm threshold.*

b. Linear displacement measuring instruments, as follows:
   1. Non-contact type measuring systems with a "resolution" equal to or better (less) than 0.2 µm within a measuring range up to 0.2 mm;
   2. Linear variable differential transformer (LVDT) systems having both of the following characteristics:
      a. 1. "Linearity" equal to or less (better) than 0.1% measured from 0 to the full operating range, for LVDT's with an operating range up to 5 mm; **or**

2. "Linearity" equal to or less (better) than 0.1% measured from 0 to 5 mm for LVDTs with an operating range greater than 5 mm; **and**

b. Drift equal to or better (less) than 0.1% per day at a standard ambient test room temperature ±1 K (±1 °C);

3. Measuring systems having both of the following characteristics:

a. Containing a laser; **and**

b. Capable of maintaining for at least 12 h, over a temperature range of ±1 K (±1 °C) around a standard temperature and a standard pressure:

1. A "resolution" over their full scale of 0.1 µm or better; **and**
2. With a "measurement uncertainty" equal to or better (less) than (0.2 + L/2,000) µm (L is the measured length in mm);

***Note:***

*Item 4-1.B.3.b.3. does not control measuring interferometer systems, without closed or open loop feedback, containing a laser to measure slide movement errors of machine tools, dimensional inspection machines, or similar equipment.*

***Technical Note:***

*In item 4-1.B.3.b. 'linear displacement' means the change of distance between the measuring probe and the measured object.*

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

***Note:***

*Item 4-1.B.3.c. does not control optical instruments, such as autocollimators, using collimated light (e.g., laser light) to detect angular displacement of a mirror.*

d. Systems for simultaneous linear-angular inspection of hemishells, having both of the following characteristics:

1. "Measurement uncertainty" along any linear axis equal to or better (less) than 3.5 µm per 5 mm; **and**
2. "Angular position deviation" equal to or less than 0.02°.

***Notes:***

*1. Item 4-1.B.3. includes machine tools other than those specified by 4-1.B.2. that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function.*

*2. Machines described in Item 4-1.B.3. are controlled if they exceed the threshold specified anywhere within their operating range.*

***Technical Note:***

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

4-1.B.4. Controlled atmosphere (vacuum or inert gas) induction furnaces, and power supplies therefor, as follows:

a. Furnaces having all of the following characteristics:

1. Capable of operation at temperatures above 1,123 K (850 °C)
2. Induction coils 600 mm or less in diameter; **and**
3. Designed for power inputs of 5 kW or more;

***Note:***

*Item 4-1.B.4.a. does not control furnaces designed for the processing of semiconductor wafers.*

b. Power supplies, with a specified output power of 5 kW or more, specially designed for furnaces specified in Item 4-1.B.4.a.

4-1.B.5. 'Isostatic presses', and related equipment, as follows:

a. 'Isostatic presses' having both of the following characteristics:

1. Capable of achieving a maximum working pressure of 69 MPa or greater; **and**
2. A chamber cavity with an inside diameter in excess of 152 mm;

b. Dies, molds, and controls specially designed for the 'isostatic presses' specified in Item 4-1.B.5.a.

***Technical Notes:***

*1. In Item 4-1.B.5. 'Isostatic presses' means equipment capable of pressurising a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal pressure in all directions within the cavity upon a workpiece or material.*

*2. In Item 4-1.B.5. the inside chamber dimension is that of the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other.*

4-1.B.6. Vibration test systems, equipment, and components as follows:

a. Electrodynamic vibration test systems, having all of the following characteristics:

1. Employing feedback or closed loop control techniques and incorporating a digital control unit;
2. Capable of vibrating at 10 $g_0$ root mean square (RMS) or more between 20 and 2000 Hz; **and**
3. Capable of imparting forces of 50 kN or greater measured 'baretable';

b. Digital control units, combined with "software" specially designed for vibration testing, with a real-time bandwidth greater than 5 kHz and being designed for a system specified in Item 4-1.B.6.a.;

c. Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force of 50 kN or greater measured 'baretable', which are usable for the systems specified in Item 4-1.B.6.a.;

d. Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force of 50 kN or greater, measured 'baretable', which are usable for the systems specified in Item 4-1.B.6.a.

***Technical Note:***

*In Item 4-1.B.6. 'baretable' means a flat table, or surface, with no fixtures or fittings.*

4-1.B.7. Vacuum or other controlled atmosphere metallurgical melting and casting furnaces and related equipment, as follows:

a. Arc remelt furnaces, arc melt furnaces and arc melt and casting furnaces having both of the following characteristics:

1. Consumable electrode capacities between 1,000 and 20,000 $cm^3$; **and**
2. Capable of operating with melting temperatures above 1,973 K (1,700 °C);

b. Electron beam melting furnaces, plasma atomization furnaces and plasma melting furnaces, having both of the following characteristics:
   1. A power of 50 kW or greater; **and**
   2. Capable of operating with melting temperatures above 1,473 K (1,200 °C);

c. Computer control and monitoring systems specially configured for any of the furnaces specified in Item 4-1.B.7.a. or 4-1.B.7.b.

d. Plasma torches specially designed for the furnaces specified in 4-1.B.7.b. having both of the following characteristics:
   1. Operating at a power greater than 50 kW; **and**
   2. Capable of operating above 1,473 K (1,200 °C);

e. Electron beam guns specially designed for the furnaces specified in 4-1.B.7.b. operating at a power greater than 50 kW.

4-1.C. Materials

None

4-1.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in Item 4-1.A.3., 4-1.B.1., 4-1.B.3., 4-1.B.5., 4-1.B.6.a., 4-1.B.6.b., 4-1.B.6.d., or 4-1.B.7.

   ***Note:***
   *"Software" specially designed or modified for systems specified in Item 4-1.B.3.d. includes "software" for simultaneous measurements of wall thickness and contour.*

2. "Software" specially designed or modified for the "development", "production", or "use" of equipment specified in Item 4-1.B.2.

   ***Note:***
   *Item 4-1.D.2 does not control part programming "software" that generates "numerical control" command codes but does not allow direct use of equipment for machining various parts.*

3. "Software" for any combination of electronic devices or system enabling such a device or such devices to function as a "numerical control" unit for machine tools, that is capable of controlling five or more interpolating axes that can be coordinated simultaneously for "contouring control".

   ***Notes:***
   *1. "Software" is controlled whether exported separately or residing in a "numerical control" unit or any electronic device or system.*
   *2. Item 4-1.D.3. does not control "software" specially designed or modified by the manufacturers of the control unit or machine tool to operate a machine tool that is not specified in Item 4-1.B.2.*

4-1.E. Technology

1. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-1.A. through 4-1.D.

## 4-2. MATERIALS

4-2.A. Equipment, Assemblies and Components

1. Crucibles made of materials resistant to liquid actinide metals, as follows:
   a. Crucibles having both of the following characteristics:
      1. A volume of between 150 $cm^3$ (150 ml) and 8,000 $cm^3$ (8 l); **and**
      2. Made of or coated with any of the following materials, or combination of the following materials, having an overall impurity level of 2% or less by weight:
         a. Calcium fluoride ($CaF_2$);
         b. Calcium zirconate (metazirconate) ($CaZrO_3$);
         c. Cerium sulphide ($Ce_2S_3$);
         d. Erbium oxide (erbia) ($Er_2O_3$);
         e. Hafnium oxide (hafnia) ($HfO_2$);
         f. Magnesium oxide (MgO);
         g. Nitrided niobium-titanium-tungsten alloy (approximately 50% Nb, 30% Ti, 20% W);
         h. Yttrium oxide (yttria) ($Y_2O_3$); **or**
         i. Zirconium oxide (zirconia) ($ZrO_2$);
   b. Crucibles having both of the following characteristics:
      1. A volume of between 50 $cm^3$ (50 ml) and 2,000 $cm^3$ (2 l); **and**
      2. Made of or lined with tantalum, having a purity of 99.9% or greater by weight;
   c. Crucibles having all of the following characteristics:
      1. A volume of between 50 $cm^3$ (50 ml) and 2,000 $cm^3$ (2 l);
      2. Made of or lined with tantalum, having a purity of 98% or greater by weight; **and**
      3. Coated with tantalum carbide, nitride, boride, or any combination thereof.
2. Platinised catalysts specially designed or prepared for promoting the hydrogen isotope exchange reaction between hydrogen and water for the recovery of tritium from heavy water or for the production of heavy water.
3. Composite structures in the form of tubes having both of the following characteristics:
   a. An inside diameter of between 75 and 400 mm; **and**
   b. Made with any of the "fibrous or filamentary materials" specified in Item 4-2.C.7.a. or carbon prepreg materials specified in Item 4-2.C.7.c.
4. Target assemblies and components for the production of tritium as follows:
   a. Target assemblies made of or containing lithium enriched in the lithium-6 isotope specially designed for the production of tritium through irradiation, including insertion in a nuclear reactor;

b. Components specially designed for the target assemblies specified in Item 4-2.A.4.a.

***Technical Note:***

*Components specially designed for target assemblies for the production of tritium may include lithium pellets, tritium getters, and specially-coated cladding.*

4-2.B. Test and Production Equipment

1. Tritium facilities or plants, and equipment therefor, as follows:
   a. Facilities or plants for the production, recovery, extraction, concentration or handling of tritium;
   b. Equipment for tritium facilities or plants as follows:
      1. Hydrogen or helium refrigeration units capable of cooling to 23 K (-250 °C) or less, with heat removal capacity greater than 150 W;
      2. Hydrogen isotope storage or hydrogen isotope purification systems using metal hydrides as the storage or purification medium.
2. Lithium isotope separation facilities or plants and systems and equipment therefor, as follows:

   ***N.B.:***

   *Certain lithium isotope separation equipment and components for the plasma separation process (PSP) are also directly applicable to uranium isotope separation and are controlled under Group 3.*

   a. Facilities or plants for the separation of lithium isotopes;
   b. Equipment for the separation of lithium isotopes based on the lithium-mercury amalgam process, as follows:
      1. Packed liquid-liquid exchange columns specially designed for lithium amalgams;
      2. Mercury or lithium amalgam pumps;
      3. Lithium amalgam electrolysis cells;
      4. Evaporators for concentrated lithium hydroxide solution.
   c. Ion exchange systems specially designed for lithium isotope separation and specially designed component parts therefor;
   d. Chemical exchange systems (employing crown ethers, cryptands, or lariat ethers) specially designed for lithium isotope separation, and specially designed component parts therefor.

4-2.C. Materials

4-2.C.1. Aluminum alloys having both of the following characteristics:

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

***Technical Note:***

*In Item 4-2.C.1. the phrase ‘capable of’ encompasses aluminium alloys before or after heat treatment.*

4-2.C.2. Beryllium metal, alloys containing more than 50% beryllium by weight, beryllium compounds, manufactures thereof, and waste or scrap of any of the foregoing.

***Note:***

*Item 4-2.C.2. does not control the following:*

*a. Metal windows for X-ray machines or for bore-hole logging devices;*

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

*c. Beryl (silicate of beryllium and aluminum) in the form of emeralds or aquamarines.*

4-2.C.3. Bismuth having both of the following characteristics:

a. A purity of 99.99% or greater by weight; **and**

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

4-2.C.4. Boron enriched in the boron-10 ($^{10}B$) isotope to greater than its natural isotopic abundance, as follows: elemental boron, compounds, mixtures containing boron, manufactures thereof, waste or scrap of any of the foregoing.

***Note:***

*In Item 4-2.C.4. mixtures containing boron include boron loaded materials.*

***Technical Note:***

*The natural isotopic abundance of boron-10 is approximately 18.5 weight percent (20 atom percent).*

4-2.C.5. Calcium having both of the following characteristics:

a. Containing less than 1,000 ppm by weight of metallic impurities other than magnesium; **and**

b. Containing less than 10 ppm by weight of boron.

4-2.C.6. Chlorine trifluoride ($ClF_3$).

4-2.C.7. "Fibrous or filamentary materials", and prepregs, as follows:

a. Carbon or aramid "fibrous or filamentary materials" having either of the following characteristics:

1. A 'specific modulus' of 12.7 x $10^6$ m or greater; **or**

2. A 'specific tensile strength' of 23.5 x $10^4$ m or greater;

***Note:***

*Item 4-2.C.7.a. does not control aramid "fibrous or filamentary materials" having 0.25% or more by weight of an ester based fibre surface modifier.*

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

1. A 'specific modulus' of 3.18 x $10^6$ m or greater; **and**

2. A 'specific tensile strength' of 7.62 x $10^4$ m or greater;

c. Thermoset resin impregnated continuous "yarns", "rovings", "tows" or "tapes" with a width of 15 mm or less (prepregs), made from carbon or glass "fibrous or filamentary materials" specified in Item 4-2.C.7.a. or Item 4-2.C.7.b.

***Technical Note:***

*The resin forms the matrix of the composite.*

***Technical Notes:***

*1. In Item 4-2.C.7. 'Specific modulus' is the Young's modulus in $N/m^2$ divided by the specific weight in $N/m^3$ when measured at a temperature of 296 ± 2 K (23 ± 2 °C) and a relative humidity of 50 ± 5%.*

*2. In Item 4-2.C.7. 'Specific tensile strength' is the ultimate tensile strength in $N/m^2$ divided by the specific weight in $N/m^3$ when measured at a temperature of 296 ± 2 K (23 ± 2 °C) and a relative humidity of 50 ± 5%.*

4-2.C.8. Hafnium metal, alloys containing more than 60% hafnium by weight, hafnium compounds containing more than 60% hafnium by weight, manufactures thereof, and waste or scrap of any of the foregoing.

4-2.C.9. Lithium enriched in the lithium-6 ($^6Li$) isotope to greater than its natural isotopic abundance, and products or devices containing enriched lithium, as follows: elemental lithium, alloys, compounds, mixtures containing lithium, manufactures thereof, waste or scrap of any of the foregoing.

***Note:***

*Item 4-2.C.9. does not control thermoluminescent dosimeters.*

***Technical Note:***

*The natural isotopic abundance of lithium-6 is approximately 6.5 weight percent (7.5 atom percent).*

4-2.C.10. Magnesium having both of the following characteristics:

a. Containing less than 200 ppm by weight of metallic impurities other than calcium; **and**

b. Containing less than 10 ppm by weight of boron.

4-2.C.11. Maraging steel 'capable of' an ultimate tensile strength of 1,950 MPa or more at 293 K (20 °C).

***Note:***

*Item 4-2.C.11. does not control forms in which all linear dimensions are 75mm or less.*

***Technical Note:***

*In Item 4-2.C.11. the phrase 'capable of' encompasses maraging steel before or after heat treatment.*

4-2.C.12. Radium-226 ($^{226}Ra$), radium-226 alloys, radium-226 compounds, mixtures containing radium-226, manufactures thereof, and products or devices containing any of the foregoing.

***Note:***

*Item 4-2.C.12. does not control the following:*

*a. Medical applicators;*

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

4-2.C.13. Titanium alloys having both of the following characteristics:

a. 'Capable of' an ultimate tensile strength of 900 MPa or more at 293 K (20 °C); **and**

b. In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.

***Technical Note:***

*In Item 4-2.C.13 the phrase 'capable of' encompasses titanium alloys before or after heat treatment.*

4-2.C.14. Tungsten, tungsten carbide, and alloys containing more than 90% tungsten by weight, having both of the following characteristics:

a. In forms with a hollow cylindrical symmetry (including cylinder segments) with an inside diameter between 100 and 300 mm; **and**

b. A mass greater than 20 kg.

***Note:***

*Item 4-2.C.14. does not control manufactures specially designed as weights or gamma-ray collimators.*

4-2.C.15. Zirconium with a hafnium content of less than 1 part hafnium to 500 parts zirconium by weight, as follows: metal, alloys containing more than 50% zirconium by weight, compounds, manufactures thereof, waste or scrap of any of the foregoing.

***Note:***

*Item 4-2.C.15. does not control zirconium in the form of foil having a thickness of 0.10 mm or less.*

4-2.C.16. Nickel powder and porous nickel metal, as follows:

***N.B.:***

*For nickel powders which are especially prepared for the manufacture of gaseous diffusion barriers see Group 3, Item 3-2.5.3.*

a. Nickel powder having both of the following characteristics:
   1. A nickel purity content of 99.0% or greater by weight; **and**
   2. A mean particle size of less than 10 µm measured by the American Society for Testing Materials (ASTM) B330 standard;

b. Porous nickel metal produced from materials specified in Item 4-2.C.16.a.

***Technical Note:***

*Item 4-2.C.16.b. refers to porous metal formed by compacting and sintering the material in Item 4-2.C.16.a. to form a metal material with fine pores interconnected throughout the structure.*

***Note:***

*Item 4-2.C.16. does not control the following:*

*a. Filamentary nickel powders;*

*b. Single porous nickel metal sheets with an area of 1,000 $cm^2$ per sheet or less.*

4-2.C.17. Tritium, tritium compounds, mixtures containing tritium in which the ratio of tritium to hydrogen atoms exceeds 1 part in 1,000, and products or devices containing any of the foregoing.

***Note:***

*Item 4-2.C.17. does not control a product or device containing less than $1.48 \times 10^3$ GBq of tritium.*

4-2.C.18. Helium-3 ($^3$He), mixtures containing helium-3, and products or devices containing any of the foregoing.

***Note:***

*Item 4-2.C.18. does not control a product or device containing less than 1 g of helium-3.*

4-2.C.19. Radionuclides appropriate for making neutron sources based on alpha-n reaction:

Actinium-225($^{225}$Ac), Curium-244($^{244}$Cm), Polonium-209($^{209}$Po), Actinium-227($^{227}$Ac), Einsteinium-253($^{253}$Es), Polonium-210($^{210}$Po), Californium-253($^{253}$Cf), Einsteinium-254($^{254}$Es), Radium-223($^{223}$Ra), Curium-240($^{240}$Cm), Gadolinium-148($^{148}$Gd), Thorium-227($^{227}$Th), Curium-241($^{241}$Cm), Plutonium-236($^{236}$Pu), Thorium-228($^{228}$Th),

Curium-242($^{242}$Cm), Plutonium-238($^{238}$Pu), Uranium-230($^{230}$U), Curium-243($^{243}$Cm), Polonium-208($^{208}$Pu), Uranium-232($^{232}$U).

In the following forms:

a. Elemental;

b. Compounds having a total activity of 37 GBq per kg or greater;

c. Mixtures having a total activity of 37 GBq per kg or greater;

d. Products or devices containing any of the foregoing.

***Note:***

*Item 4-2.C.19. does not control a product or device containing less than 3.7 GBq of activity.*

4-2.C.20 Rhenium and alloys containing 90% by weight or more rhenium, and alloys of rhenium and tungsten containing 90% by weight or more of any combination of rhenium and tungsten, having both of the following characteristics:

a. In forms with a hollow cylindrical symmetry (including cylinder segments) with an inside diameter between 100 and 300 mm; **and**

b. A mass greater than 20 Kg.

4-2.D. Software

None

4-2.E. Technology

1. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-2.A. through 4-2.D.

## 4-3. URANIUM ISOTOPE SEPARATION EQUIPMENT AND COMPONENTS (OTHER THAN LISTED IN GROUP 3)

4-3.A. Equipment, Assemblies and Components

4-3.A.1. Frequency changers or generators, usable as a variable frequency or fixed frequency motor drive, having all of the following characteristics:

***N.B.:***

*1. Frequency changers and generators especially designed or prepared for the gas centrifuge process are controlled under Group 3, Item 3-2.5.1.*

*2. "Software" specially designed to enhance or release the performance of frequency changers or generators to meet the characteristics below is controlled in 4-3.D.2. and 4-3.D.3.*

a. Multiphase output providing a power of 40 VA or greater;

b. Operating at a frequency of 600 Hz or more; **and**

c. Frequency control better (less) than 0.2%.

***Notes:***

*1. Item 4-3.A.1 only controls frequency changers intended for specific industrial machinery and/or consumer goods (machine tools, vehicles, etc.) if the frequency changers can meet the characteristics above when removed, and subject to the Principal Element General Note.*

*2. For the purpose of export control, Global Affairs Canada will determine whether or not a particular frequency changer meets the characteristics above, taking into account hardware and software constraints.*

***Technical Note:***

1. *Frequency changers in Item 4-3.A.1. are also known as converters or inverters.*
2. *The characteristics specified in item 4-3.A.1. may be met by certain equipment marketed such as: Generators, Electronic Test Equipment, AC Power Supplies, Variable Speed Motor Drives, Variable speed Drives (VSD's), Variable Frequency Drives (VFD's), Adjustable Frequency Drives (AFD's), or Adjustable Speed Drives (ASD's).*

4-3.A.2. Lasers, laser amplifiers and oscillators as follows:

a. Copper vapour lasers having both of the following characteristics:
   1. Operating at wavelengths between 500 and 600 nm; **and**
   2. An average output power equal to or greater than 30 W;

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

c. Neodymium-doped (other than glass) lasers with an output wavelength between 1,000 and 1,100 nm having either of the following:
   1. Pulse-excited and Q-switched with a pulse duration equal to or greater than 1 ns, and having either of the following:
      a. A single-transverse mode output with an average output power greater than 40 W; **or**
      b. A multiple-transverse mode output with an average output power greater than 50 W; **or**
   2. Incorporating frequency doubling to give an output wavelength between 500 and 550 nm with an average output power of greater than 40 W;

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

e. Tunable pulsed dye laser amplifiers and oscillators having all of the following characteristics:
   1. Operating at wavelengths between 300 and 800 nm;
   2. An average output power greater than 30 W;
   3. A repetition rate greater than 1 kHz; **and**
   4. Pulse width less than 100 ns;

   ***Note:***

   *Item 4-3.A.2.e. does not control single mode oscillators.*

f. Alexandrite lasers having all of the following characteristics:
   1. Operating at wavelengths between 720 and 800 nm;
   2. A bandwidth of 0.005 nm or less;
   3. A repetition rate greater than 125 Hz; **and**
   4. An average output power greater than 30 W;

g. Pulsed carbon dioxide ($CO_2$) lasers having all of the following characteristics:
   1. Operating at wavelengths between 9,000 and 11,000 nm;
   2. A repetition rate greater than 250 Hz;
   3. An average output power greater than 500 W; **and**
   4. Pulse width of less than 200 ns;

   ***Note:***
   *Item 4-3.A.2.g. does not control the higher power (typically 1 to 5 kW) industrial $CO_2$ lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width greater than 200 ns.*

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

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

j. Pulsed carbon monoxide (CO) lasers having all of the following characteristics:
   1. Operating at wavelengths between 5,000 and 6,000 nm;
   2. A repetition rate greater than 250 Hz;
   3. An average output power greater than 200 W; **and**
   4. Pulse width of less than 200 ns.

   ***Note:***
   *Item 4-3.A.2.j. does not control the higher power (typically 1 to 5 kW) industrial CO lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width greater than 200 ns.*

4-3.A.3. Valves having all of the following characteristics:

a. A nominal size of 5 mm or greater;

b. Having a bellows seal; **and**

c. Wholly made of or lined with aluminium, aluminium alloy, nickel, or nickel alloy containing more than 60% nickel by weight.

***Technical Note:***
*For valves with different inlet and outlet diameter, the nominal size parameter in Item 4-3.A.3.a. refers to the smallest diameter.*

4-3.A.4. Superconducting solenoidal electromagnets having all of the following characteristics:

a. Capable of creating magnetic fields greater than 2 T;

b. A ratio of length to inner diameter greater than 2;

c. Inner diameter greater than 300 mm; **and**

d. Magnetic field uniform to better than 1% over the central 50% of the inner volume.

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

***N.B.:***

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

4-3.A.5. High-power direct current power supplies having both of the following characteristics:

a. Capable of continuously producing, over a time period of 8 h, 100 V or greater with current output of 500 A or greater; **and**

b. Current or voltage stability better than 0.1% over a time period of 8 h.

4-3.A.6. High-voltage direct current power supplies having both of the following characteristics:

a. Capable of continuously producing, over a time period of 8 h, 20 kV or greater with current output of 1 A or greater; **and**

b. Current or voltage stability better than 0.1% over a time period of 8 h.

4-3.A.7. All types of pressure transducers capable of measuring absolute pressures and having all of the following characteristics:

a. Pressure sensing elements made of or protected by aluminium, aluminium alloy, aluminum oxide (alumina or sapphire), nickel, nickel alloy with more than 60% nickel by weight, or fully fluorinated hydrocarbon polymers;

b. Seals, if any, essential for sealing the pressure sensing element, and in direct contact with the process medium, made of or protected by aluminium, aluminium alloy, aluminium oxide (alumina or sapphire), nickel, nickel alloys with more than 60% nickel by weight, or fully fluorinated hydrocarbon polymers; **and**

c. Having either of the following characteristics:

1. A full scale of less than 13 kPa and an "accuracy" of better than 1% of full scale; **or**
2. A full scale of 13 kPa or greater and an "accuracy" of better than 130 Pa, when measuring at 13 kPa.

***Technical Notes:***

*1. In Item 4-3.A.7. pressure transducers are devices that convert pressure measurements into a signal.*

*2. In Item 4-3.A.7. "accuracy" includes non-linearity, hysteresis and repeatability at ambient temperature.*

4-3.A.8. Vacuum pumps having all of the following characteristics:

a. Input throat size equal to or greater than 380 mm;

b. Pumping speed equal to or greater than 15 $m^3/s$; **and**

c. Capable of producing an ultimate vacuum better than 13.3 mPa.

***Technical Notes***

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

*2. The ultimate vacuum is determined at the input of the pump with the input of the pump blocked off.*

4-3.A.9. Bellows-sealed scroll-type compressors and bellows-sealed scroll-type vacuum pumps having all of the following characteristics:

a. Capable of an inlet volume flow rate of 50 $m^3/h$ or greater;

b. Capable of a pressure ratio of 2:1 or greater; **and**

c. Having all surfaces that come in contact with the process gas made from any of the following materials:

1. Aluminium or aluminium alloy;
2. Aluminium oxide;
3. Stainless steel;
4. Nickel or nickel alloy;
5. Phosphor bronze; **or**
6. Fluoropolymers.

***Technical Notes:***

*1. In a scroll compressor or vacuum pump, crescent-shaped pockets of gas are trapped between one or more pairs of intermeshed spiral vanes, or scrolls, one of which moves while the other remains stationary. The moving scroll orbits the stationary scroll, it does not rotate. As the moving scroll orbits the stationary scroll, the gas pockets diminish in size (i.e. they are compressed) as they move toward the outlet port of the machine.*

*2. In a bellows-sealed scroll compressor or vacuum pump, the process gas is totally isolated from the lubricated parts of the pump and from the external atmosphere by a metal bellows. One end of the bellows is attached to the moving scroll and the other end is attached to the stationary housing of the pump.*

*3. Flouropolymers include, but are not limited to , the following materials:*

*a. polytetrafluoroethylene (PTFE);*

*b. Fluorinated Ethylene Propylene (FEP);*

*c. Perfluoroalkoxy (PFA);*

*d. Polychlorotrifluoroethylene (PCTFE);* ***and***

*e. Vinylidene fluoridehexafluoropropylene copolymer.*

4-3.B. Test and Production Equipment

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

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

a. Rotor assembly equipment for assembly of gas centrifuge rotor tube sections, baffles, and end caps;

***Note:***

*Item 4-3.B.2.a. includes precision mandrels, clamps, and shrink fit machines.*

b. Rotor straightening equipment for alignment of gas centrifuge rotor tube sections to a common axis;

***Technical Note:***

*In Item 4-3.B.2.b. such equipment normally consists of precision measuring probes linked to a computer that subsequently controls the action of, for example, pneumatic rams used for aligning the rotor tube sections.*

c. Bellows-forming mandrels and dies for producing single-convolution bellows.

***Technical Note:***

*The bellows referred to in Item 4-3.B.2.c. have all of the following characteristics:*

*1. Inside diameter between 75 and 400 mm;*

*2. Length equal to or greater than 12.7 mm;*

3. *Single convolution depth greater than 2 mm;* ***and***
4. *Made of high-strength aluminium alloys, maraging steel, or high strength "fibrous or filamentary materials".*

3. Centrifugal multiplane balancing machines, fixed or portable, horizontal or vertical, as follows:
   a. Centrifugal balancing machines designed for balancing flexible rotors having a length of 600 mm or more and having all of the following characteristics:
      1. Swing or journal diameter greater than 75 mm;
      2. Mass capability of from 0.9 to 23 kg; **and**
      3. Capable of balancing speed of revolution greater than 5,000 rpm;
   b. Centrifugal balancing machines designed for balancing hollow cylindrical rotor components and having all of the following characteristics:
      1. Journal diameter greater than 75 mm;
      2. Mass capability of from 0.9 to 23 kg;
      3. A minimum achievable residual specific unbalance equal to or less than 10 g-mm/kg per plane; **and**
      4. Belt drive type.
4. Filament winding machines and related equipment, as follows:
   a. Filament winding machines having all of the following characteristics:
      1. Having motions for positioning, wrapping, and winding fibres coordinated and programmed in two or more axes;
      2. Specially designed to fabricate composite structures or laminates from "fibrous or filamentary materials"; **and**
      3. Capable of winding cylindrical tubes with an internal diameter between 75 and 650 mm and lengths of 300 mm or greater;
   b. Coordinating and programming controls for the filament winding machines specified in Item 4-3.B.4.a.;
   c. Precision mandrels for the filament winding machines specified in Item 4-3.B.4.a.
5. Electromagnetic isotope separators designed for, or equipped with, single or multiple ion sources capable of providing a total ion beam current of 50 mA or greater.

***Notes:***

1. *Item 4-3.B.5. includes separators capable of enriching stable isotopes as well as those for uranium.*

   ***N.B:***

   *A separator capable of separating the isotopes of lead with a one-mass unit difference is inherently capable of enriching the isotopes of uranium with a three-unit mass difference.*
2. *Item 4-3.B.5. includes separators with the ion sources and collectors both in the magnetic field and those configurations in which they are external to the field.*

***Technical Note:***

*A single 50 mA ion source cannot produce more than 3 g of separated highly enriched uranium (HEU) per year from natural abundance feed.*

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

***N.B.:***

*Mass spectrometers especially designed or prepared for analysing on-line samples of uranium hexafluoride ($UF_6$) are controlled, see Group 3.*

a. Inductively coupled plasma mass spectrometers (ICP/MS);
b. Glow discharge mass spectrometers (GDMS);
c. Thermal ionisation mass spectrometers (TIMS);
d. Electron bombardment mass spectrometers having both of the following features:
    1. A molecular beam inlet system that injects a collimated beam of analyte molecules into a region of the ion source where the molecules are ionised by an electron beam; **and**
    2. One or more cold traps that can be cooled to a temperature of 193 K (-80 °C) or less in order to trap analyte molecules that are not ionised by the electron beam;
e. Mass spectrometers equipped with a microfluorination ion source designed for actinides or actinide fluorides.

***Technical Notes:***

*1. Item 4-3.B.6.d. describes mass spectrometers that are typically used for isotopic analysis of $UF_6$ gas samples.*

*2. Electron bombardment mass spectrometers in item 4-3.B.6.d. are also known as electron impact mass spectrometers or electron ionisation mass spectrometers.*

*3. In item 4-3.B.6.d.2. a "cold trap" is a device that traps gas molecules by condensing or freezing them on cold surfaces. For the purposes of this entry, a closed-loop gaseous helium cryogenic vacuum pump is not a cold trap.*

4-3.C. Materials

None

4-3.D. Software

1. "Software" specially designed for the "use" of equipment specified in Items 4-3.A.1., 4-3.B.3. or 4-3.B.4.
2. "Software" or encryption keys/codes specially designed to enhance or release the performance characteristics of equipment not controlled in Item 4-3.A.1. so that it meets or exceeds the characteristics specified in Item 4-3.A.1.
3. "Software" specially designed to enhance or release the performance characteristics of equipment controlled in Item 4-3.A.1.

4-3.E. Technology

1. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-3.A. through 4-3.D.

## 4-4. HEAVY WATER PRODUCTION PLANT RELATED EQUIPMENT (OTHER THAN LISTED IN GROUP 3)

4-4.A. Equipment, Assemblies and Components

1. Specialised packings which may be used in separating heavy water from ordinary water, having both of the following characteristics:
   a. Made of phosphor bronze mesh chemically treated to improve wettability; **and**
   b. Designed to be used in vacuum distillation towers.
2. Pumps capable of circulating solutions of concentrated or dilute potassium amide catalyst in liquid ammonia ($KNH_2/NH_3$), having all of the following characteristics:
   a. Airtight (i.e., hermetically sealed);
   b. A capacity greater than 8.5 $m^3$/h; **and**
   c. Either of the following characteristics:
      1. For concentrated potassium amide solutions (1% or greater), an operating pressure of 1.5 to 60 MPa; **or**
      2. For dilute potassium amide solutions (less than 1%), an operating pressure of 20 to 60 MPa.
3. Turboexpanders or turboexpander-compressor sets having both of the following characteristics:
   a. Designed for operation with an outlet temperature of 35 K (-238 °C) or less; **and**
   b. Designed for a throughput of hydrogen gas of 1,000 kg/h or greater.

4-4.B. Test and Production Equipment

1. Not used since 2017
2. Hydrogen-cryogenic distillation columns having all of the following characteristics:
   a. Designed for operation at internal temperatures of 35 K (-238 °C) or less;
   b. Designed for operation at internal pressures of 0.5 to 5 MPa;
   c. Constructed of either:
      1. Stainless steel of the Society of Automotive Engineers International (SAE) 300 series with low sulphur content and with an austenitic ASTM (or equivalent standard) grain size number of 5 or greater; **or**
      2. Equivalent materials which are both cryogenic and hydrogen ($H_2$) compatible; **and**
   d. With internal diameters of 30 cm or greater and ‘effective lengths’ of 4 m or greater.

   ***Technical Note:***
   *The term ‘effective length’ means the active height of packing material in a packed-type column, or the active height of internal contractor plates in a plate-type column.*
3. Not used since 2013

4-4.C. Materials

None

4-4.D. Software

None

4-4.E. Technology

1. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-4.A. through 4-4.D.

## 4-5. TEST AND MEASUREMENT EQUIPMENT FOR THE DEVELOPMENT OF NUCLEAR EXPLOSIVE DEVICES

4-5.A. Equipment, Assemblies and Components

1. Photomultiplier tubes having both of the following characteristics:
   a. Photocathode area of greater than 20 $cm^2$; **and**
   b. Anode pulse rise time of less than 1 ns.

4-5.B. Test and Production Equipment

1. Flash X-ray generators or pulsed electron accelerators having either of the following sets of characteristics:
   a. 1. An accelerator peak electron energy of 500 keV or greater but less than 25 MeV; **and**
      2. With a figure of merit (K) of 0.25 or greater; **or**
   b. 1. An accelerator peak electron energy of 25 MeV or greater, **and**
      2. A peak power greater than 50 MW.

   ***Note:***

   *Item 4-5.B.1. does not control accelerators that are component parts of devices designed for purposes other than electron beam or X-ray radiation (electron microscopy, for example) nor those designed for medical purposes.*

   ***Technical Notes:***

   1. *The figure of merit K is defined as: $K=1.7 \times 10^3 V^{2.65}Q$. V is the peak electron energy in million electron volts. If the accelerator beam pulse duration is less than or equal to 1 µs, then Q is the total accelerated charge in Coulombs. If the accelerator beam pulse duration is greater than 1 µs then Q is the maximum accelerated charge in 1 µs. Q equals the integral of i with respect to t, over the lesser of 1 µs or the time duration of the beam pulse ($Q=\int idt$) where i is beam current in amperes and t is the time in seconds.*
   2. *Peak power = (peak potential in volts) x (peak beam current in amperes).*
   3. *In machines based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1 µs or the duration of the bunched beam packet resulting from one microwave modulator pulse.*
   4. *In machines based on microwave accelerating cavities, the peak beam current is the average current in the time duration of a bunched beam packet.*

2. High-velocity gun systems (propellant gas, coil, electromagnetic, and electrothermal types, and other advanced systems) capable of accelerating projectiles to 1.5 km/s or greater.

   ***Note:***

   *This item does not control guns specially designed for high-velocity weapon systems.*

3. High-speed cameras and imaging devices and components therefor, as follows:

***N.B.:***

*"Software" specially designed to enhance or release the performance of cameras or imaging devices to meet the characteristics below is controlled in 4-5.D.1. and 4-5.D.2.*

a. Streak cameras and specially designed components therefor, as follows:
   1. Streak cameras with writing speeds greater than 0.5 mm/µs;
   2. Electronic streak cameras capable of 50 ns or less time resolution;
   3. Streak tubes for cameras specified in Item 4-5.B.3.a.2;
   4. Plug-ins specially designed for use with streak cameras which have modular structures and that enable the performance specifications in 4-5.B.3.a.1 or 4-5.B.3.a.2.;
   5. Synchronizing electronics units, rotor assemblies consisting of turbines, mirrors and bearings specially designed for cameras specified in 4-5.B.3.a.1.

b. Framing cameras and specially designed components therefor as follows:
   1. Framing cameras with recording rates greater than 225,000 frames per second;
   2. Framing cameras capable of 50 ns or less frame exposure time;
   3. Framing tubes and solid-state imaging devices having a fast image gating (shutter) time of 50 ns or less specially designed for cameras specified in Item 4-5.B.3.b.1 or 4-5.B.3.b.2.;
   4. Plug-ins specially designed for use with framing cameras which have modular structures and that enable the performance specifications in 4-5.B.3.c.1. or 4-5.B.3.b.2.;
   5. Synchronizing electronics units, rotor assemblies consisting of turbines, mirrors and bearings specially designed for cameras specified in 4-5.B.3.b.1 or 4-5.B.3.b.2.

c. Solid-state or electron tube cameras and specially designed components therefor as follows:
   1. Solid-state or electron tube cameras with a fast image gating (shutter) time of 50 ns or less;
   2. Solid-state imaging devices and image intensifiers tubes having a fast image gating (shutter) time of 50 ns or less specially designed for cameras specified in 4-5.B.3.c.1.;
   3. Electro-optical shuttering devices (Kerr or Pockels cells) with a fast image gating (shutter) time of 50 ns or less;
   4. Plug-ins specially designed for use with cameras which have modular structures and that enable the performance specifications in 4-5.B.3.c.1.

***Technical Note:***

*High speed single frame cameras can be used alone to produce a single image of a dynamic event or several such cameras can be combined in a sequentially-triggered system to produce multiple images of an event.*

4. Not used since 2013
5. Specialised instrumentation for hydrodynamic experiments, as follows:
   a. Velocity interferometers for measuring velocities exceeding 1 km/s during time intervals of less than 10 µs;

***Note:***

*Item 4-5.B.5.a. includes velocity interferometers such as VISARs (Velocity Interferometer Systems for any reflector) and DLIs (Doppler Laser Interferometers) and PDV (Photonic Doppler Velocimeters) also known as Het-V (Heterodyne Velocimeters).*

b. Shock pressure gauges capable of measuring pressures greater than 10 GPa, including gauges made with manganin, ytterbium, and polyvinylidene fluoride (PVDF/polyvinyl difluoride ($PVF_2$));

c. Quartz pressure transducers for pressures greater than 10 GPa.

6. High-speed pulse generators, and pulse heads therefor, having both of the following characteristics:

   a. Output voltage greater than 6 V into a resistive load of less than 55 **Ω**; **and**

   b. 'Pulse transition time' less than 500 ps.

   ***Technical Note:***

   *1. In Item 4-5.B.6.b. 'pulse transition time' is defined as the time interval between 10% and 90% voltage amplitude.*

   *2. Pulse heads are impulse forming networks designed to accept a voltage step function and shape it into a variety of pulse forms that can include rectangular, triangular, step, impulse, exponential, or monocycle types. Pulse heads can be an integral part of the pulse generator, they can be a plug-in module to the device or they can be an externally connected device.*

7. High explosive containment vessels, chambers, containers and other similar containment devices designed for the testing of high explosives or explosive devices and having both of the following characteristics:

   a. Designed to fully contain an explosion equivalent to 2 kg of trinitrotoluene (TNT) or greater; **and**

   b. Having design elements or features enabling real time or delayed transfer of diagnostic or measurement information.

4-5.C. Materials

None

4-5.D. Software

1. "Software" or encryption keys/codes specially designed to enhance or release the performance characteristics of equipment not controlled in Item 4-5.B.3. so that it meets or exceeds the characteristics specified in Item 4-5.B.3.

2. "Software" or encryption keys/codes specially designed to enhance or release the performance characteristics of equipment controlled in Item 4-5.B.3.

4-5.E. Technology

"Technology" according to the General Technology Note for the "development", "production" or "use" of equipment, material or "software" specified in 4-5.A. through 4-5.D.

## 4-6. COMPONENTS FOR NUCLEAR EXPLOSIVE DEVICES

4-6.A. Equipment, Assemblies and Components

1. Detonators and multipoint initiation systems, as follows:

   a. Electrically driven explosive detonators, as follows:

      1. Exploding bridge (EB);

2. Exploding bridge wire (EBW);
3. Slapper;
4. Exploding foil initiators (EFI);

b. Arrangements using single or multiple detonators designed to nearly simultaneously initiate an explosive surface over an area greater than 5,000 $mm^2$ from a single firing signal with an initiation timing spread over the surface of less than 2.5 µs.

***Note:***

*Item 4-6.A.1. does not control detonators using only primary explosives, such as lead azide.*

***Technical Note:***

*In Item 4-6.A.1. the detonators of concern all utilise a small electrical conductor (bridge, bridge wire, or foil) that explosively vapourises when a fast, high-current electrical pulse is passed through it. In nonslapper types, the exploding conductor starts a chemical detonation in a contacting high-explosive material such as PETN (pentaerythritoltetranitrate). In slapper detonators, the explosive vapourisation of the electrical conductor drives a flyer or slapper across a gap, and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by magnetic force. The term exploding foil detonator may refer to either an EB or a slapper-type detonator. Also, the word initiator is sometimes used in place of the word detonator.*

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

a. Detonator firing sets (initiation systems, firesets), including electronically-charged, explosively-driven and optically-driven firing sets designed to drive multiple controlled detonators specified by Item 4-6.A.1. above;

b. Modular electrical pulse generators (pulsers) having all of the following characteristics:

1. Designed for portable, mobile, or ruggedised-use;
2. Capable of delivering their energy in less than 15 µs into loads of less than 40 Ω;
3. Having an output greater than 100 A;
4. No dimension greater than 30 cm;
5. Weight less than 30 kg; **and**
6. Specified to operate over an extended temperature range of 223 to 373 K (-50 ° to 100 °C) or specified as suitable for aerospace applications.

c. Micro-firing units having all of the following characteristics:

1. No dimension greater than 35 mm;
2. Voltage rating of equal to or greater than 1kV; **and**
3. Capacitance of equal to or greater than 100 nF.

***Note:***

*Optically driven firing sets include both those employing laser initiation and laser charging. Explosively-driven firing sets include both explosive ferroelectric and explosive ferromagnetic firing set types. Item 4-6.A.2.b. includes xenon flashlamp drivers.*

3. Switching devices as follows:
   a. Cold-cathode tubes, whether gas filled or not, operating similarly to a spark gap, having all of the following characteristics:
      1. Containing three or more electrodes;
      2. Anode peak voltage rating of 2.5 kV or more;
      3. Anode peak current rating of 100 A or more; **and**
      4. Anode delay time of 10 µs or less;

      ***Note:***
      *Item 4-6.A.3.a. includes gas krytron tubes and vacuum sprytron tubes.*
   b. Triggered spark-gaps having both of the following characteristics:
      1. Anode delay time of 15 µs or less; **and**
      2. Rated for a peak current of 500 A or more;
   c. Modules or assemblies with a fast switching function having all of the following characteristics:
      1. Anode peak voltage rating greater than 2 kV;
      2. Anode peak current rating of 500 A or more; **and**
      3. Turn-on time of 1 µs or less.
4. Pulse discharge capacitors having either of the following sets of characteristics:
   a. 1. Voltage rating greater than 1.4 kV;
      2. Energy storage greater than 10 J;
      3. Capacitance greater than 0.5 µF; **and**
      4. Series inductance less than 50 nH; **or**
   b. 1. Voltage rating greater than 750 V;
      2. Capacitance greater than 0.25 µF; **and**
      3. Series inductance less than 10 nH.
5. Neutron generator systems, including tubes, having both of the following characteristics:
   a. Designed for operation without an external vacuum system; **and**
   b. 1. Utilising electrostatic acceleration to induce a tritium-deuterium nuclear reaction; **or**
      2. Utilising acceleration to induce a deuterium-deuterium nuclear reaction and capable of an output of $3x10^9$ neutrons/s or greater.
6. Striplines to provide low inductance path to detonators with the following characteristics;
   a. Voltage rating greater than 2kV; **and**
   b. Inductance of less than 20 nH.

4-6.B. Test and Production Equipment

None

4-6.C. Materials

1. High explosive substances or mixtures, containing more than 2% by weight of any of the following:
   a. Cyclotetramethylenetetranitramine (HMX) (CAS 2691-41-0);
   b. Cyclotrimethylenetrinitramine (RDX) (CAS 121-82-4);
   c. Triaminotrinitrobenzene (TATB) (CAS 3058-38-6);

d. Aminodinitrobenzo-furoxan or 7 amino-4,6 nitrobenzofurazane-1-oxide (ADNBF) (CAS 97096-78-1);
e. 1,1-diamino-2,2-dinitroethylene (DADE or FOX7) (CAS 145250-81-3);
f. 2,4-dinitroimidazole (DNI) (CAS 5213-49-0);
g. Diaminoazoxyfurazan (DAAOF or DAAF) (CAS78644-89-0);
h. Diaminotrinitrobenzene (DATB) (CAS 1630-08-6);
i. Dinitroglycoluril (DNGU or DINGU) (CAS 55510-04-8);
j. 2,6-Bis (picrylamino)-3,5-dinitropyridine (PYX) (CAS 38082-89-2);
k. 3,3′-diamino-2,2′,4,4′,6,6′-hexanitrobiphenylor dipicramide (DIPAM) (CAS 17215-44-0);
l. Diaminoazofurazan (DAAzF) (CAS 78644-90-3);
m. 1,4,5,8-tetranitro-pyridazino[4,5-d] pyridazine (TNP) (CAS 229176-04-9);
n. Hexanitrostilbene (HNS) (CAS 20062-22-0); **or**
o. Any explosive with a crystal density greater than 1.8 g/cm$^3$ and having a detonation velocity greater than 8,000 m/s.

4-6.D. Software

None

4-6.E. Technology

1. “Technology” according to the General Technology Note for the “development”, “production” or “use” of equipment, material or “software” specified in 4-6.A. through 4-6.D.

## DEFINITIONS OF TERMS USED IN GROUPS 3 AND 4

"Accuracy"

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

"Angular position deviation"

The maximum difference between angular position and the actual, very accurately measured angular position after the workpiece mount of the table has been turned out of its initial position.

"Basic scientific research"

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

"Contouring control"

Two or more "numerically controlled" motions operating in accordance with instructions that specify the next required position and the required feed rates to that position. These feed rates are varied in relation to each other so that a desired contour is generated (Ref.: International Organization for Standardization (ISO) 2806 (1994) as amended).

"Development"

Is related to all phases prior to "production", such as: design, design research, design analysis, design concepts, assembly and testing of prototypes, pilot production schemes, design data, process of transforming design data into a product, configuration design, integration design, layouts.

"Fibrous or filamentary materials"

Means continuous 'filament', 'monofilaments', 'yarns', 'rovings', 'tows', or 'tapes'.

N.B.: *'Filament' or 'monofilament' is the smallest increment of fibre, usually several µm in diameter.*

*'Roving' is a bundle (typically 12-120) of approximately parallel 'strands'.*

*'Strand' is a bundle of 'filaments' (typically over 200) arranged approximately parallel.*

*'Tape' is a material constructed of interlaced or unidirectional 'filaments', 'strands', 'rovings', 'tows', or 'yarns', etc., usually preimpregnated with resin.*

*'Tow' is a bundle of 'filaments', usually approximately parallel.*

*'Yarn' is a bundle of twisted 'strands'.*

'Filament'

See "Fibrous or filamentary materials".

"In the public domain"

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

"Linearity"

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

"Measurement uncertainty"

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

"Microprogram"

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

"Monofilament"

See "Fibrous or filamentary materials".

"Numerical control"

The automatic control of a process performed by a device that makes use of numeric data usually introduced as the operation is in progress (Ref.: ISO 2382 (2015)).

"other elements"

All elements other than hydrogen, uranium and plutonium

"Positioning accuracy"

Of "numerically controlled" machine tools is to be determined and presented in accordance with Item 4-1.B.2., in conjunction with the requirements below:

a. Test conditions (ISO 230/2 (1988), paragraph 3):
    1. For 12 h before and during measurements, the machine tool and accuracy measuring equipment will be kept at the same ambient temperature. During the premeasurement time, the slides of the machine will be continuously cycled identically to the way they will be cycled during the accuracy measurements;
    2. The machine shall be equipped with any mechanical, electronic, or "software" compensation to be exported with the machine;
    3. Accuracy of measuring equipment for the measurements shall be at least four times more accurate than the expected machine tool accuracy;
    4. Power supply for slide drives shall be as follows:
        a. Line voltage variation shall not be greater than ±10% of nominal rated voltage;
        b. Frequency variation shall not be greater than ±2 Hz of normal frequency;
        c. Lineouts or interrupted service are not permitted.

b. Test program (paragraph 4):
    1. Feed rate (velocity of slides) during measurement shall be the rapid traverse rate;

<u>N.B.:</u> *In the case of machine tools which generate optical quality surfaces, the feed rate shall be equal to or less than 50 mm per minute;*

2. Measurements shall be made in an incremental manner from one limit of the axis travel to the other without returning to the starting position for each move to the target position;
3. Axes not being measured shall be retained at mid-travel during test of an axis.

c. Presentation of test results (paragraph 2): The results of the measurements must include:
   1. "Positioning accuracy" (A); **and**
   2. The mean reversal error (B).

"Production"

Means all production phases, such as: construction, production engineering, manufacture, integration, assembly (mounting), inspection, testing, and quality assurance.

"Program"

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

"Resolution"

The least increment of a measuring device; on digital instruments, the least significant bit. (Ref.: American National Standards Institute (ANSI) B-89.1.12)

'Roving'

See "Fibrous and filamentary materials".

"Software"

A collection of one or more "programs" or "microprograms" fixed in any tangible medium of expression.

'Strand'

See "Fibrous or filamentary materials".

'Tape'

See "Fibrous or filamentary materials".

"Technical assistance"

May take forms, such as: instruction, skills, training, working knowledge, consulting services.

*N.B.:* *"Technical assistance" may involve transfer of "technical data".*

"Technical data"

May take forms such as blueprints, plans, drawings, photoprints or negatives, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions, whether in written form or recorded on other media or devices such as disk, tape, read-only memories.

"Technology"

Specific information required for the "development", "production" or "use", of an item. This information may take the form of "technical data" or "technical assistance".

'Tow'

See "Fibrous and filamentary materials".

“Use”

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

‘Yarn’

See “Fibrous and filamentary materials”.

## ACRONYMS AND ABBREVIATIONS USED IN GROUPS 3 AND 4

**Note:** The International System of Units (SI) is used in Group 3 and Group 4. In all cases, the physical quantity defined in SI units should be considered the official recommended control value.

Commonly used abbreviations (and their prefixes denoting size) in Group 3 and Group 4 are as follows:

| | | |
|---|---|---|
| A | ampere(s) | Electric current |
| CAS | Chemical Abstracts Service | |
| °C | degree(s) Celsius | Temperature |
| cm | centimetre(s) | Length |
| $cm^2$ | square centimetre(s) | Area |
| $cm^3$ | cubic centimetre(s) | Volume |
| ° | degree(s) | Angle |
| g | gram(s) | Mass |
| $g_0$ | acceleration of gravity (9.80665 $m/s^2$) | Acceleration |
| GBq | gigabecquerel(s) | Activity (radioactive) |
| GPa | gigapascal(s) | Pressure |
| Gy | gray(s) | Absorbed ionising radiation |
| GHz | gigahertz | Frequency |
| H | henry(s) | Electrical inductance |
| h | hour(s) | Time |
| Hz | hertz | Frequency |
| J | joule(s) | Energy, work, heat |
| KeV | Kiloelectron volt(s) | Energy, electrical |
| kg | kilogram(s) | Mass |
| kHz | kilohertz | Frequency |
| kN | kilonewton(s) | Force |
| kj | kilojoule(s) | Energy, work, heat |
| kPa | kilopascal(s) | Pressure |
| kV | kilovolt(s) | Electrical potential |
| kW | kilowatt(s) | Power |
| K | kelvin | Thermodynamic temperature |
| l | litre(s) | Volume (liquids) |
| MeV | megaelectron volt(s) | Energy, electrical |
| m | metre(s) | Length |
| $m^2$ | square metre(s) | Area |
| $m^3$ | cubic metre(s) | Volume |

| | | |
|---|---|---|
| mA | milliamp(s) | Electric current |
| ml | millilitre(s) | Volume |
| mm | millimetre(s) | Length |
| mPa | millipascal(s) | Pressure |
| min | minute(s) | Time |
| MPa | megapascal(s) | Pressure |
| MW | megawatt(s) | Power |
| µF | microfarad(s) | Electrical capacitance |
| µm | micrometre(s) | Length |
| µs | microsecond(s) | Time |
| N | newton(s) | Force |
| nF | nanofarad(s) | Electrical capacitance |
| nH | nanohenry(s) | Electrical inductance |
| nm | nanometre(s) | Length |
| ns | nanosecond(s) | Time |
| Ω | ohm(s) | Electric resistance |
| Pa | pascal(s) | Pressure |
| ps | picosecond(s) | Time |
| rpm | revolution(s) per minute | Angular velocity |
| s | second(s) | Time |
| ″ | second(s) of arc | Angle |
| T | tesla(s) | Magnetic flux density |
| u | Atomic mass unit | Atomic mass |
| V | volt(s) | Electrical potential |
| W | Watt(s) | Power |

# GROUP 5 – MISCELLANEOUS GOODS AND TECHNOLOGY

## Forest Products

### 5101. Logs of all species of wood *(All destinations)*

### 5102. Pulpwood of all species of wood *(All destinations)*

### 5103. Blocks, bolts, blanks, boards and any other material or product of red cedar that is suitable for use in the manufacture of shakes or shingles. *(All destinations)*

### 5104. Softwood Lumber Products *(United States)*

1. Softwood lumber products, as described in Annex 1A to the Softwood Lumber Agreement Between the Government of Canada and the Government of the United States of America, signed on September 12, 2006, as it read on October 12, 2015, excluding those that are described in paragraphs 3 to 5 of that Annex 1A.
2. Paragraph 5 of that Annex 1A is to be read without reference to the requirement set out in item (e) of that paragraph.
3. The references to the Harmonized Tariff Schedule of the United States (HTSUS) tariff classifications in that Annex 1A are to be read as references to the corresponding Canadian tariff classifications set out in Annex 1B to the agreement referred to in subsection (1).
4. The references to “imported”, “importer” and “importation” in that Annex 1A are to be read as “exported”, “exporter” and “exportation”, respectively, and the reference to “importés” in the French version of that Annex 1B is to be read as “exportés”.

## Agriculture and Food Products

### 5201. Peanut Butter that is classified under tariff item No. 2008.11.10 in the list of Tariff Provisions set out in the schedule to the Customs Tariff. *(All destinations)*

### 5203. Sugar-containing Products *(United States)*

Sugar-containing products that are classified under subheadings 1701.91.54, 1704.90.74, 1806.20.75, 1806.20.95, 1806.90.55, 1901.90.56, 2101.10.54, 2101.20.54, 2106.90.78 and 2106.90.95 of *Harmonised Tariff Schedule of the United States* (1999) (United States International Trade Commission Pub. 2831, 19 U.S.C. § 1202 (1988)).

### 5204. Sugars, Syrups and Molasses *(United States and U.S. Foreign Trade Zones)*

Sugars, Syrups and Molasses that are classified under subheadings 1701.12.10, 1701.91.10, 1701.99.10, 1702.90.10, and 2106.90.44 of *Harmonised Tariff Schedule of the United States* (1995) (United States International Trade Commission Pub. 2831, 19 U.S.C. § 1202 (1988)).

### 5205. High-Sugar-containing Products *(EU country or other CETA beneficiary)*

High-sugar-containing products classified under subheadings ex 1302.20, ex 1806.10, ex 1806.20, ex 2101.12, ex 2101.20 and ex 2106.90 of Annex 5-A to Annex 5 of the Protocol on Rules of Origin and Origin Procedures of CETA (Annex 5-A), containing 65 percent or more by net weight of added cane or beet sugar classified under subheadings 1701.91 to 1701.99 of Annex 5-A, for export to an EU country or other CETA beneficiary that

(a) originate in Canada and comply with the product description and sufficient production criteria referred to in Table A.1 of Annex 5-A;

(b) contain cane or beet sugar that has been refined exclusively in Canada;
(c) are not included in another item in this List; and
(d) are eligible for tariff elimination in accordance with the schedules in Annex 2-A of CETA.

### 5206. Sugar Confectionery and Chocolate Preparations *(EU country or other CETA beneficiary)*

Sugar confectionery and chocolate preparations classified under headings and subheadings 17.04, 1806.31, 1806.32 and 1806.90 of Annex 5-A to Annex 5 of the Protocol on Rules of Origin and Origin Procedures of CETA (Annex 5-A) for export to an EU country or other CETA beneficiary that

(a) originate in Canada and comply with the product description and sufficient production criteria referred to in Table A.2 of Annex 5-A;
(b) are not included in another item in this List; and
(c) are eligible for tariff elimination in accordance with the schedules in Annex 2-A of CETA.

### 5207. Processed Foods *(EU country or other CETA beneficiary)*

Processed foods classified under headings and subheadings 19.01, ex 1902.11, ex 1902.19, ex 1902.20, ex 1902.30, 1904.10, 1904.20, 1904.90, 19.05, 2009.81, ex 2009.89, 2103.90, ex 2106.10 and ex 2106.90 of Annex 5-A to Annex 5 of the Protocol on Rules of Origin and Origin Procedures of CETA (Annex 5-A) for export to an EU country or other CETA beneficiary that

(a) originate in Canada and comply with the product description and sufficient production criteria referred to in Table A.3 of Annex 5-A;
(b) are not included in another item in this List; and
(c) are eligible for tariff elimination in accordance with the schedules in Annex 2-A of CETA.

### 5208. Dog and Cat Food *(EU country or other CETA beneficiary)*

Dog and cat food classified under subheadings 2309.10 and ex 2309.90 of Annex 5-A to Annex 5 of the Protocol on Rules of Origin and Origin Procedures of CETA (Annex 5-A) for export to an EU country or other CETA beneficiary that

(a) originates in Canada and complies with the product description and sufficient production criteria referred to in Table A.4 of Annex 5-A;
(b) is not included in another item in this List; and
(c) is eligible for tariff elimination in accordance with the schedules in Annex 2-A of CETA.

## Apparel Goods

### 5209. Apparel Goods *(EU country or other CETA beneficiary)*

Apparel goods classified under headings and subheadings 6102.30, 61.04, 6108.92, 61.14, 62.01 and 62.05 of Annex 5-A to Annex 5 of the Protocol on Rules of Origin and Origin Procedures of CETA (Annex 5-A) for export to an EU country or other CETA beneficiary that

(a) originate in Canada and comply with the product description and sufficient production criteria referred to in Table C.2 of Annex 5-A;
(b) are not included in another item in this List; and
(c) are eligible for tariff elimination in accordance with the schedules in Annex 2-A of CETA.

## Vehicles

### 5210. Vehicles *(EU country or other CETA beneficiary)*

Vehicles classified under subheadings 8703.21, 8703.22, 8703.23, 8703.24, 8703.31, 8703.32, 8703.33, 8703.80 and 8703.90 of the *Council Regulation (EEC) No 2658/87 of 23 July 1987 on the tariff and statistical nomenclature and on the Common Customs Tariff*, made by the European Union, for export to an EU country or other CETA beneficiary that

(a) originate in Canada and comply with the product description and sufficient production criteria referred to in Table D.1 of Annex 5-A to Annex 5 of the Protocol on Rules of Origin and Origin Procedures of CETA;

(b) are not included in another item in this List; and

(c) are eligible for tariff elimination in accordance with the schedules in Annex 2-A of CETA.

## Foreign Origin Goods and Technology

## United States Origin Goods and Technology

### 5400. United States Origin Goods and Technology

All goods and technology of United States origin, unless they are included elsewhere in this List, whether in bond or cleared by the Canada Border Services Agency, other than goods or technology that have been further processed or manufactured outside the United States so as to result in a substantial change in value, form or use of the goods or technology or in the production of new goods or technology.

*(All destinations other than the United States)*

## Goods and Technology in Transit

### 5401. Goods and Technology in Transit

1. All goods and technology that originate outside Canada that are included in this List, whether in bond or cleared by the Canada Border Services Agency, other than goods or technology that are in transit on a through journey on a billing that originates outside Canada if the billing
   a. indicates that the ultimate destination of the goods or technology is a country other than Canada; *(All destinations other than the United States)* **and**
   b. in the case of goods or technology that are shipped from the United States, is accompanied by a certified true copy of the United States *Shipper's Export Declaration*, and that Declaration does not contain terms which conflict with those of the billing and is presented to the Canada Border Services Agency. *(All destinations other than the United States)*

## Other Military and Strategic Goods and Technology

### 5501. Blinding Laser Weapons *(All destinations)*

Laser weapons that are specifically designed, as their sole combat function or as one of their combat functions, to cause permanent blindness to the naked eye or to the eye with corrective eyesight devices.

### 5502. Nuclear Fusion Reactors

1. Subject to sub-item 2., systems, equipment, material, components, software and technology for use in research, development, design, testing, demonstration, or training related to nuclear fusion or the construction and operation of a nuclear fusion reactor, including:

a. reactor assemblies incorporating toroidal and poloidal field coils;
b. independent electrical and magnet power supply systems;
c. high-power microwave radio frequency systems; **and**
d. feedback, control and data acquisition systems.

*(All destinations)*

2. This item does not apply to data:
   a. that is contained in published books or periodicals or that is otherwise available to the public; **or**
   b. that has been made available without restrictions on its further dissemination.

## 5503. Anti-personnel Mines *(All destinations)*

Anti-personnel mines as defined in section 2 of the *Anti-Personnel Mines Convention Implementation Act*.

## 5504. Strategic Goods and Technology

1. In this item the terms "development", "production", "software", "spacecraft", "technology" and "use" have the same meaning as in the "Definitions for Terms Used in Groups 1 and 2" of the Guide.
2. Strategic goods and technology as follows:
   a. goods and technology referred to in Group 1 of the Guide as follows:
      i. Global navigation satellite systems receiving equipment referred to in item 1-7.A.5. of the Guide, the associated software referred to in item 1-7.D. of the Guide, and the associated technology referred to in item 1-7.E. of the Guide; **and**
      ii. propulsion and space-related equipment referred to in items 1-9.A.4. to 1-9.A.11. of the Guide, the associated software referred to in item 1-9.D. of the Guide, and the associated technology referred to in item 1-9.E. of the Guide;
   b. subject to the General Software Note in Group 1 of the Guide, software that is specially designed or modified for the development or use of the goods or technology referred to in paragraphs d. to i.;
   c. subject to the General Technology Note in Group 1 of the Guide, technology that is specially designed or modified for the development or production of the goods or technology referred to in paragraphs d. to i.;
   d. payloads specially designed or modified for "spacecraft", and specially designed components therefor not controlled elsewhere by Group 1 of the Guide;
   e. ground control stations for telemetry, tracking and control of space launch vehicles or "spacecraft", and specially designed components therefor;
   f. chemiluminescent compounds specially designed or modified for military use, and specially designed components therefor;
   g. radiation-hardened microelectronic circuits that meet or exceed all of the following, and specially designed components therefor, namely:
      i. a total dose of $5 \times 10^5$ Rads (SI);
      ii. a dose rate upset of $5 \times 10^8$ Rads (SI)/s;
      iii. a neutron dose of $1 \times 10^{14}$ N/cm$^2$;
      iv. a single event upset of $1 \times 10^{-7}$ or less error/bit/day; **and**
      v. single event latch-up free and having a dose rate latch-up of $5 \times 10^8$ Rads (SI)/s or greater;

*(All destinations other than United States)*

h. nuclear weapons design and test equipment, as follows:

i. any article, material, equipment or device which is specially designed or modified for use in the design, development or fabrication of nuclear weapons or nuclear explosive devices;

*(All destinations)*

ii. any article, material, equipment or device which is specially designed or modified for use in the devising, carrying out or evaluating of nuclear weapons tests or other nuclear explosions;

*(All destinations)*

**and**

i. any other articles not specifically set out in paragraphs a. to h. or in Group 2 or Group 6 that are United States origin goods or technology, which have been determined under Parts 120 to 130 of Title 22 of the International Traffic in Arms Regulations of the Code of Federal Regulations (United States) as having substantial military applicability, and which have been specially designed or modified for military purposes.

*(All destinations other than United States)*

## 5505. Goods and Technology for Certain Uses (Catch-all)

1. Goods and technology whether or not included elsewhere on the List if their properties and any information made known to the exporter by any intermediary or final consignee or from any other source would lead a reasonable person to suspect that they will be used:
   a. in the development, production, handling, operation, maintenance, storage, detection, identification or dissemination of:
      i. chemical or biological weapons,
      ii. nuclear explosive or radiological dispersal devices, **or**
      iii. materials or equipment that could be used in such weapons or devices;
   b. in the development, production, handling, operation, maintenance or storage of:
      i. missiles or other systems capable of delivering chemical or biological weapons or nuclear explosive or radiological dispersal devices, **or**
      ii. materials or equipment that could be used in such missiles or systems; **or**
   c. in any facility used for any of the activities described in paragraphs a. and b.
2. Goods and technology whether or not included elsewhere on the List if the Minister has determined, on the basis of their properties and any additional information relating to such matters as their intended end-use or the identity or conduct of their intermediary or final consignees, that they are likely to be used in the activities or facilities referred to in subitem (1).
3. Subitem (1) applies to goods and technology intended for export to all destinations unless
   a. they are intended for end-use in Argentina, Australia, Austria, Belgium, Bulgaria, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Republic of Korea, Spain, Sweden, Switzerland, Turkey, Ukraine, the United Kingdom or the United States; **and**
   b. their intermediary consignees, if any, are located in those countries; **and**
   c. their final consignee is located in one of those countries.
4. Subitem (2) applies to goods and technology intended for export to all destinations.

# GROUP 6 – MISSILE TECHNOLOGY CONTROL REGIME LIST

***Note:***

*Terms in "double quotation marks" are defined terms. Refer to Definitions at the end of Group 6.*

***GENERAL TECHNOLOGY NOTE:***

*The transfer of "technology" directly associated with any goods controlled in Group 6 is controlled according to the provisions in each Item to the extent permitted by national legislation. The approval of any Group 6 item for export also authorizes the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance, or repair of the item.*

***Note:***

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

***GENERAL SOFTWARE NOTE:***

*Group 6 does not control "software" which is either:*

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

***Note:***

*The General Software Note only applies to general purpose, mass market "software".*

***GENERAL MINIMUM SOFTWARE NOTE:***

*The approval of any Group 6 item for export also authorizes the export, or transfer, to the same end user of the minimum "software", excluding source code, required for the installation, operation, maintenance or repair of the item in order to ensure the item's safe operation as originally intended.*

***Note:***

*The General Minimum Software Note also authorizes export of "software" intended to correct defects (bug fixes) in a previously legally exported item, provided that the capability and/or performance of the item are not otherwise enhanced.*

***CHEMICAL ABSTRACTS SERVICE (CAS) NUMBERS:***

*In some instances chemicals are listed by name and CAS number. Chemicals of the same structural formula (including hydrates) are controlled regardless of name or CAS number. CAS numbers are shown to assist in identifying whether a particular chemical or mixture is controlled, irrespective of nomenclature. CAS numbers cannot be used as unique identifiers because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.*

# CATEGORY I

## 6-1. COMPLETE DELIVERY SYSTEMS

*(All destinations applies to all 6-1 Items)*

6-1.A. Equipment, Assemblies and Components

1. Complete rocket systems (including ballistic missiles, space launch vehicles, and sounding rockets) capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km.
2. Complete unmanned aerial vehicle systems (including cruise missiles, target drones and reconnaissance drones) capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km.

6-1.B. Test and Production Equipment

1. "Production facilities" specially designed for the systems specified in 6-1.A.

6-1.C. Materials

None

6-1.D. Software

1. "Software" specially designed or modified for the "use" of "production facilities" specified in 6-1.B.
2. "Software" specially designed or modified to coordinate the function of more than one subsystem in systems specified in 6-1.A.

***Note :***

*For a manned aircraft converted to operate as an unmanned aerial vehicle specified in 6-1.A.2., Item 6-1.D.2. includes "software", as follows:*

*a. "Software" specially designed or modified to integrate the conversion equipment with the aircraft system functions;*

*b. "Software" specially designed or modified to operate the aircraft as an unmanned aerial vehicle.*

6-1.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-1.A., 6-1.B., or 6-1.D.

## 6-2. COMPLETE SUBSYSTEMS USABLE FOR COMPLETE DELIVERY SYSTEMS

*(All destinations applies to all 6-2 Items)*

6-2.A. Equipment, Assemblies and Components

1. Complete subsystems usable in the systems specified in 6-1.A., as follows:
   a. Individual rocket stages usable in the systems specified in 6-1.A.;
   b. Re-entry vehicles usable in the systems specified in 6-1.A., and, as follows, equipment designed or modified therefor, except as provided in the Note below 6-2.A.1. for those designed for non-weapon payloads:
      1. Heat shields, and components therefor, fabricated of ceramic or ablative materials;

2. Heat sinks and components therefor fabricated of light-weight, high heat capacity materials;
3. Electronic equipment specially designed for re-entry vehicles;

c. Rocket propulsion subsystems, usable in the systems specified in 6-1.A., as follows:
1. Solid propellant rocket motors or hybrid rocket motors having a total impulse capacity equal to or greater than 1.1 x $10^6$ Ns;
2. Liquid propellant rocket engines or gel propellant rocket motors integrated, or designed or modified to be integrated, into a liquid propellant or gel propellant propulsion system which has a total impulse capacity equal to or greater than 1.1 x $10^6$ Ns;

***Note:***

*Liquid propellant apogee engines or station-keeping engines specified in 6-2.A.1.c.2., designed or modified for use on satellites, may be treated as Category II, if the subsystem is exported subject to end-use statements and quantity limits appropriate for the excepted end-use stated above, when having a vacuum thrust not greater than 1kN.*

d. 'Guidance sets', usable in the systems specified in 6-1.A., capable of achieving system accuracy of 3.33% or less of the "range" (e.g., a 'CEP' of 10 km or less at a "range" of 300 km), except as provided in the Note below 6-2.A.1. for those designed for missiles with a "range" under 300 km or manned aircraft;

***Technical Notes:***

*1. A 'guidance set' integrates the process of measuring and computing a vehicle's position and velocity (i.e. navigation) with that of computing and sending commands to the vehicle's flight control systems to correct the trajectory.*

*2. 'CEP' (circle of equal probability) is a measure of accuracy, defined as the radius of the circle centred at the target, at a specific range, in which 50% of the payloads impact.*

e. Thrust vector control subsystems, usable in the systems specified in 6-1.A., except as provided in the Note below 6-2.A.1. for those designed for rocket systems that do not exceed the "range"/"payload" capability of systems specified in 6-1.A.;

***Technical Note:***

*6-2.A.1.e. includes the following methods of achieving thrust vector control:*

*a. Flexible nozzle;*

*b. Fluid or secondary gas injection;*

*c. Movable engine or nozzle;*

*d. Deflection of exhaust gas stream (jet vanes or probes);*

*e. Use of thrust tabs.*

f. Weapon or warhead safing, arming, fuzing, and firing mechanisms, usable in the systems specified in 6-1.A., except as provided in the Note below 6-2.A.1. for those designed for systems other than those specified in 6-1.A.

***Note:***

*The exceptions in 6-2.A.1.b., 6-2.A.1.d., 6-2.A.1.e. and 6-2.A.1.f. above may be treated as Category II if the subsystem is exported subject to end-use statements and quantity limits appropriate for the excepted end-use stated above.*

6-2.B. Test and Production Equipment

1. "Production facilities" specially designed for the subsystems specified in 6-2.A.
2. "Production equipment" specially designed for the subsystems specified in 6-2.A.

6-2.C. Materials

None

6-2.D. Software

1. "Software" specially designed or modified for the "use" of "production facilities" specified in 6-2.B.1.
2. "Software" specially designed or modified for the "use" of rocket motors or engines specified in 6-2.A.1.c.
3. "Software", specially designed or modified for the operation or maintenance of 'guidance sets' specified in 6-2.A.1.d.

   ***Note:***
   *6-2.D.3. includes "software", specially designed or modified to enhance the performance of ´guidance sets´ to achieve or exceed the accuracy specified in 6-2.A.1.d.*
4. "Software" specially designed or modified for the operation or maintenance of subsystems or equipment specified in 6-2.A.1.b.3.
5. "Software" specially designed or modified for the operation or maintenance of subsystems in 6-2.A.1.e.
6. "Software" specially designed or modified for the operation or maintenance of subsystems in 6-2.A.1.f.

   ***Note:***
   *Subject to end-use statements appropriate for the excepted end-use, "software" controlled by 6-2.D.2. to 6-2.D.6. may be treated as Category II as follows:*
   1. *Under 6-2.D.2. if specially designed or modified for liquid propellant apogee engines or station keeping engines, designed or modified for satellite applications as specified in the Note to 6-2.A.1.c.2.;*
   2. *Under 6-2.D.3. if designed for missiles with a "range" of under 300 km or manned aircraft;*
   3. *Under 6-2.D.4. if specially designed or modified for re-entry vehicles designed for non-weapon payloads;*
   4. *Under 6-2.D.5. if designed for rocket systems that do not exceed the "range"/"payload" capability of systems specified in 6-1.A.;*
   5. *Under 6-2.D.6. if designed for systems other than those specified in 6-1.A.*

6-2.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-2.A., 6-2.B. or 6-2.D.

# CATEGORY II

## 6-3. PROPULSION COMPONENTS AND EQUIPMENT

6-3.A. Equipment, Assemblies and Components

1. Turbojet and turbofan engines, as follows:

a. Engines having all of the following characteristics:
   1. ‘Maximum thrust value’ greater than 400 N (achieved un-installed) excluding civil certified engines with a ‘maximum thrust value’ greater than 8.89 kN (achieved un-installed);
   2. Specific fuel consumption of 0.15 kg $N^{-1}$ $h^{-1}$ or less (at maximum continuous power at sea level static conditions using the ICAO standard atmosphere);
   3. ‘Dry weight’ less than 750 kg; **and**
   4. ‘First-stage rotor diameter’ less than 1 m;

   ***Technical Notes:***
   1. *In 6-3.A.1.a.1., ‘maximum thrust value’ is the manufacturer’s demonstrated maximum thrust for the engine type un-installed at sea level static conditions using the ICAO standard atmosphere. The civil type certified thrust value will be equal to or less than the manufacturer’s demonstrated maximum thrust for the engine type.*
   2. *‘Dry weight’ is the weight of the engine without fluids (fuel, hydraulic fluid, oil, etc.) and does not include the nacelle (housing).*
   3. *‘First-stage rotor diameter’ is the diameter of the first rotating stage of the engine, whether a fan or compressor, measured at the leading edge of the blade tips.*

b. Engines designed or modified for systems specified in 6-1.A. or 6-19.A.2., regardless of thrust, specific fuel consumption, ‘dry weight’ or ‘first-stage motor diameter’.

***Note:***

*Governments may permit the export of engines specified in 6-3.A.1. as part of a manned aircraft or in quantities appropriate for replacement parts for a manned aircraft.*

2. Ramjet, scramjet, pulse jet, detonation, or ‘combined cycle’ engines, including devices to regulate combustion, and specially designed components therefor, usable in the systems specified in 6-1.A. or 6-19.A.2.

   ***Technical Notes:***
   1. *In Item 6-3.A.2., ‘combined cycle’ engine is the engine that employs two or more cycles of the following engine types: gas-turbine (turbojet, turboprop, turbofan and turboshaft), ramjet, scramjet, pulse jet, detonation or rocket motor or rocket engine (liquid/gel/solid-propellant and hybrid).*
   2. *In Item 6-3.A.2., detonation engines utilise detonation to produce a rise in effective pressure across the combustion chamber. Examples of detonation engines include pulse detonation engines, rotating detonation engines or continuous wave detonation engines.*

3. Rocket motor cases, ‘insulation’ components and nozzles for solid propellant or hybrid rocket motors usable in the subsystems specified in 6-2.A.1.c.1. or 6-20.A.1.b.1.

   ***Technical Note:***

   *In 6-3.A.3. ‘insulation’ intended to be applied to the components of a rocket motor, i.e. the case, nozzle inlets, case closures, includes cured or semi-cured compounded rubber components comprising sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps.*

   ***Note:***

   *Refer to 6-3.C.2. for ‘insulation’ material in bulk or sheet form.*

4. Staging mechanisms, separation mechanisms, and interstages therefor, usable in the systems specified in 6-1.A.

   ***Note:***
   *See also Item 6-11.A.5.*

   ***Technical Note:***
   *Staging and separation mechanisms specified in 6-3.A.4. may contain some of the following components:*
   *- Pyrotechnic bolts, nuts and shackles;*
   *- Ball locks;*
   *- Circular cutting devices;*
   *- Flexible linear shaped charges (FLSC).*

5. Liquid slurry and gel propellant (including oxidisers) control systems, and specially designed components therefor, usable in the systems specified in 6-1.A., designed or modified to operate in vibration environments greater than 10 g rms between 20 Hz and 2 kHz.

   ***Notes:***
   *1. The only servo valves, pumps and gas turbines specified in 6-3.A.5. are the following:*
      *a. Servo valves designed for flow rates equal to or greater than 24 litres per minute, at an absolute pressure equal to or greater than 7 MPa, that have an actuator response time of less than 100 ms;*
      *b. Pumps, for liquid propellants, with shaft speeds equal to or greater than 8,000 rpm at the maximum operating mode or with discharge pressures equal to or greater than 7 MPa.*
      *c. Gas turbines, for liquid propellant turbopumps, with shaft speeds equal to or greater than 8,000 rpm at the maximum operating mode.*
   *2. Governments may permit the export of systems and components specified in 6-3.A.5. as part of a satellite.*

6. Specially designed components for hybrid rocket motors specified in 6-2.A.1.c.1. and 6-20.A.1.b.1.

7. Radial ball bearings having all tolerances specified in accordance with ISO 492 Tolerance Class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or other national equivalents), or better and having all the following characteristics:
   a. An inner ring bore diameter between 12 and 50 mm;
   b. An outer ring outside diameter between 25 and 100 mm; **and**
   c. A width between 10 and 20 mm.

8. Liquid or gel propellant tanks specially designed for the propellants controlled in Item 6-4.C. or other liquid or gel propellants used in the systems specified in 6-1.A.1.

9. ‘Turboprop engine systems’ specially designed for the systems in 6-1.A.2. or 6-19.A.2., and specially designed components therefor, having a maximum power greater than 10 kW (achieved uninstalled at sea level static conditions using the ICAO standard atmosphere), excluding civil certified engines.

   ***Technical Note:***
   *For the purposes of Item 6-3.A.9., a ‘turboprop engine system’ incorporates all of the following:*
   *a. Turboshaft engine;* ***and***
   *b. Power transmission system to transfer the power to a propeller.*

10. Combustion chambers and nozzles for liquid propellant rocket engines or gel propellant rocket motors usable in the subsystems specified in 6-2.A.1.c.2. or 6-20.A.1.b.2.

6-3.B. Test and Production Equipment

1. "Production facilities" specially designed for equipment or materials specified in 6-3.A.1., 6-3.A.2., 6-3.A.3., 6-3.A.4., 6-3.A.5., 6-3.A.6., 6-3.A.8., 6-3.A.9., 6-3.A.10. or 6-3.C.
2. "Production equipment" specially designed for equipment or materials specified in 6-3.A.1., 6-3.A.2., 6-3.A.3., 6-3.A.4., 6-3.A.5., 6-3.A.6. 6-3.A.8., 6-3.A.9., 6-3.A.10. or 6-3.C.
3. Flow-forming machines, usable in the "production" of propulsion components and equipment (e.g. motor cases and interstages) for systems specified in 6-1.A., having all of the following, and specially designed components therefor:
   a. Equipped with, or according to the manufacturer's technical specification are capable of being equipped with, numerical control units or a computer control; **and**
   b. More than two axes which can be co-ordinated simultaneously for contouring control.

   ***Technical Note:***
   *Machines combining the function of spin-forming and flow-forming are, for the purpose of this item, regarded as flow-forming machines.*

6-3.C. Materials

1. 'Interior lining' usable for rocket motor cases in the subsystems specified in 6-2.A.1.c.1. or specially designed for subsystems specified in 6-20.A.1.b.1.

   ***Technical Note:***
   *In 6-3.C.1. 'interior lining' suited for the bond interface between the solid propellant and the case or insulating liner is usually a liquid polymer based dispersion of refractory or insulating materials e.g. carbon filled HTPB or other polymer with added curing agents to be sprayed or screeded over a case interior.*
2. 'Insulation' material in bulk form usable for rocket motor cases in the subsystems specified in 6-2.A.1.c.1. or specially designed for subsystems specified in 6-20.A.1.b.1.

   ***Technical Note:***
   *In 6-3.C.2. 'insulation' intended to be applied to the components of a rocket motor, i.e. the case, nozzle inlets, case closures, includes cured or semi-cured compounded rubber sheet stock containing an insulating or refractory material. It may also be incorporated as stress relief boots or flaps specified in 6-3.A.3.*

6-3.D. Software

1. "Software" specially designed or modified for the "use" of "production facilities" and flow-forming machines specified in 6-3.B.1. or 6-3.B.3.
2. "Software" specially designed or modified for the "use" of equipment specified in 6-3.A.1., 6-3.A.2., 6-3.A.4., 6-3.A.5., 6-3.A.6. or 6-3.A.9.

   ***Notes:***
   *1. Governments may permit the export of "software" specially designed or modified for the "use" of engines specified in 6-3.A.1. as part of a manned aircraft or as replacement "software" therefor.*

2. *Governments may permit the export of "software" specially designed or modified for the "use" of propellant control systems specified in 6-3.A.5. as part of a satellite or as replacement "software" therefor.*

3. "Software" specially designed or modified for the "development" of equipment specified in 6-3.A.2., 6-3.A.3. or 6-3.A.4.

6-3.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 6-3.A.1., 6-3.A.2., 6-3.A.3., 6-3.A.4., 6-3.A.5., 6-3.A.6., 6-3.A.8., 6-3.A.9., 6-3.A.10., 6-3.B., 6-3.C. or 6-3.D.

## 6-4. PROPELLANTS, CHEMICALS AND PROPELLANT PRODUCTION

6-4.A. Equipment, Assemblies and Components

None

6-4.B. Test and Production Equipment

1. "Production equipment", and specially designed components therefor, for the "production", handling or acceptance testing of liquid propellants or propellant constituents specified in 6-4.C.
2. "Production equipment", other than that described in 6-4.B.3., and specially designed components therefor, for the production, handling, mixing, curing, casting, pressing, machining, extruding or acceptance testing of solid propellants or propellant constituents specified in 6-4.C.
3. Equipment as follows, and specially designed components therefor:
   a. Batch mixers having all of the following:
      1. Designed or modified for mixing under vacuum in the range of zero to 13.326 kPa;
      2. Capable of controlling the temperature of the mixing chamber;
      3. A total volumetric capacity of 110 litres or more; **and**
      4. At least one 'mixing/kneading shaft' mounted off centre;

      ***Note:***
      *In Item 6-4.B.3.a.4. the term 'mixing/kneading shaft' does not refer to deagglomerators or knife-spindles.*
   b. Continuous mixers having any of the following:
      1. Designed or modified for mixing under vacuum in the range of zero to 13.326 kPa;
      2. Capable of controlling the temperature of the mixing chamber; **and**
      3. Any of the following:
         a. Two or more mixing/kneading shafts; **or**
         b. All of the following:
            1. A single rotating and oscillating shaft with kneading teeth/pins; **and**
            2. Kneading teeth/pins inside the casing of the mixing chamber;
   c. Fluid energy mills usable for grinding or milling substances specified in 6-4.C.;

d. Metal powder "production equipment" usable for the "production", in a controlled environment, of spherical, spheroidal or atomised materials specified in 6-4.C.2.c., 6-4.C.2.d. or 6-4.C.2.e.

***Note:***

*6-4.B.3.d. includes:*

*a. Plasma generators (high frequency arc-jet) usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;*

*b. Electroburst equipment usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;*

*c. Equipment usable for the "production" of spherical aluminium powders by powdering a melt in an inert medium (e.g. nitrogen).*

***Notes:***

*1. The only batch mixers, continuous mixers, usable for solid propellants or propellants constituents specified in 6-4.C., and fluid energy mills specified in 6-4.B., are those specified in 6-4.B.3.*

*2. Forms of metal powder "production equipment" not specified in 6-4.B.3.d. are to be evaluated in accordance with 6-4.B.2.*

6-4.C. Materials

***N.B.:***

*CAS numbers included in Item 6-4.C. are Technical Notes. For the use of CAS numbers in Group 6, see the Introduction section - Chemical Abstracts Service (CAS) Numbers Note.*

6-4.C.1. Composite and composite modified double base propellants.

6-4.C.2. Fuel substances as follows:

a. Hydrazine (*CAS 302-01-2*) with a concentration of more than 70%;

b. Hydrazine derivatives as follows:

1. Monomethylhydrazine (MMH) (*CAS 60-34-4*);
2. Unsymmetrical dimethylhydrazine (UDMH) (*CAS 57-14-7*);
3. Hydrazine mononitrate (*CAS 13464-97-6*);
4. Trimethylhydrazine (*CAS 1741-01-1*);
5. Tetramethylhydrazine (*CAS 6415-12-9*);
6. N,N diallylhydrazine (*CAS 5164-11-4*);
7. Allylhydrazine (*CAS 7422-78-8*);
8. Ethylene dihydrazine (*CAS 6068-98-0*);
9. Monomethylhydrazine dinitrate;
10. Unsymmetrical dimethylhydrazine nitrate;
11. Hydrazinium azide (*CAS 14546-44-2*);
12. 1,1-Dimethylhydrazinium azide (*CAS 227955-52-4*) / 1,2-Dimethylhydrazinium azide (*CAS 299177-50-7*);
13. Hydrazinium dinitrate (*CAS 13464-98-7*);
14. Diimido oxalic acid dihydrazine (*CAS 3457-37-2*);
15. 2-hydroxyethylhydrazine nitrate (HEHN);
16. Hydrazinium perchlorate (*CAS 27978-54-7*);
17. Hydrazinium diperchlorate (*CAS 13812-39-0*);
18. Methylhydrazine nitrate (MHN) (*CAS 29674-96-2*);

19. 1,1-Diethylhydrazine nitrate (DEHN) / 1,2-Diethylhydrazine nitrate (DEHN) (*CAS 363453-17-2*);
20. 3,6-dihydrazino tetrazine nitrate (DHTN);

***Technical Note:***

*3,6-dihydrazino tetrazine nitrate is also referred to as 1,4-dihydrazine nitrate.*

c. Spherical or spheroidal aluminium powder (*CAS 7429-90-5*) in particle size of less than 200 x $10^{-6}$ m (200 µm) and an aluminium content of 97% by weight or more, if at least 10% of the total weight is made up of particles of less than 63 µm, according to ISO 2591-1:1988 or national equivalents;

***Technical Note:***

*A particle size of 63 µm (ISO R-565) corresponds to 250 mesh (Tyler) or 230 mesh (ASTM standard E-11).*

d. Metal powders of any of the following: zirconium (*CAS 7440-67-7*), beryllium (*CAS 7440-41-7*), magnesium (*CAS 7439-95-4*) or alloys of these, if at least 90% of the total particles by particle volume or weight are made up of particles of less than 60µm (determined by measurement techniques such as using a sieve, laser diffraction or optical scanning), whether spherical, atomised, spheroidal, flaked or ground, consisting of 97% by weight or more of any of the above mentioned metals;

***Note:***

*In a multimodal particle distribution (e.g. mixtures of different grain sizes) in which one or more modes are controlled, the entire powder mixture is controlled.*

***Technical Note:***

*The natural content of hafnium (CAS 7440-58-6) in the zirconium (typically 2% to 7%) is counted with the zirconium.*

e. Metal powders of either boron (*CAS 7740-42-8*) or boron alloys with a boron content of 85% or more by weight, if at least 90% of the total particles by particle volume or weight are made up of particles of less than 60µm (determined by measurement techniques such as using a sieve, laser diffraction or optical scanning), whether spherical, atomised, spheroidal, flaked or ground;

***Note:***

*In a multimodal particle distribution (e.g. mixtures of different grain sizes) in which one or more modes are controlled, the entire powder mixture is controlled.*

f. High energy density materials, usable in the systems specified in 6-1.A. or 6-19.A., as follows:
   1. Mixed fuels that incorporate both solid and liquid fuels, such as boron slurry, having a mass- based energy density of 40 x $10^6$ J/kg or greater;
   2. Other high energy density fuels and fuel additives (e.g., cubane, ionic solutions, JP-10) having a volume-based energy density of 37.5 x $10^9$ J/$m^3$ or greater, measured at 20°C and one atmosphere (101.325 kPa) pressure.

      ***Note:***

      *Item 6-4.C.2.f.2. does not control fossil refined fuels and biofuels produced from vegetables, including fuels for engines certified for use in civil aviation, unless specifically formulated for systems specified in 6-1.A. or 6-19.A.*

g. Hydrazine replacement fuels as follows:

1. 2-Dimethylaminoethylazide (DMAZ) (*CAS 86147-04-8*).

6-4.C.3. Oxidisers/Fuels as follows:

Perchlorates, chlorates or chromates mixed with powdered metals or other high energy fuel components.

6-4.C.4. Oxidiser substances as follows:

a. Oxidiser substances usable in liquid propellant rocket engines as follows:
   1. Dinitrogen trioxide (*CAS 10544-73-7*);
   2. Nitrogen dioxide (*CAS 10102-44-0*)/dinitrogen tetroxide (*CAS 10544-72-6*);
   3. Dinitrogen pentoxide (*CAS 10102-03-1*);
   4. Mixed Oxides of Nitrogen (MON);

   ***Technical Note:***

   *Mixed Oxides of Nitrogen (MON) are solutions of Nitric Oxide (NO) in Dinitrogen Tetroxide/Nitrogen Dioxide ($N_2O_4/NO_2$) that can be used in missile systems. There are a range of compositions that can be denoted as MONi or MONij where i and j are integers representing the percentage of Nitric Oxide in the mixture (e.g. MON3 contains 3% Nitric Oxide, MON25 25% Nitric Oxide. An upper limit is MON40, 40% by weight).*

   5. Inhibited Red Fuming Nitric Acid (IRFNA) (*CAS 8007-58-7*);
   6. Compounds composed of fluorine and one or more of other halogens, oxygen or nitrogen;

      ***Note:***

      *Item 6-4.C.4.a.6. does not control Nitrogen Trifluoride ($NF_3$) (CAS 7783-54-2) in a gaseous state as it is not usable for missile applications.*

b. Oxidiser substances usable in solid propellant rocket motors as follows:
   1. Ammonium perchlorate (AP) (*CAS 7790-98-9*);
   2. Ammonium dinitramide (ADN) (*CAS 140456-78-6*);
   3. Nitro-amines (cyclotetramethylene - tetranitramine (HMX) (*CAS 2691-41-0*); cyclotrimethylene - trinitramine (RDX) (*CAS 121-82-4*));
   4. Hydrazinium nitroformate (HNF) (*CAS 20773-28-8*);
   5. 2,4,6,8,10,12-Hexanitrohexaazaisowurtzitane (CL-20) (*CAS 135285-90-4*).

6-4.C.5. Polymeric substances, as follows:

a. Carboxy - terminated polybutadiene (including carboxyl - terminated polybutadiene) (CTPB);
b. Hydroxy - terminated polybutadiene (including hydroxyl - terminated polybutadiene) (HTPB) (*CAS 69102-90-5*);
c. Glycidyl azide polymer (GAP), including hydroxyl - terminated GAP;
d. Polybutadiene - Acrylic Acid (PBAA);
e. Polybutadiene - Acrylic Acid - Acrylonitrile (PBAN) (*CAS 25265-19-4* / *CAS 68891-50-9*);
f. Polytetrahydrofuran polyethylene glycol (TPEG).

***Technical Note:***

*Polytetrahydrofuran polyethylene glycol (TPEG) is a block co-polymer of poly 1,4-Butanediol (CAS 110-63-4) and polyethylene glycol (PEG) (CAS 25322-68-3).*

g. Polyglycidyl nitrate (PGN or poly-GLYN) (*CAS 27814-48-8*).

6-4.C.6. Other propellant additives and agents as follows:

a. Bonding agents as follows:

1. Tris (1-(2-methyl)aziridinyl) phosphine oxide (MAPO) (*CAS 57-39-6*);
2. 1,1',1"-trimesoyl-tris(2-ethylaziridine) (HX-868, BITA) (*CAS 7722-73-8*);
3. Tepanol (HX-878), reaction product of tetraethlylene-pentamine, acrylonitrile and glycidol (*CAS 68412-46-4*);
4. Tepan (HX-879), reaction product of tetraethlylene-pentamine and acrylonitrile (*CAS 68412-45-3*);
5. Polyfunctional aziridine amides with isophthalic, trimesic, isocyanuric, or trimethyladipic backbone also having a 2-methyl or 2-ethyl aziridine group;

***Note:***

*Item 6-4.C.6.a.5. includes:*

*1. 1,1'-Isophthaloyl-bis(2-methylaziridine) (HX-752) (CAS 7652-64-4);*
*2. 2,4,6-tris(2-ethyl-1-aziridinyl)-1,3,5-triazine (HX-874) (CAS 18924-91-9);*
*3. 1,1'-trimethyladipoylbis(2-ethylaziridine) (HX-877) (CAS 71463-62-2).*

b. Curing reaction catalysts as follows:

Triphenyl bismuth (TPB) (*CAS 603-33-8*);

c. Burning rate modifiers as follows:

1. Carboranes, decaboranes, pentaboranes and derivatives thereof;
2. Ferrocene derivatives, as follows:
   a. Catocene (*CAS 37206-42-1*);
   b. Ethyl ferrocene (*CAS 1273-89-8*);
   c. n-Propyl ferrocene (*CAS 1273-92-3*) / iso-propyl ferrocene (*CAS 12126-81-7*);
   d. n-Butyl ferrocene (*CAS 31904-29-7*);
   e. Pentyl ferrocene (*CAS 1274-00-6*);
   f. Dicyclopentyl ferrocene (*CAS 125861-17-8*);
   g. Dicyclohexyl ferrocene;
   h. Diethyl ferrocene (*CAS 1273-97-8*);
   i. Dipropyl ferrocene;
   j. Dibutyl ferrocene (*CAS 1274-08-4*);
   k. Dihexyl ferrocene (*CAS 93894-59-8*);
   l. Acetyl ferrocene (*CAS 1271-55-2*) / 1,1'-diacetyl ferrocene (*CAS 1273-94-5*);
   m. Ferrocene carboxylic acid (*CAS 1271-42-7*) / 1,1'-Ferrocenedicarboxylic acid (*CAS 1293-87-4*);
   n. Butacene (*CAS 125856-62-4*);

o. Other ferrocene derivatives usable as rocket propellant burning rate modifiers;

***Note:***
*Item 6-4.C.6.c.2.o does not control ferrocene derivatives that contain a six carbon aromatic functional group attached to the ferrocene molecule.*

d. Esters and plasticisers as follows:
1. Triethylene glycol dinitrate (TEGDN) (*CAS 111-22-8*);
2. Trimethylolethane trinitrate (TMETN) (*CAS 3032-55-1*);
3. 1,2,4-butanetriol trinitrate (BTTN) (*CAS 6659-60-5*);
4. Diethylene glycol dinitrate (DEGDN) (*CAS 693-21-0*);
5. 4,5 diazidomethyl-2-methyl-1,2,3-triazole (iso- DAMTR);
6. Nitratoethylnitramine (NENA) based plasticisers, as follows:
   a. Methyl-NENA (*CAS 17096-47-8*);
   b. Ethyl-NENA (*CAS 85068-73-1*);
   c. Butyl-NENA (*CAS 82486-82-6*);
7. Dinitropropyl based plasticisers, as follows:
   a. Bis (2,2-dinitropropyl) acetal (BDNPA) (*CAS 5108-69-0*);
   b. Bis (2,2-dinitropropyl) formal (BDNPF) (*CAS 5917-61-3*);

e. Stabilisers as follows:
1. 2-Nitrodiphenylamine (*CAS 119-75-5*);
2. N-methyl-p-nitroaniline (*CAS 100-15-2*).

6-4.C.7. ‘Gel propellants’ specifically formulated for use in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

***Technical Note:***
*A ‘gel propellant’ is a fuel or oxidiser formulation using a gellant such as silicates, kaolin (clay), carbon or any polymeric gellant.*

***Technical Note:***
*Substance groupings in Item 6-4.C. (e.g. fuels, oxidisers, etc.) describe typical applications of propellant substances. A substance remains specified by Item 4.C. even when used in an application other than the typical one indicated by its grouping (e.g. hydrazinium perchlorate (CAS 27978-54-7) is grouped as a fuel but can also be used as an oxidiser).*

6-4.D. Software

1. “Software” specially designed or modified for the operation or maintenance of equipment specified in 6-4.B. for the “production” and handling of materials specified in 6-4.C.

6-4.E. Technology

1. “Technology”, in accordance with the General Technology Note, for the “development”, “production” or “use” of equipment or materials specified in 6-4.B. and 6-4.C.

## 6-5. RESERVED FOR FUTURE USE

## 6-6. PRODUCTION OF STRUCTURAL COMPOSITES, PYROLYTIC DEPOSITION AND DENSIFICATION, AND STRUCTURAL MATERIALS

6-6.A. Equipment, Assemblies and Components

1. Composite structures, laminates, and manufactures thereof, specially designed for use in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. and the subsystems specified in 6-2.A. or 6-20.A.
2. Resaturated pyrolised (i.e. carbon-carbon) components having all of the following:

   a. Designed for rocket systems; **and**

   b. Usable in the systems specified in 6-1.A. or 6-19.A.1.

6-6.B. Test and Production Equipment

1. Equipment for the "production" of structural composites, fibres, prepregs or preforms, usable in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2., as follows, and specially designed components, and accessories therefor:
   a. Filament winding machines or 'fibre/tow placement machines', of which the motions for positioning, wrapping and winding fibres can be co-ordinated and programmed in three or more axes, designed to fabricate composite structures or laminates from fibrous or filamentary materials, and co-ordinating and programming controls;
   b. 'Tape-laying machines' of which the motions for positioning and laying tape can be co-ordinated and programmed in two or more axes, designed for the manufacture of composite airframes and missile structures;

      ***Note:***

      *For the purposes of 6-6.B.1.a. and 6-6.B.1.b., the following definitions apply:*

      *1. A 'filament band' is a single continuous width of fully or partially resin-impregnated tape, tow, or fibre. Fully or partially resin-impregnated 'filament bands' include those coated with dry powder that tacks upon heating.*

      *2. 'Fibre/tow-placement machines' and 'tape-laying machines' are machines that perform similar processes that use computer-guided heads to lay one or several 'filament bands' onto a mold to create a part or a structure. These machines have the ability to cut and restart individual 'filament band' courses during the laying process.*

      *3. 'Fibre/tow-placement machines' have the ability to place one or more 'filament bands' having widths less than or equal to 25.4 mm. This refers to the minimum width of material the machine can place, regardless of the upper capability of the machine.*

      *4. 'Tape-laying machines' have the ability to place one or more 'filament bands' having widths less than or equal to 304.8 mm, but cannot place 'filaments bands' with a width equal to or less than 25.4 mm. This refers to the minimum width of material the machine can place, regardless of the upper capability of the machine.*

   c. Multi-directional, multi-dimensional weaving machines or interlacing machines, including adapters and modification kits for weaving, interlacing or braiding fibres to manufacture composite structures;

      ***Note:***

      *6-6.B.1.c. does not control textile machinery not modified for the end-uses stated.*

   d. Equipment designed or modified for the production of fibrous or filamentary materials as follows:
      1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, or polycarbosilane) including special provision to strain the fibre during heating;

2. Equipment for the vapour deposition of elements or compounds on heated filament substrates;
3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);

e. Equipment designed or modified for special fibre surface treatment or for producing prepregs and preforms, including rollers, tension stretchers, coating equipment, cutting equipment and clicker dies.

***Note:***

*Examples of components and accessories for the machines specified in 6-6.B.1. are moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.*

2. Nozzles specially designed for the processes referred to in 6-6.E.3.
3. Isostatic presses having all of the following characteristics:
   a. Maximum working pressure equal to or greater than 69 MPa;
   b. Designed to achieve and maintain a controlled thermal environment of 600° C or greater; **and**
   c. Possessing a chamber cavity with an inside diameter of 254 mm or greater.
4. Chemical vapour deposition furnaces designed or modified for the densification of carbon-carbon composites.
5. Equipment and process controls, other than those specified in 6-6.B.3. or 6-6.B.4., designed or modified for densification and pyrolysis of structural composite rocket nozzles and re-entry vehicle nose tips.

6-6.C. Materials

1. Resin impregnated fibre prepregs and metal coated fibre preforms, for the goods specified in 6-6.A.1., made either with organic matrix or metal matrix utilising fibrous or filamentary reinforcements having a specific tensile strength greater than $7.62 \times 10^4$ m and a specific modulus greater than $3.18 \times 10^6$ m.

   ***Note:***

   *The only resin impregnated fibre prepregs specified in 6-6.C.1. are those using resins with a glass transition temperature (Tg), after cure, exceeding 145° C as determined by ASTM D4065 or national equivalents.*

   ***Technical Notes:***

   *1. In Item 6-6.C.1. 'specific tensile strength' is the ultimate tensile strength in $N/m^2$ divided by the specific weight in $N/m^3$, measured at a temperature of (296 ± 2)K ((23 ± 2)° C) and a relative humidity of (50 ± 5)%.*

   *2. In Item 6-6.C.1. 'specific modulus' is the Young's modulus in $N/m^2$ divided by the specific weight in $N/m^3$, measured at a temperature of (296 ± 2)K ((23 ± 2)° C) and a relative humidity of (50 ± 5)%.*

2. Resaturated pyrolised (i.e. carbon-carbon) materials having all of the following:
   a. Designed for rocket systems; **and**
   b. Usable in the systems specified in 6-1.A. or 6-19.A.1.
3. Fine grain graphites with a bulk density of at least 1.72 g/cc measured at 15º C and having a grain size of $100 \times 10^{-6}$ m (100 µm) or less, usable for rocket nozzles and re-entry vehicle nose tips, which can be machined to any of the following products:

a. Cylinders having a diameter of 120 mm or greater and a length of 50 mm or greater;
b. Tubes having an inner diameter of 65 mm or greater and a wall thickness of 25 mm or greater and a length of 50 mm or greater; **or**
c. Blocks having a size of 120 mm x 120 mm x 50 mm or greater.

4. Pyrolytic or fibrous reinforced graphites usable for rocket nozzles and re-entry vehicle nose tips usable in systems specified in 6-1.A. or 6-19.A.1.
5. Ceramic composite materials (dielectric constant less than 6 at any frequency from 100 MHz to 100 GHz) for use in missile radomes usable in systems specified in 6-1.A. or 6-19.A.1.
6. High-temperature ceramic materials as follows:
   a. Bulk machinable silicon-carbide reinforced unfired ceramic usable for nose tips usable in systems specified in 6-1.A. or 6-19.A.1.;
   b. Reinforced silicon-carbide ceramic composites usable for nose tips, re-entry vehicles, nozzle flaps, usable in systems specified in 6-1.A. or 6-19.A.1.
   c. Bulk machinable ceramic composite materials consisting of an 'Ultra High Temperature Ceramic (UHTC)' matrix with a melting point equal to or greater than 3,000° C and reinforced with fibres or filaments, usable for missile components (such as nose-tips, re-entry vehicles, leading edges, jet vanes, control surfaces or rocket motor throat inserts) in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

***Note:***

*Item 6-6.C.6.c. does not control 'Ultra High Temperature Ceramic (UHTC)' materials in non-composite form.*

***Technical Note:***

*'Ultra High Temperature Ceramics (UHTC)' includes:*

1. *Titanium diboride (TiB2);*
2. *Zirconium diboride (ZrB2);*
3. *Niobium diboride (NbB2);*
4. *Hafnium diboride (HfB2);*
5. *Tantalum diboride (TaB2);*
6. *Titanium carbide (TiC);*
7. *Zirconium carbide (ZrC);*
8. *Niobium carbide (NbC);*
9. *Hafnium carbide (HfC);*
10. *Tantalum carbide (TaC).*

7. Materials for the fabrication of missile components in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2, as follows:
   a. Tungsten and alloys in particulate form with a tungsten content of 97% by weight or more and a particle size of 50 $x10^{-6}$ m (50 µm) or less;
   b. Molybdenum and alloys in particulate form with a molybdenum content of 97% by weight or more and a particle size of 50 $x10^{-6}$ m (50 µm) or less;
   c. Tungsten materials in the solid form having all of the following:
      1. Any of the following material compositions:
         a. Tungsten and alloys containing 97% by weight or more of tungsten;

b. Copper infiltrated tungsten containing 80% by weight or more of tungsten; **or**
c. Silver infiltrated tungsten containing 80% by weight or more of tungsten; **and**

2. Able to be machined to any of the following products:
   a. Cylinders having a diameter of 120 mm or greater and a length of 50 mm or greater;
   b. Tubes having an inner diameter of 65 mm or greater and a wall thickness of 25 mm or greater and a length of 50 mm or greater; **or**
   c. Blocks having a size of 120 mm x 120 mm x 50 mm or greater.

8. Maraging steels, usable in the systems specified in 6-1.A. or 6-19.A.1., having all of the following:
   a. Having an ultimate tensile strength, measured at 20° C, equal to or greater than:
      1. 0.9 GPa in the solution annealed stage; **or**
      2. 1.5 GPa in the precipitation hardened stage; **and**
   b. Any of the following forms:
      1. Sheet, plate or tubing with a wall or plate thickness equal to or less than 5.0 mm; **or**
      2. Tubular forms with a wall thickness equal to or less than 50 mm and having an inner diameter equal to or greater than 270 mm.

   ***Technical Note:***
   *Maraging steels are iron alloys:*
   *a. Generally characterised by high nickel, very low carbon content and use substitutional elements or precipitates to produce strengthening and age-hardening of the alloy;* ***and***
   *b. Subjected to heat treatment cycles to facilitate the martensitic transformation process (solution annealed stage) and subsequently age hardened (precipitation hardened stage).*

9. Titanium-stabilized duplex stainless steel (Ti-DSS) usable in the systems specified in 6-1.A. or 6-19.A.1. and having all of the following:
   a. Having all of the following characteristics:
      1. Containing 17.0 - 23.0% by weight of chromium and 4.5 - 7.0% by weight of nickel;
      2. Having a titanium content of greater than 0.10% by weight; **and**
      3. A ferritic-austenitic microstructure (also referred to as a two-phase microstructure) of which at least 10% by volume (according to ASTM E-1181-87 or national equivalents) is austenite; **and**
   b. Any of the following forms:
      1. Ingots or bars having a size of 100 mm or more in each dimension;
      2. Sheets having a width of 600 mm or more and a thickness of 3 mm or less; **or**
      3. Tubes having an outer diameter of 600 mm or more and a wall thickness of 3 mm or less.

6-6.D. Software

1. "Software" specially designed or modified for the operation or maintenance of equipment specified in 6-6.B.1.
2. "Software" specially designed or modified for the equipment specified in 6-6.B.3., 6-6.B.4. or 6-6.B.5.

6-6.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 6-6.A., 6-6.B., 6-6.C. or 6-6.D.
2. "Technical data" (including processing conditions) and procedures for the regulation of temperature, pressures or atmosphere in autoclaves or hydroclaves when used for the production of composites or partially processed composites, usable for equipment or materials specified in 6-6.A. or 6-6.C.
3. "Technology" for the "production" of pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1,300° C to 2,900° C temperature range at pressures of 130 Pa (1 mm Hg) to 20 kPa (150 mm Hg) including "technology" for the composition of precursor gases, flow-rates, and process control schedules and parameters.

## 6-7. RESERVED FOR FUTURE USE

## 6-8. RESERVED FOR FUTURE USE

## 6-9. INSTRUMENTATION, NAVIGATION AND DIRECTION FINDING

6-9.A. Equipment, Assemblies and Components

1. Integrated flight instrument systems which include gyrostabilisers or automatic pilots, designed or modified for use in the systems specified in 6-1.A., or 6-19.A.1. or 6-19.A.2. and specially designed components therefor.
2. Gyro-astro compasses and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, and specially designed components therefor.
3. Linear accelerometers, designed for use in inertial navigation systems or in guidance systems of all types, usable in the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2., having all of the following characteristics, and specially designed components therefor:
   a. 'Scale factor' 'repeatability' less (better) than 1,250 ppm; **and**
   b. 'Bias' 'repeatability' less (better) than 1,250 micro g.

   ***Note:***
   *Item 6-9.A.3. does not control accelerometers specially designed and developed as Measurement While Drilling (MWD) sensors for use in downhole well service operations.*

   ***Technical Notes:***
   1. *'Bias' is defined as the accelerometer output when no acceleration is applied.*
   2. *'Scale factor' is defined as the ratio of change in output to a change in the input.*
   3. *The measurement of 'bias' and 'scale factor' refers to one sigma standard deviation with respect to a fixed calibration over a period of one year.*

4. *'Repeatability' is defined according to IEEE Standard for Inertial Sensor Terminology 528-2001 in the Definitions section paragraph 2.214 titled repeatability (gyro, accelerometer) as follows:*

   *'The closeness of agreement among repeated measurements of the same variable under the same operating conditions when changes in conditions or non-operating periods occur between measurements.'*

4. All types of gyros usable in the systems specified in 6-1.A., 6-19.A.1 or 6-19.A.2., with a rated 'drift rate' 'stability' of less than 0.5 degrees (1 sigma or rms) per hour in a 1 g environment, and specially designed components therefor.

   ***Technical Notes:***

   1. *'Drift rate' is defined as the component of gyro output that is functionally independent of input rotation and is expressed as an angular rate. (IEEE STD 528-2001 paragraph 2.56)*
   2. *'Stability' is defined as a measure of the ability of a specific mechanism or performance coefficient to remain invariant when continuously exposed to a fixed operating condition. (This definition does not refer to dynamic or servo stability.) (IEEE STD 528-2001 paragraph 2.247)*

5. Accelerometers or gyros of any type, designed for use in inertial navigation systems or in guidance systems of all types, specified to function at acceleration levels greater than 100 g, and specially designed components therefor.

   ***Note:***

   *6-9.A.5. does not include accelerometers that are designed to measure vibration or shock.*

6. 'Inertial measurement equipment or systems' using accelerometers specified in 6-9.A.3. or 6-9.A.5. or gyros specified in 6-9.A.4. or 6-9.A.5., and specially designed components therefor.

   ***Note:***

   *Item 6-9.A.6. includes:*

   a. *Attitude and Heading Reference Systems (AHRSs);*
   b. *Gyrocompasses;*
   c. *Inertial Measurement Units (IMUs);*
   d. *Inertial Navigation Systems (INSs);*
   e. *Inertial Reference Systems (IRSs);*
   f. *Inertial Reference Units (IRUs).*

   ***Technical Note:***

   *'Inertial measurement equipment or systems' specified in Item 6-9.A.6. incorporate accelerometers or gyros to measure changes in velocity and orientation in order to determine or maintain heading or position without requiring an external reference once aligned.*

7. 'Integrated navigation systems', designed or modified for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. and capable of providing a navigational accuracy of 200 m CEP or less.

   ***Technical Note:***

   *An 'integrated navigation system' typically incorporates all of the following components:*

   a. *An inertial measurement device (e.g. an attitude and heading reference system, inertial reference unit, or inertial navigation system);*

*b. One or more external sensors used to update the position and/or velocity, either periodically or continuously throughout the flight (e.g. satellite navigation receiver, radar altimeter, and/or Doppler radar);* ***and***

*c. Integration hardware and software.*

***N.B.:***

*For integration "software", see Item 6-9.D.4.*

8. Three axis magnetic heading sensors having all of the following characteristics, and specially designed components therefor:
   a. Internal tilt compensation in pitch (+/-90 degrees) and roll (+/-180 degrees) axes;
   b. Azimuthal accuracy better (less) than 0.5 degrees rms at latitudes of +/-80 degrees, referenced to local magnetic field; **and**
   c. Designed or modified to be integrated with flight control and navigation systems.

***Note:***

*Flight control and navigation systems in Item 6-9.A.8. include gyrostabilisers, automatic pilots and inertial navigation systems.*

6-9.B. Test and Production Equipment

1. "Production equipment", and other test, calibration and alignment equipment, other than that described in 6-9.B.2., designed or modified to be used with equipment specified in 6-9.A.

***Note:***

*Equipment specified in 6-9.B.1. includes the following:*

*a. For laser gyro equipment, the following equipment used to characterise mirrors, having the threshold accuracy shown or better:*
   *1. Scatterometer (10 ppm);*
   *2. Reflectometer (50 ppm);*
   *3. Profilometer (5 Angstroms);*

*b. For other inertial equipment:*
   *1. Inertial Measurement Unit (IMU) Module Tester;*
   *2. IMU Platform Tester;*
   *3. IMU Stable Element Handling Fixture;*
   *4. IMU Platform Balance Fixture;*
   *5. Gyro Tuning Test Station;*
   *6. Gyro Dynamic Balance Station;*
   *7. Gyro Run-In/Motor Test Station;*
   *8. Gyro Evacuation and Filling Station;*
   *9. Centrifuge Fixture for Gyro Bearings;*
   *10. Accelerometer Axis Align Station;*
   *11. Accelerometer Test Station;*
   *12. Fibre Optic Gyro Coil Winding Machines.*

2. Equipment as follows:
   a. Balancing machines having all the following characteristics:
      1. Not capable of balancing rotors/assemblies having a mass greater than 3 kg;
      2. Capable of balancing rotors/assemblies at speeds greater than 12,500 rpm;

3. Capable of correcting unbalance in two planes or more; **and**
4. Capable of balancing to a residual specific unbalance of 0.2 g mm per kg of rotor mass;

b. Indicator heads (sometimes known as balancing instrumentation) designed or modified for use with machines specified in 6-9.B.2.a.;

c. Motion simulators/rate tables (equipment capable of simulating motion) having all of the following characteristics:
   1. Two or more axes;
   2. Designed or modified to incorporate sliprings or integrated non-contact devices capable of transferring electrical power, signal information, or both; **and**
   3. Having any of the following characteristics:
      a. For any single axis having all of the following:
         1. Capable of rates of 400 degrees/s or more, or 30 degrees/s or less; **and**
         2. A rate resolution equal to or less than 6 degrees/s and an accuracy equal to or less than 0.6 degrees/s;
      b. Having a worst-case rate stability equal to or better (less) than plus or minus 0.05% averaged over 10 degrees or more; **or**
      c. A positioning "accuracy" equal to or less (better) than 5 arc second;

d. Positioning tables (equipment capable of precise rotary positioning in any axes) having all of the following characteristics:
   1. Two or more axes; **and**
   2. A positioning "accuracy" equal to or less (better) than 5 arc second;

e. Centrifuges capable of imparting accelerations greater than 100 g and designed or modified to incorporate sliprings or integrated non-contact devices capable of transferring electrical power, signal information, or both.

***Notes:***

1. *The only balancing machines, indicator heads, motion simulators, rate tables, positioning tables and centrifuges specified in Item 6-9. are those specified in 6-9.B.2.*
2. *6-9.B.2.a. does not control balancing machines designed or modified for dental or other medical equipment.*
3. *6-9.B.2.c. and 6-9.B.2.d. do not control rotary tables designed or modified for machine tools or for medical equipment.*
4. *Rate tables not controlled by 6-9.B.2.c. and providing the characteristics of a positioning table are to be evaluated according to 6-9.B.2.d.*
5. *Equipment that has the characteristics specified in 6-9.B.2.d. which also meets the characteristics of 6-9.B.2.c. will be treated as equipment specified in 6-9.B.2.c.*
6. *Item 6-9.B.2.c. applies whether or not sliprings or integrated non-contact devices are fitted at the time of export.*
7. *Item 6-9.B.2.e. applies whether or not sliprings or integrated non-contact devices are fitted at the time of export.*

6-9.C. Materials

None

6-9.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-9.A. or 6-9.B.
2. Integration "software" for the equipment specified in 6-9.A.1.
3. Integration "software" specially designed for the equipment specified in 6-9.A.6.
4. Integration "software", designed or modified for the 'integrated navigation systems' specified in 6-9.A.7.

***Note:***
*A common form of integration "software" employs Kalman filtering.*

6-9.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-9.A., 6-9.B. or 6-9.D.

***Note:***
*Governments may permit the export of equipment or "software" specified in 6-9.A. or 6-9.D. as part of a manned aircraft, satellite, land vehicle, marine/submarine vessel or geophysical survey equipment or in quantities appropriate for replacement parts for such applications.*

## 6-10. FLIGHT CONTROL

6-10.A. Equipment, Assemblies and Components

1. Pneumatic, hydraulic, mechanical, electro-optical, or electromechanical flight control systems (including fly-by-wire and fly-by-light systems) designed or modified for the systems specified in 6-1.A.
2. Attitude control equipment designed or modified for the systems specified in 6-1.A.
3. Flight control servo valves designed or modified for the systems in 6-10.A.1. or 6-10.A.2., and designed or modified to operate in a vibration environment greater than 10 g rms between 20 Hz and 2 kHz.

***Notes:***

*1. Governments may permit the export of systems, equipment or valves specified in 6-10.A. as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.*

*2. For conversion of manned aircraft to operate as unmanned aerial vehicles specified in 6-1.A.2., Item 6-10.A. includes the systems, equipment and valves designed or modified to enable operation of manned aircraft as unmanned aerial vehicles.*

6-10.B. Test and Production Equipment

1. Test, calibration, and alignment equipment specially designed for equipment specified in 6-10.A.

6-10.C. Materials

None

6-10.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-10.A. or 6-10.B.

***Note:***

*Governments may permit the export of "software" specified in 6-10.D.1. as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.*

6-10.E. Technology

1. Design "technology" for integration of air vehicle fuselage, propulsion system and lifting control surfaces, designed or modified for the systems specified in 6-1.A.2. or 6-19.A.2., to optimise aerodynamic performance throughout the flight regime of an unmanned aerial vehicle.
2. Design "technology" for integration of the flight control, guidance, and propulsion data into a flight management system, designed or modified for the systems specified in 6-1.A.1. or 6-19.A.1., for optimisation of rocket system trajectory.
3. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-10.A., 6-10.B. or 6-10.D.

## 6-11. AVIONICS

6-11.A. Equipment, Assemblies and Components

1. Radar and laser radar systems, including altimeters, designed or modified for use in the systems specified in 6-1.A.

   ***Technical Note:***

   *Laser radar systems embody specialised transmission, scanning, receiving and signal processing techniques for utilisation of lasers for echo ranging, direction finding and discrimination of targets by location, radial speed and body reflection characteristics.*
2. Passive sensors for determining bearings to specific electromagnetic sources (direction finding equipment) or terrain characteristics, designed or modified for use in the systems specified in 6-1.A.
3. Receiving equipment for 'navigation satellite systems', having any of the following characteristics, and specially designed components therefor:
   a. Designed or modified for use in systems specified in 6-1.A.; **or**
   b. Designed or modified for airborne applications and having any of the following:
      1. Capable of providing navigation information at speeds in excess of 600 m/s;
      2. Employing decryption, designed or modified for military or governmental services, to gain access to a 'navigation satellite system' secure signal/data; **or**
      3. Being specially designed to employ anti-jam features (e.g. null steering antenna or electronically steerable antenna) to function in an environment of active or passive countermeasures.

         ***Note:***

         *6-11.A.3.b.2. and 6-11.A.3.b.3. do not control equipment designed for commercial, civil or 'Safety of Life' (e.g. data integrity, flight safety) 'navigation satellite system' services.*

***Technical Note:***

*In Item 6-11.A.3., 'navigation satellite system' includes Global Navigation Satellite Systems (GNSS; e.g. GPS, GLONASS, Galileo or BeiDou) and Regional Navigation Satellite Systems (RNSS; e.g. NavIC, QZSS).*

4. Electronic assemblies and components, designed or modified for use in the systems specified in 6-1.A. or 6-19.A. and specially designed for military use and operation at temperatures in excess of 125° C.

***Note:***

*1. Equipment specified in 6-11.A.1., 6-11.A.2., 6-11.A.3. and 6-11.A.4. includes the following:*

*a. Terrain contour mapping equipment;*

*b. Scene mapping and correlation (both digital and analogue) equipment;*

*c. Doppler navigation radar equipment;*

*d. Passive interferometer equipment;*

*e. Imaging sensor equipment (both active and passive).*

5. Umbilical and interstage electrical connectors specially designed for systems specified in 6-1.A.1. or 6-19.A.1.

***Technical Note:***

*Interstage connectors referred to in 6-11.A.5. also include electrical connectors installed between systems specified in 6-1.A.1. or 6-19.A.1. and their "payload".*

***Note:***

*Governments may permit the export of equipment specified in 6-11.A. as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft.*

6-11.B. Test and Production Equipment

None

6-11.C. Materials

None

6-11.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-11.A.1., 6-11.A.2. or 6-11.A.4.
2. "Software" specially designed for the "use" of equipment specified in 6-11.A.3.

6-11.E. Technology

1. Design "technology" for protection of avionics and electrical subsystems against Electromagnetic Pulse (EMP) and Electromagnetic Interference (EMI) hazards from external sources, as follows:
   a. Design "technology" for shielding systems;
   b. Design "technology" for the configuration of hardened electrical circuits and subsystems;
   c. Design "technology" for determination of hardening criteria for the above.
2. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-11.A. or 6-11.D.

## 6-12. LAUNCH SUPPORT

### 6-12.A. Equipment, Assemblies and Components

1. Apparatus and devices designed or modified for the handling, control, activation and launching of the systems specified in 6-1.A., 6-19.A.1., or 6-19.A.2.
2. Vehicles designed or modified for the transport, handling, control, activation and launching of the systems specified in 6-1.A.
3. Gravity meters (gravimeters) or gravity gradiometers, designed or modified for airborne or marine use, usable for systems specified in 6-1.A., as follows, and specially designed components therefor:
   a. Gravity meters having all of the following:
      1. A static or operational accuracy equal to or less (better) than 0.7 milligal (mgal); **and**
      2. A 'time to steady-state registration' of two minutes or less;

      ***Technical Note:***
      *In Item 6-12.A.3.a.2., 'time to steady-state registration' (also referred to as the gravity meter's response time) is the time over which the disturbing effects of platform-induced acceleration (high frequency noise) are reduced.*
   b. Gravity gradiometers.
4. Telemetry and telecontrol equipment, including ground equipment, designed or modified for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

   ***Notes:***
   *1. 6-12.A.4. does not control equipment designed or modified for manned aircraft or satellites.*
   *2. 6-12.A.4. does not control ground based equipment designed or modified for terrestrial or marine applications.*
   *3. 6-12.A.4. does not control equipment designed for commercial, civil or 'Safety of Life' (e.g., data integrity, flight safety) GNSS services.*
5. Precision tracking systems, usable for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. as follows:
   a. Tracking systems which use a code translator installed on the rocket or unmanned aerial vehicle in conjunction with either surface or airborne references or navigation satellite systems to provide real-time measurements of inflight position and velocity;
   b. Range instrumentation radars including associated optical/infrared trackers with all of the following capabilities:
      1. Angular resolution better than 1.5 mrad;
      2. Range of 30 km or greater with a range resolution better than 10 m rms; **and**
      3. Velocity resolution better than 3 m/s.
6. Thermal batteries designed or modified for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

   ***Note:***
   *Item 6-12.A.6. does not control thermal batteries specially designed for rocket systems or unmanned aerial vehicles that are not capable of a "range" equal to or greater than 300 km.*

***Technical Note:***

*Thermal batteries are single use batteries that contain a solid non-conducting inorganic salt as the electrolyte. These batteries incorporate a pyrolytic material that, when ignited, melts the electrolyte and activates the battery.*

6-12.B. Test and Production Equipment

None

6-12.C. Materials

None

6-12.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-12.A.1.
2. "Software" which processes post-flight, recorded data, enabling determination of vehicle position throughout its flight path, specially designed or modified for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.
3. "Software" specially designed or modified for the "use" of equipment specified in 6-12.A.4. or 6-12.A.5., usable for systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2.

6-12.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-12.A. or 6-12.D.

## 6-13. COMPUTERS

6-13.A. Equipment, Assemblies and Components

1. Analogue computers, digital computers or digital differential analysers, designed or modified for use in the systems specified in 6-1.A., having any of the following characteristics:
   a. Rated for continuous operation at temperatures from below -45° C to above +55° C; **or**
   b. Designed as ruggedised or "radiation hardened".

6-13.B. Test and Production Equipment

None

6-13.C. Materials

None

6-13.D. Software

None

6-13.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 6-13.A.

***Note:***

*Governments may permit the export of Item 6-13. equipment as part of a manned aircraft or satellite or in quantities appropriate for replacement parts for manned aircraft .*

## 6-14. ANALOGUE TO DIGITAL CONVERTERS

6-14.A. Equipment, Assemblies and Components

1. Analogue-to-digital converters, usable in the systems specified in 6-1.A., having any of the following characteristics:
   a. Designed to meet military specifications for ruggedised equipment; **or**
   b. Designed or modified for military use and being any of the following types:
      1. Analogue-to-digital converter "microcircuits", which are "radiation-hardened" or have all of the following characteristics:
         a. Rated for operation in the temperature range from below -54° C to above +125° C; **and**
         b. Hermetically sealed; **or**
      2. Electrical input type analogue-to-digital converter printed circuit boards or modules, having all of the following characteristics:
         a. Rated for operation in the temperature range from below -45° C to above +80° C; **and**
         b. Incorporating "microcircuits" specified in 6-14.A.1.b.1.

6-14.B. Test and Production Equipment

None

6-14.C. Materials

None

6-14.D. Software

None

6-14.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 6-14.A.

## 6-15. TEST FACILITIES AND EQUIPMENT

6-15.A. Equipment, Assemblies and Components

None

6-15.B. Test and Production Equipment

1. Vibration test equipment, usable for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. or the subsystems specified in 6-2.A. or 6-20.A., and components therefor, as follows:
   a. Vibration test systems employing feedback or closed loop techniques and incorporating a digital controller, capable of vibrating a system at an acceleration equal to or greater than 10 g rms between 20 Hz and 2 kHz while imparting forces equal to or greater than 50 kN, measured 'bare table';
   b. Digital controllers, combined with specially designed vibration test "software", with a 'real-time control bandwidth' greater than 5 kHz and designed for use with vibration test systems specified in 6-15.B.1.a.;

***Technical Note:***

*'Real-time control bandwidth' is defined as the maximum rate at which a controller can execute complete cycles of sampling, processing data and transmitting control signals.*

c. Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force equal to or greater than 50 kN, measured 'bare table', and usable in vibration test systems specified in 6-15.B.1.a.;

d. Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force equal to or greater than 50 kN, measured 'bare table', and usable in vibration test systems specified in 6-15.B.1.a.

***Technical Note:***

*Vibration test systems incorporating a digital controller are those systems, the functions of which are, partly or entirely, automatically controlled by stored and digitally coded electrical signals.*

2. 'Aerodynamic test facilities' for speeds of Mach 0.9 or more, usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A. or 6-20.A.

***Note:***

*Item 6-15.B.2 does not control wind tunnels for speeds of Mach 3 or less with dimension of the 'test cross section size' equal to or less than 250 mm.*

***Technical Notes:***

1. *'Aerodynamic test facilities' includes wind tunnels and shock tunnels for the study of airflow over objects.*
2. *'Test cross section size' means the diameter of the circle, or the side of the square, or the longest side of the rectangle, or the major axis of the ellipse at the largest 'test cross section' location. 'Test cross section' is the section perpendicular to the flow direction.*

3. Test benches/stands, usable for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. or the subsystems specified in 6-2.A. or 6-20.A., which have the capacity to handle solid or liquid propellant rockets, motors or engines having a thrust greater than 68 kN, or which are capable of simultaneously measuring the three axial thrust components.

4. Environmental chambers as follows, usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A. or 6-20.A.:

   a. Environmental chambers having all of the following characteristics:

      1. Capable of simulating any of the following flight conditions:

         a. Altitude equal to or greater than 15 km; **or**

         b. Temperature range from below –50º C to above +125º C; **and**

      2. Incorporating, or designed or modified to incorporate, a shaker unit or other vibration test equipment to produce vibration environments equal to or greater than 10 g rms, measured 'bare table', between 20 Hz and 2 kHz while imparting forces equal to or greater than 5 kN;

         ***Technical Notes:***

         1. *Item 6-15.B.4.a.2. describes systems that are capable of generating a vibration environment with a single wave (e.g. a sine wave) and systems capable of generating a broad band random vibration (i.e. power spectrum).*

2. *In Item 6-15.B.4.a.2., designed or modified means the environmental chamber provides appropriate interfaces (e.g. sealing devices) to incorporate a shaker unit or other vibration test equipment as specified in this Item.*

b. Environmental chambers capable of simulating all of the following flight conditions:

1. Acoustic environments at an overall sound pressure level of 140 dB or greater (referenced to 2 x $10^{-5}$ N/$m^2$) or with a total rated acoustic power output of 4 kW or greater; **and**

2. Any of the following:

a. Altitude equal to or greater than 15 km; **or**

b. Temperature range from below -50° C to above +125° C.

5. Accelerators capable of delivering electromagnetic radiation produced by bremsstrahlung from accelerated electrons of 2 MeV or greater, and equipment containing those accelerators, usable for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. or the subsystems specified in 6-2.A. or 6-20.A.

***Note:***

*6-15.B.5. does not control equipment specially designed for medical purposes.*

***Technical Note:***

*In Item 6-15.B. 'bare table' means a flat table, or surface, with no fixture or fittings.*

6. 'Aerothermodynamic test facilities', usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A. or 6-20.A, having any of the following characteristics:

a. an electrical power supply equal to or greater than 5 MW; **or**

b. a gas supply total pressure equal to or greater than 3 MPa.

***Technical note:***

*'Aerothermodynamic test facilities' include plasma arc jet facilities and plasma wind tunnels for the study of thermal and mechanical effects of airflow on objects.*

6-15.C. Materials

None

6-15.D. Software

1. "Software" specially designed or modified for the "use" of equipment specified in 6-15.B. usable for testing systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. or subsystems specified in 6-2.A. or 6-20.A.

6-15.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-15.B. or 6-15.D.

## 6-16. MODELLING-SIMULATION AND DESIGN INTEGRATION

6-16.A. Equipment, Assemblies and Components

1. Specially designed hybrid (combined analogue/digital) computers for modelling, simulation or design integration of systems specified in 6-1.A. or the subsystems specified in 6-2.A.

***Note:***

*This control only applies when the equipment is supplied with "software" specified in 6-16.D.1.*

6-16.B. Test and Production Equipment

None

6-16.C. Materials

None

6-16.D. Software

1. "Software" specially designed for modelling, simulation, or design integration of the systems specified in 6-1.A. or the subsystems specified in 6-2.A. or 6-20.A.

***Technical Note:***

*The modelling includes in particular the aerodynamic and thermodynamic analysis of the systems.*

6-16.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-16.A. or 6-16.D.

## 6-17. STEALTH

6-17.A. Equipment, Assemblies and Components

1. Devices for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A. or 6-20.A.

6-17.B. Test and Production Equipment

1. Systems, specially designed for radar cross section measurement, usable for the systems specified in 6-1.A., 6-19.A.1. or 6-19.A.2. or the subsystems specified in 6-2.A.

6-17.C. Materials

1. Materials for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A.

***Notes:***

*1. 6-17.C.1. includes structural materials and coatings (including paints), specially designed for reduced or tailored reflectivity or emissivity in the microwave, infrared or ultraviolet spectra.*

*2. 6-17.C.1. does not control coatings (including paints) when specially used for thermal control of satellites.*

6-17.D. Software

1. "Software" specially designed for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures (i.e. stealth technology), for applications usable for the systems specified in 6-1.A. or 6-19.A. or the subsystems specified in 6-2.A.

***Note:***
*6-17.D.1. includes "software" specially designed for analysis of signature reduction.*

6-17.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment, materials or "software" specified in 6-17.A., 6-17.B., 6-17.C. or 6-17.D.

***Note:***
*6-17.E.1. includes databases specially designed for analysis of signature reduction.*

## 6-18. NUCLEAR EFFECTS PROTECTION

6-18.A. Equipment, Assemblies and Components

1. "Radiation Hardened" "microcircuits" usable in protecting rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 6-1.A.
2. 'Detectors' specially designed or modified to protect rocket systems and unmanned aerial vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 6-1.A.

***Technical Note:***
*A 'detector' is defined as a mechanical, electrical, optical or chemical device that automatically identifies and records, or registers a stimulus such as an environmental change in pressure or temperature, an electrical or electromagnetic signal or radiation from a radioactive material. This includes devices that sense by one time operation or failure.*

3. Radomes designed to withstand a combined thermal shock greater than $4.184 \times 10^6$ J/m$^2$ accompanied by a peak over pressure of greater than 50 kPa, usable in protecting rocket systems and unmanned aerial vehicles against nuclear effects (e.g., Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems specified in 6-1.A.

6-18.B. Test and Production Equipment

None

6-18.C. Materials

None

6-18.D. Software

None

6-18.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 6-18.A.

## 6-19. OTHER COMPLETE DELIVERY SYSTEMS

6-19.A. Equipment, Assemblies and Components

1. Complete rocket systems (including ballistic missiles, space launch vehicles, and sounding rockets), not specified in 6-1.A.1., capable of a "range" equal to or greater than 300 km.
2. Complete unmanned aerial vehicle systems (including cruise missiles, target drones and reconnaissance drones), not specified in 6-1.A.2., capable of a "range" equal to or greater than 300 km.
3. Complete unmanned aerial vehicle systems, not specified in 6-1.A.2. or 6-19.A.2., having all of the following:
   a. Having any of the following:
      1. An autonomous flight control and navigation capability; **or**
      2. Capability of controlled flight out of the direct vision range involving a human operator; **and**
   b. Having any of the following:
      1. Incorporating an aerosol dispensing system/mechanism with a capacity greater than 20 litres; **or**
      2. Designed or modified to incorporate an aerosol dispensing system/mechanism with a capacity greater than 20 litres.

***Note:***

*Item 6-19.A.3. does not control model aircraft, specially designed for recreational or competition purposes.*

***Technical Notes:***

*1. An aerosol consists of particulate or liquids other than fuel components, by-products or additives, as part of the "payload" to be dispersed in the atmosphere. Examples of aerosols include pesticides for crop dusting and dry chemicals for cloud seeding.*

*2. An aerosol dispensing system/mechanism contains all those devices (mechanical, electrical, hydraulic, etc.), which are necessary for storage and dispersion of an aerosol into the atmosphere. This includes the possibility of aerosol injection into the combustion exhaust vapour and into the propeller slip stream.*

6-19.B. Test and Production Equipment

1. "Production facilities" specially designed for the systems specified in 6-19.A.1 or 6-19.A.2.

6-19.C. Materials

None

6-19.D. Software

1. "Software" which coordinates the function of more than one subsystem, specially designed or modified for "use" in the systems specified in 6-19.A.1. or 6-19.A.2.

***Note:***

*For a manned aircraft converted to operate as an unmanned aerial vehicle specified in 6-19.A.2., Item 6-19.D.1. includes "software", as follows:*

*a. "Software" specially designed or modified to integrate the conversion equipment with the aircraft system functions;*

*b. "Software" specially designed or modified to operate the aircraft as an unmanned aerial vehicle.*

6-19.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment specified in 6-19.A.1. or 6-19.A.2.

## 6-20. OTHER COMPLETE SUBSYSTEMS

6-20.A. Equipment, Assemblies and Components

1. Complete subsystems as follows:
   a. Individual rocket stages, not specified in 6-2.A.1., usable in systems specified in 6-19.A.;
   b. Rocket propulsion subsystems, not specified in 6-2.A.1., usable in the systems specified in 6-19.A.1., as follows:
      1. Solid propellant rocket motors or hybrid rocket motors having a total impulse capacity equal to or greater than $8.41 \times 10^5$ Ns, but less than $1.1 \times 10^6$ Ns;
      2. Liquid propellant rocket engines or gel propellant rocket motors integrated, or designed or modified to be integrated, into a liquid propellant or gel propellant propulsion system which has a total impulse capacity equal to or greater than $8.41 \times 10^5$ Ns, but less than $1.1 \times 10^6$ Ns.

6-20.B. Test and Production Equipment

1. "Production facilities" specially designed for the subsystems specified in 6-20.A.
2. "Production equipment" specially designed for the subsystems specified in 6-20.A.

6-20.C. Materials

None

6-20.D. Software

1. "Software" specially designed or modified for the systems specified in 6-20.B.1.
2. "Software", not specified in 6-2.D.2., specially designed or modified for the "use" of rocket motors or engines specified in 6-20.A.1.b.

6-20.E. Technology

1. "Technology", in accordance with the General Technology Note, for the "development", "production" or "use" of equipment or "software" specified in 6-20.A., 6-20.B. or 6-20.D.

## GROUP 6 – DEFINITIONS

For the purpose of Group 6, the following definitions apply:

"Accuracy"

Usually measured in terms of inaccuracy, means the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

"Basic scientific research"

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

"Development"

Is related to all phases prior to "production" such as:

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

"In the public domain"

This means "software" or "technology" which has been made available without restrictions upon its further dissemination. (Copyright restrictions do not remove "software" or "technology" from being "in the public domain".)

"Microcircuit"

A device in which a number of passive and/or active elements are considered as indivisibly associated on or within a continuous structure to perform the function of a circuit.

"Microprograms"

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

"Payload"

The total mass that can be carried or delivered by the specified rocket system or unmanned aerial vehicle (UAV) system that is not used to maintain flight.

*Note: The particular equipment, subsystems, or components to be included in the "payload" depends on the type and configuration of the vehicle under consideration.*

*Technical Notes:*

*1. Ballistic Missiles*

*a. "Payload" for systems with separating re-entry vehicles (RVs) includes:*

*1. The RVs, including:*

*a. Dedicated guidance, navigation, and control equipment;*

*b. Dedicated countermeasures equipment;*

*2. Munitions of any type (e.g. explosive or non-explosive);*

*3. Supporting structures and deployment mechanisms for the munitions (e.g. hardware used to attach to, or separate the RV from, the bus/post-boost vehicle) that can be removed without violating the structural integrity of the vehicle;*

*4. Mechanisms and devices for safing, arming, fuzing or firing;*

*5. Any other countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that separate from the RV bus/post-boost vehicle;*

*6. The bus/post-boost vehicle or attitude control/velocity trim module not including systems/subsystems essential to the operation of the other stages.*

*b. "Payload" for systems with non-separating re-entry vehicles includes:*

*1. Munitions of any type (e.g. explosive or non-explosive);*

*2. Supporting structures and deployment mechanisms for the munitions that can be removed without violating the structural integrity of the vehicle;*

*3. Mechanisms and devices for safing, arming, fuzing or firing;*

*4. Any countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle.*

*2. Space Launch Vehicles*

*"Payload" includes:*

*a. Spacecraft (single or multiple), including satellites;*

*b. Spacecraft-to-launch vehicle adapters including, if applicable, apogee/perigee kick motors or similar manoeuvering systems and separation systems.*

*3. Sounding Rockets*

*"Payload" includes:*

*a. Equipment required for a mission, such as data gathering, recording or transmitting devices for mission-specific data;*

*b. Recovery equipment (e.g. parachutes) that can be removed without violating the structural integrity of the vehicle.*

*4. Cruise Missiles*

*"Payload" includes:*

*a. Munitions of any type (e.g. explosive or non-explosive);*

*b. Supporting structures and deployment mechanisms for the munitions that can be removed without violating the structural integrity of the vehicle;*

*c. Mechanisms and devices for safing, arming, fuzing or firing;*

*d. Countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle;*

*e. Signature alteration equipment that can be removed without violating the structural integrity of the vehicle.*

*5. Other UAVs*

*"Payload" includes:*

*a. Munitions of any type (e.g. explosive or non-explosive);*

*b. Mechanisms and devices for safing, arming, fuzing or firing;*

*c. Countermeasures equipment (e.g. decoys, jammers or chaff dispensers) that can be removed without violating the structural integrity of the vehicle;*

*d. Signature alteration equipment that can be removed without violating the structural integrity of the vehicle;*

*e. Equipment required for a mission such as data gathering, recording or transmitting devices for mission-specific data and supporting structures that can be removed without violating the structural integrity of the vehicle;*

*f. Recovery equipment (e.g. parachutes) that can be removed without violating the structural integrity of the vehicle.*

*g. Munitions supporting structures and deployment mechanisms that can be removed without violating the structural integrity of the vehicle.*

"Production"

Means all production phases such as:

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

"Production equipment"

Means tooling, templates, jigs, mandrels, moulds, dies, fixtures, alignment mechanisms, test equipment, other machinery and components therefor, limited to those specially designed or modified for "development" or for one or more phases of "production".

"Production facilities"

Means "production equipment" and specially designed "software" therefor integrated into installations for "development" or for one or more phases of "production".

"Programs"

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

"Radiation hardened"

Means that the component or equipment is designed or rated to withstand radiation levels which meet or exceed a total irradiation dose of $5 \times 10^5$ rads (Si).

"Range"

The maximum distance that the specified rocket system or unmanned aerial vehicle (UAV) system is capable of travelling in the mode of stable flight as measured by the projection of its trajectory over the surface of the Earth.

<u>*Technical Notes:*</u>

*1. The maximum capability based on the design characteristics of the system, when fully loaded with fuel or propellant, will be taken into consideration in determining "range".*

2. *The "range" for both rocket systems and UAV systems will be determined independently of any external factors such as operational restrictions, limitations imposed by telemetry, data links or other external constraints.*
3. *For rocket systems, the "range" will be determined using the trajectory that maximises "range", assuming ICAO standard atmosphere with zero wind.*
4. *For UAV systems, the "range" will be determined for a one-way distance using the most fuel-efficient flight profile (e.g. cruise speed and altitude), assuming ICAO standard atmosphere with zero wind.*

"Software"

A collection of one or more "programs", or "microprograms", fixed in any tangible medium of expression.

"Technology"

Means specific information which is required for the "development", "production" or "use" of a product. The information may take the form of "technical data" or "technical assistance".

"Technical assistance"

May take forms such as:
- instruction
- skills
- training
- working knowledge
- consulting services

"Technical data"

May take forms such as:
- blueprints
- plans
- diagrams
- models
- formulae
- engineering designs and specifications
- manuals and instructions written or recorded on other media or devices such as:
    - disk
    - tape
    - read-only memories

"Use"

Means:
- operation
- installation (including on-site installation)
- maintenance
- repair
- overhaul
- refurbishing

## GROUP 6 – TERMINOLOGY

Where the following terms appear in Group 6, they are to be understood according to the explanations below:

a. "Specially designed" describes equipment, parts, components, materials or "software" which, as a result of "development", have unique properties that distinguish them for certain predetermined purposes. For example, a piece of equipment that is "specially designed" for use in a missile will only be considered so if it has no other function or use. Similarly, a piece of manufacturing equipment that is "specially designed" to produce a certain type of component will only be considered such if it is not capable of producing other types of components.

b. "Designed or modified" describes equipment, parts or components which, as a result of "development," or modification, have specified properties that make them fit for a particular application. "Designed or modified" equipment, parts, components or "software" can be used for other applications. For example, a titanium coated pump designed for a missile may be used with corrosive fluids other than propellants.

c. "Usable in", "usable for", "usable as" or "capable of" describes equipment, parts, components, materials or "software" which are suitable for a particular purpose. There is no need for the equipment, parts, components or "software" to have been configured, modified or specified for the particular purpose. For example, any military specification memory circuit would be "capable of" operation in a guidance system.

d. "Modified" in the context of "software" describes "software" which has been intentionally changed such that it has properties that make it fit for specified purposes or applications. Its properties may also make it suitable for purposes or applications other than those for which it was "modified".

## UNITS, CONSTANTS, ACRONYMS AND ABBREVIATIONS USED IN GROUP 6

| | |
|---|---|
| ABEC | Annular Bearing Engineers Committee |
| ABMA | American Bearing Manufactures Association |
| ANSI | American National Standards Institute |
| Angstrom | $1 \times 10^{-10}$ metre |
| ASTM | American Society for Testing and Materials |
| bar | unit of pressure |
| °C | degree Celsius |
| cc | cubic centimetre |
| CAS | Chemical Abstracts Service |
| CEP | Circle of Equal Probability |
| dB | decibel |
| g | gram; also, acceleration due to gravity |
| GHz | gigahertz |
| GNSS | Global Navigation Satellite System<br>e.g. 'BeiDou'<br>'Galileo'<br>'GLONASS' – Global'naya Navigatsionnaya Sputnikovaya Sistema<br>'GPS' – Global Positioning System |
| h | hour |
| Hz | hertz |
| HTPB | Hydroxy-Terminated Polybutadiene |
| ICAO | International Civil Aviation Organisation |
| IEEE | Institute of Electrical and Electronic Engineers |
| IR | Infrared |
| ISO | International Organization for Standardization |
| J | joule |
| JIS | Japanese Industrial Standard |
| K | Kelvin |
| kg | kilogram |
| kHz | kilohertz |
| km | kilometre |
| kN | kilonewton |
| kPa | kilopascal |
| kW | kilowatt |
| m | metre |
| MeV | million electron volt or mega electron volt |
| MHz | megahertz |
| milligal | $10^{-5}$ m/s$^2$ (also called mGal, mgal or milligalileo) |
| mm | millimetre |
| mm Hg | mm of mercury |

| | |
|---|---|
| MPa | megapascal |
| mrad | milliradian |
| ms | millisecond |
| µm | micrometre |
| N | newton |
| Pa | pascal |
| ppm | parts per million |
| rads (Si) | radiation absorbed dose |
| RF | radio frequency |
| rms | root mean square |
| RNSS | Regional Navigation Satellite System<br>e.g. 'NavIC' – Indian Regional Navigation Satellite System<br>'QZSS'– Quasi Zenith Satellite System |
| rpm | revolutions per minute |
| RV | Re-entry Vehicles |
| s | second |
| Tg | glass transition temperature |
| Tyler | Tyler mesh size, or Tyler standard sieve series |
| UAV | Unmanned Aerial Vehicle |
| UV | Ultra violet |

## TABLE OF CONVERSIONS USED IN GROUP 6

| Unit (from) | Unit (to) | Conversion |
|---|---|---|
| bar | pascal (Pa) | 1 bar = 100 kPa |
| g (gravity) | $m/s^2$ | 1 g = 9.80665 $m/s^2$ |
| mrad (millirad) | degrees (angle) | 1 mrad ≈ 0.0573° |
| rads | ergs/gram of Si | 1 rad (Si) = 100 ergs/gram of silicon<br>(= 0.01 gray [Gy]) |
| Tyler 250 mesh | mm | For a Tyler 250 mesh, mesh opening 0.063 mm |

# GROUP 7 – CHEMICAL AND BIOLOGICAL WEAPONS NON-PROLIFERATION LIST

***Notes:***

1. *Terms in "double quotation marks" are defined terms. Refer to "Group 7 - Definitions".*
2. *In items 7-3. and 7-4. the numbers in brackets following the chemical name in each item is the Chemical Abstracts Service Registry number for that chemical as listed in the Chemical Abstracts Service Registry Handbook published by the American Chemical Society, Washington, D.C.*
3. *Mixtures containing any quantity of CWC Schedule 1A and 1B chemicals/precursors (Items 7-3.1. and 7-3.2.) are also controlled.*
4. *Mixtures containing any quantity of chemicals/precursors listed in the CWC Schedules 2A, 2B, 3A and 3B (items 7-3.3. through 7-3.6.) and Australia Group (item 7-4.) are controlled unless the listed chemical is an ingredient in a product identified as a consumer good packaged for retail sale or packaged for personal use.*
5. *Item 7-3. is based on the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction. (known as the Chemical Weapons Convention or CWC.) The other items in the Group are based on the Australia Group (AG).*

***CHEMICAL ABSTRACTS SERVICE (CAS) NUMBERS:***

*Chemicals are listed by name, Chemical Abstract Service (CAS) number and CWC Schedule (where applicable). Chemicals of the same structural formula (e.g., 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. However, CAS numbers cannot be used as unique identifiers in all situations because some forms of the listed chemical have different CAS numbers, and mixtures containing a listed chemical may also have different CAS numbers.*

## DUAL-USE CHEMICAL MANUFACTURING FACILITIES AND EQUIPMENT, CHEMICAL WEAPONS AND RELATED SOFTWARE AND TECHNOLOGY

7-1. Equipment, Assemblies and Components

None

7-2. Manufacturing Facilities and Equipment

***Notes:***

1. *The objective of these controls should not be defeated by the transfer of any non-controlled item containing one or more controlled components where the controlled component or components are the principal element of the item and can feasibly be removed or used for other purposes.*

   ***N.B.:***

   *In judging whether the controlled component or components are to be considered the principal element, governments should weigh the factors of quantity, value, and technological know-how involved and other special circumstances which might establish the controlled component or components as the principal element of the item being procured.*
2. *The objective of these controls should not be defeated by the transfer of a whole plant, on any scale, which has been designed to produce any CW agent or AG-controlled precursor chemical.*
3. *The materials used for gaskets, packing, seals, screws, washers or other materials performing a sealing function do not determine the status of control of the items listed below, provided that such components are designed to be interchangeable.*

7-2.1. Reaction Vessels, Reactors or Agitators, Storage Tanks, Containers or Receivers, Heat Exchangers or Condensers, Distillation or Absorption Columns, Valves, Multi-walled Piping, Pumps, Filling Equipment, Incinerators and prefabricated repair assemblies as follows:

a. Reaction vessels or reactors, with or without agitators, with total internal (geometric) volume greater than 0.1 $m^3$ (100 l) and less than 20 $m^3$ (20,000 l), where all surfaces that come in direct contact with the chemical(s) being processed or contained are made from the following materials:
   1. Nickel or alloys with more than 40% nickel by weight;
   2. Alloys with more than 25% nickel and 20% chromium by weight;
   3. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
   4. Glass or glass-lined (including vitrified or enamelled coating);
   5. Tantalum or tantalum alloys;
   6. Titanium or titanium alloys;
   7. Zirconium or zirconium alloys; **or**
   8. Niobium (columbium) or niobium alloys.

   ***N.B.:***
   *For prefabricated repair assemblies and their specially designed components, see 7-2.1.k.*

b. Agitators designed for use in the above-mentioned reaction vessels or reactors; and impellers, blades or shafts designed for such agitators; where all surfaces of the agitator that come in direct contact with the chemical(s) being processed or contained are made from any of the following materials:
   1. Nickel or alloys with more than 40% nickel by weight;
   2. Alloys with more than 25% nickel and 20% chromium by weight;
   3. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
   4. Glass or glass-lined (including vitrified or enamelled coating);
   5. Tantalum or tantalum alloys;
   6. Titanium or titanium alloys;
   7. Zirconium or zirconium alloys; **or**
   8. Niobium (columbium) or niobium alloys.

c. Storage tanks, containers or receivers with a total internal (geometric) volume greater than 0.1 $m^3$ (100 l) where all surfaces that come in direct contact with the chemical(s) being processed or contained are made from the following materials:
   1. Nickel or alloys with more than 40% nickel by weight;
   2. Alloys with more than 25% nickel and 20% chromium by weight;
   3. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
   4. Glass or glass-lined (including vitrified or enamelled coating);
   5. Tantalum or tantalum alloys;
   6. Titanium or titanium alloys;
   7. Zirconium or zirconium alloys; **or**
   8. Niobium (columbium) or niobium alloys.

   ***N.B.:***
   *For prefabricated repair assemblies and their specially designed components, see 7-2.1.l.*

d. Heat exchangers or condensers with a heat transfer surface area of greater than 0.15 $m^2$, and less than 20 $m^2$; and tubes, plates, coils, or blocks (cores) designed for such heat exchangers or condensers, where all surfaces that come in direct contact with the chemical(s) being processed are made from the following materials:

1. Nickel or alloys with more than 40% nickel by weight;
2. Alloys with more than 25% nickel and 20% chromium by weight;
3. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
4. Glass or glass-lined (including vitrified or enamelled coating);
5. Graphite or carbon-graphite;
6. Tantalum or tantalum alloys;
7. Titanium or titanium alloys;
8. Zirconium or zirconium alloys;
9. Silicon carbide;
10. Titanium carbide; **or**
11. Niobium (columbium) or niobium alloys.

***Technical Note:***

*Carbon-graphite is a composition consisting of amorphous carbon and graphite, in which the graphite content is eight percent or more by weight.*

e. Distillation or absorption columns of internal diameter greater than 0.1 m; and liquid distributors, vapour distributors or liquid collectors designed for such distillation or absorption columns, where all surfaces that come in direct contact with the chemical(s) being processed are made from the following materials:
   1. Nickel or alloys with more than 40% nickel by weight;
   2. Alloys with more than 25% nickel and 20% chromium by weight;
   3. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
   4. Glass or glass-lined (including vitrified or enamelled coating);
   5. Graphite or carbon-graphite;
   6. Tantalum or tantalum alloys;
   7. Titanium or titanium alloys;
   8. Zirconium or zirconium alloys; **or**
   9. Niobium (columbium) or niobium alloys.

   ***Technical Note:***

   *Carbon-graphite is a composition consisting of amorphous carbon and graphite, in which the graphite content is eight percent or more by weight.*

f. Valves
   1. Valves, having both of the following:
      a. A nominal size greater than 1.0 cm (3/8”) and
      b. All surfaces that come in direct contact with the chemical(s) being produced, processed, or contained are made from the materials of construction in Technical Note 1 of this entry;
   2. Valves, not already identified in 7-2.1.f.1., having all of the following:
      a. A nominal size equal to or greater than 2.54 cm (1”) and equal to or less than 10.16 cm (4”)
      b. Casings (valve bodies) or preformed casing liners,
      c. A closure element designed to be interchangeable, and
      d. All surfaces of the casing (valve body) or preformed case liner that come in direct contact with the chemical(s) being produced, processed, or contained are made from the materials of construction in Technical Note 1 of this entry.

3. Components, as follows:
   a. Casings (valve bodies) designed for valves in 7-2.1.f.1. or 7-2.1.f.2., in which all surfaces that come in direct contact with the chemical(s) being produced, processed, or contained are made from the materials of construction in Technical Note 1 of this entry;
   b. Preformed casing liners designed for valves in 7-2.1.f.1. or 7-2.1.f.2., in which all surfaces that come in direct contact with the chemical(s) being produced, processed, or contained are made from the materials of construction in Technical Note 1 of this entry.

***Technical Note 1:***

*Materials of construction for valves include any of the following:*

1. *Nickel or alloys with more than 40% nickel by weight;*
2. *Alloys with more than 25% nickel and 20% chromium by weight;*
3. *Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);*
4. *Glass or glass-lined (including vitrified or enamelled coating);*
5. *Tantalum or tantalum alloys;*
6. *Titanium or titanium alloys;*
7. *Zirconium or zirconium alloys;*
8. *Niobium (columbium) or niobium alloys;* ***or***
9. *Ceramics materials as follows:*
   a. *Silicon carbide with a purity of 80% or more by weight;*
   b. *Aluminum oxide (alumina) with a purity of 99.9% or more by weight;* ***or***
   c. *Zirconium oxide (zirconia);*

***Technical Note 2:***

*The 'nominal size' is defined as the smaller of the inlet and outlet port diameters.*

g. Multi-walled piping incorporating a leak detection port, in which all surfaces that come in direct contact with the chemical(s) being processed or contained are made from the following materials:
   1. Nickel or alloys with more than 40% nickel by weight;
   2. Alloys with more than 25% nickel and 20% chromium by weight;
   3. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
   4. Glass or glass-lined (including vitrified or enamelled coating);
   5. Graphite or carbon-graphite;
   6. Tantalum or tantalum alloys;
   7. Titanium or titanium alloys;
   8. Zirconium or zirconium alloys; **or**
   9. Niobium (columbium) or niobium alloys.

***Technical Note:***

*Carbon-graphite is a composition consisting of amorphous carbon and graphite, in which the graphite content is eight percent or more by weight.*

h. Multiple-seal and seal-less pumps with manufacturer's specified maximum flow-rate greater than 0.6 $m^3$/h, or vacuum pumps with manufacturer's specified maximum flow-rate greater than 5 $m^3$/h (under standard temperature (273 K (0° C)) and pressure (101.3 kPa) conditions), and casings (pump bodies), preformed casing liners, impellers, rotors or jet pump nozzles designed for such pumps, in which all surfaces that come

into direct contact with the chemical(s) being processed are made from any of the following materials:

1. Nickel or alloys with more than 40% nickel by weight;
2. Alloys with more than 25% nickel and 20% chromium by weight;
3. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
4. Glass or glass-lined (including vitrified or enamelled coating);
5. Graphite or carbon-graphite;
6. Tantalum or tantalum alloys;
7. Titanium or titanium alloys;
8. Zirconium or zirconium alloys;
9. Ceramics;
10. Ferrosilicon (high silicon iron alloys); **or**
11. Niobium (columbium) or niobium alloys.

***Technical Note 1:***

*Carbon-graphite is a composition consisting of amorphous carbon and graphite, in which the graphite content is eight percent or more by weight.*

***Technical Note 2:***

*The seals referred to in this control come into direct contact with the chemical(s) being processed (or are designed to), and provide a sealing function where a rotary or reciprocating drive shaft passes through a pump body.*

i. Remotely operated filling equipment in which all surfaces that come in direct contact with the chemical(s) being processed are made from the following materials:
   1. Nickel or alloys with more than 40% nickel by weight; **or**
   2. Alloys with more than 25% nickel and 20% chromium by weight.

j. Incinerators designed to destroy CW agents, AG-controlled precursors or chemical munitions, having specially designed waste supply systems, special handling facilities, and an average combustion chamber temperature greater than 1,000° C, in which all surfaces in the waste supply system that come into direct contact with the waste products are made from or lined with the following materials:
   1. Nickel or alloys with more than 40% nickel by weight;
   2. Alloys with more than 25% nickel and 20% chromium by weight; **or**
   3. Ceramics.

***Technical Note:***

*For the listed materials in the above entries 7-2.1.a. to 7-2.1.j., the term 'alloy' when not accompanied by a specific elemental concentration is understood as identifying those alloys where the identified metal is present in a higher percentage by weight than any other element.*

k. Prefabricated repair assemblies and their specially designed components, that:
   1. are designed for mechanical attachment to glass-lined reaction vessels or reactors specified in 7-2.1.a.; **and**
   2. have metallic surfaces, that come in direct contact with the chemical(s) being processed, which are made from tantalum or tantalum alloys.

l. Prefabricated repair assemblies and their specially designed components, that:
   1. are designed for mechanical attachment to glass-lined storage tanks, containers or receivers specified in 7-2.1.c; **and**

2. have metallic surfaces, that come in direct contact with the chemical(s) being processed, which are made from tantalum or tantalum alloys.

*Statement of Understanding*

*These controls do not apply to equipment which is specially designed for use in civil applications (for example, food processing, pulp and paper processing or water purification, etc.) and is, by the nature of its design, inappropriate for use in storing, processing, producing or conducting and controlling the flow of chemical warfare agents or any of the AG-controlled precursors chemicals.*

7-2.2. Deleted.

***N.B.:***

*For remotely operated filling equipment, see 7-2.1.i .*

7-2.3. Deleted.

***N.B.:***

*For incinerators, see 7-2.1.j .*

7-2.4. Toxic gas monitors and monitoring systems, and their dedicated detecting components as follows: detectors; sensor devices; replaceable sensor cartridges; and dedicated software for such equipment

a. Designed for continuous operation and usable for the detection of chemical warfare agents, or AG-controlled precursors at concentrations of less than 0.3 mg/m$^3$; **or**

b. Designed for the detection of cholinesterase-inhibiting activity.

*(Item 7-2. applies to all destinations except Argentina, Australia, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Cyprus, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States.)*

7-3. CWC Materials

*(All destinations applies to all 7-3 Items)*

1. CWC Schedule 1 A Toxic Chemicals:

a. O-Alkyl (equal to or less than C10, including cycloalkyl) alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) - phosphonofluoridate;

e.g. Sarin (GB): O-Isopropyl methylphosphono-fluoridate, (CAS 107-44-8);

Soman (GD): O-Pinacolyl methyl-phosphono-fluoridate, (CAS 96-64-0);

b. O-Alkyl (equal to or less than C10, including cycloalkyl) N,N-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphoramidocyanidates;

e.g. Tabun: O-Ethyl N,N-dimethylphosphoramidocyanidate, (CAS 77-81-6);

c. O-Alkyl (H or equal to or less than C10, including cycloalkyl) S-2-dialkyl (Methyl, Ethyl, n-Propyl or Isopropyl)-aminoethyl alkyl (Methyl, Ethyl, n-Propyl or Isopropyl) phosphonothiolates and corresponding alkylated or protonated salts;

e.g. VX: O-Ethyl S-2-diisopropylaminoethyl methylphosphonothiolate, (CAS 50782-69-9);

d. Sulphur mustards:

2-Chloroethylchloromethylsulphide, (CAS 2625-76-5);

Mustard gas: Bis(2-chloroethyl) sulphide, (CAS 505-60-2);

Bis(2-chloroethylthio) methane, (CAS 63869-13-6);

Sesquimustard: 1,2-Bis(2-chloroethylthio)ethane, (CAS 3563-36-8);

1,3-Bis(2-chloroethylthio)-n-propane, (CAS 63905-10-2);

1,4-Bis(2-chloroethylthio)-n-butane, (CAS 142868-93-7);
1,5-Bis(2-chloroethylthio)-n-pentane, (CAS 142868-94-8);
Bis (2-chloroethylthiomethyl) ether; (CAS 63918-90-1);
O-Mustard: Bis(2-chloroethylthioethyl)ether, (CAS 63918-89-8);

e. Lewisites:
Lewisite 1: 2-Chlorovinyldichloroarsine, (CAS 541-25-3);
Lewisite 2: Bis(2-chlorovinyl)chloroarsine, (CAS 40334-69-8);
Lewisite 3: Tris (2-chlorovinyl) arsine, (CAS 40334-70-1);

f. Nitrogen mustards:
HN1: Bis (2-chloroethyl)ethylamine, (CAS 538-07-8);
HN2: Bis (2-chloroethyl)methylamine, (CAS 51-75-2);
HN3: Tris (2-chloroethyl)amine, (CAS 555-77-1);

g. Saxitoxin, (CAS 35523-89-8);

h. Ricin, (CAS 9009-86-3).

2. CWC Schedule 1 B Precursors:
   a. Alkyl (Me, Et, n-Pr or i-Pr) phosphonyldifluorides;
      e.g. DF: Methylphosphonyldifluoride, (CAS 676-99-3);
   b. O-Alkyl (H equal to or less than C10, including cycloalkyl) O-2-dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonites and corresponding alkylated or protonated salts;
      e.g. QL: O-Ethyl O-2-diisopropylamino- ethyl methylphosphonite, (CAS 57856-11-8);
   c. Chlorosarin: O-Isopropyl methylphosphonochloridate, (CAS 1445-76-7);
   d. Chlorosoman: O-Pinacolyl methylphosphonochloridate, (CAS 7040-57-5).
3. CWC Schedule 2 A Toxic Chemicals:
   a. Amiton: O,O-Diethyl S-[2-(diethylamino)ethyl] phosphor-othiolate, (CAS 78-53-5) and corresponding alkylated or protonated salts;
   b. PFIB: 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene, (CAS 382-21-8);
   c. BZ: 3-Quinuclidinyl benzilate, (CAS 6581-06-2).
4. CWC Schedule 2 B Precursors:
   a. Chemicals, except for those listed in Item 7-3.1. or 7-3.2., containing a phosphorus atom to which is bonded one methyl, ethyl or propyl (normal or iso) group but not further carbon atoms, such as:
      1. Dimethyl methylphosphonate, (CAS 756-79-6);
      2. Methylphosphonyl dichloride, (CAS 676-97-1);

      ***Note:***
      *This Item does not control Fonofos: O-Ethyl S-phenyl ethylphosphonothiolothionate, (CAS 944-22-9).*
   b. N,N-Dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidic dihalides;
   c. Dialkyl (Me, Et, n-Pr or i-Pr) N,N-Dialkyl (Me, Et, n-Pr or i-Pr)-phosphoramidates;
   d. Arsenic trichloride, (CAS 7784-34-1);
   e. 2,2-diphenyl-2-hydroxyacetic acid, (CAS 76-93-7);
   f. Quinuclidin-3-ol, (CAS 1619-34-7);
   g. N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethyl-2-chlorides and corresponding protonated salts;

h. N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-ols and corresponding protonated salts;

***Note:***

*This Item does not control:*

*a. N,N-Dimethylaminoethanol, (CAS 108-01-0) and corresponding protonated salts;*

*b. N,N-Diethylaminoethanol, (CAS 100-37-8) and corresponding protonated salts.*

i. N,N-Dialkyl (Me, Et, n-Pr or i-Pr)aminoethane-2-thiols and corresponding protonated salts;

j. Thiodiglycol: Bis(2-hydroxyethyl)sulfide, (CAS 111-48-8);

k. Pinacolyl alcohol: 3,3-Dimethylbutan-2-ol, (CAS 464-07-3).

l. N,N-Diisopropylaminoethanethiol hydrochloride (41480-75-5)

5. CWC Schedule 3 A Toxic Chemicals:

a. Phosgene: Carbonyl dichloride, (CAS 75-44-5);

b. Cyanogen chloride, (CAS 506-77-4);

c. Hydrogen cyanide, (CAS 74-90-8);

d. Chloropicrin: Trichloronitromethane, (CAS 76-06-2).

6. CWC Schedule 3 B Precursors:

a. Phosphorus oxychloride, (CAS 10025-87-3);

b. Phosphorus trichloride, (CAS 7719-12-2);

c. Phosphorus pentachloride, (CAS 10026-13-8);

d. Trimethyl phosphite, (CAS 121-45-9);

e. Triethyl phosphite, (CAS 122-52-1);

f. Dimethyl phosphite, (CAS 868-85-9);

g. Diethyl phosphite, (CAS 762-04-9);

h. Sulphur monochloride, (CAS 10025-67-9);

i. Sulphur dichloride, (CAS 10545-99-0);

j. Thionyl chloride, (CAS 7719-09-7);

k. Ethyldiethanolamine, (CAS 139-87-7);

l. Methyldiethanolamine, (CAS 105-59-9);

m. Triethanolamine, (CAS 102-71-6).

7-4. AG Materials

1. Chemical Weapons Precursor Chemicals, as follows:

a. 3-hydroxy-1-methylpiperidine, (CAS 3554-74-3);

b. Potassium fluoride, (CAS 7789-23-3);

c. 2-chloroethanol, (CAS 107-07-3);

d. Dimethylamine, (CAS 124-40-3);

e. Dimethylamine hydrochloride, (CAS 506-59-2);

f. Hydrogen fluoride, (CAS 7664-39-3);

g. Methyl benzilate, (CAS 76-89-1);

h. 3-quinuclidone, (CAS 3731-38-2);

i. Pinacolone, (CAS 75-97-8);

j. Potassium cyanide, (CAS 151-50-8);

k. Potassium bifluoride, (CAS 7789-29-9);

l. Ammonium bifluoride, (CAS 1341-49-7);

m. Sodium bifluoride, (CAS 1333-83-1);
n. Sodium fluoride, (CAS 7681-49-4);
o. Sodium cyanide, (CAS 143-33-9);
p. Phosphorus pentasulphide, (CAS 1314-80-3);
q. Diisopropylamine, (CAS 108-18-9);
r. Diethylaminoethanol, (CAS 100-37-18);
s. Sodium sulphide, (CAS 1313-82-2);
t. Triethanolamine hydrochloride, (CAS 637-39-8);
u. Triisopropyl phosphite, (CAS 116-17-6);
v. O,O-Diethyl phosphorothioate, (CAS 2465-65-8);
w. O,O-Diethyl phosphorodithioate, (CAS 298-06-6);
x. Sodium hexafluorosilicate, (CAS 16893-85-9).
y. Diethylamine (CAS 109-89-7).

7-5. Software

Controls on "software" transfer only apply where specifically indicated in section 7-2 above, and do not apply to "software" which is either:

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

7-6. Technology

"Technology", including licences, directly associated with

- CW agents specified by 7-3;
- AG-controlled precursors specified by 7-4; **or**
- AG-controlled dual-use equipment items specified by 7-2.

This includes:

a. transfer of "technology" ("technical data") by any means, including electronic media, fax or telephone;
b. transfer of "technology" in the form of "technical assistance".

***Notes:***

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

*2. The approval for export of any AG-controlled item of dual-use equipment also authorises the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance, or repair of that item.*

## DUAL-USE BIOLOGICAL EQUIPMENT, BIOLOGICAL WEAPONS AND RELATED SOFTWARE AND TECHNOLOGY

7-11. Equipment, Assemblies and Components

None

7-12. Biological Test, Inspection and Production Equipment, as follows:

1. Complete containment facilities and related equipment as follows:
   a. Complete containment facilities that meet the criteria for P3 or P4 (BL3, BL4, L3, L4,) containment as specified in the WHO Laboratory Biosafety Manual (3rd edition, Geneva, 2004).
   b. Equipment designed for fixed installation in containment facilities specified in 7-12.1.a., as follows:
      i. Double-door pass through decontamination autoclaves;
      ii. Breathing air suit decontamination showers;
      iii. Mechanical-seal or inflatable-seal walkthrough doors.
2. Fermenters
   a. Fermenters capable of cultivation of micro-organisms or of live cells for the production of viruses or toxins, without the propagation of aerosols, having a total internal volume of 20 litres or greater.
   b. Components designed for such fermenters, as follows:
      i. cultivation chambers designed to be sterilized or disinfected in situ;
      ii. cultivation chamber holding devices; **or**
      iii. process control units capable of simultaneously monitoring and controlling two or more fermentation system parameters (e.g. temperature, pH, nutrients, agitation, dissolved oxygen, air flow, foam control).

   ***Note:***
   *Fermenters include bioreactors (including single-use (disposable) bioreactors), chemostats and continuous-flow systems.*
3. Centrifugal Separators

   Centrifugal separators capable of the continuous separation of pathogenic microorganisms, without the propagation of aerosols, and having all the following characteristics:
   a. one or more sealing joints within the steam containment area;
   b. a flow rate greater than 100 litres per hour;
   c. components of polished stainless steel or titanium; **and**
   d. capable of in-situ steam sterilisation in a closed state.

   ***Technical Note:***
   *Centrifugal separators include decanters.*
4. Cross (tangential) flow filtration equipment
   a. Cross (tangential) flow filtration equipment capable of separation of microorganisms, viruses, toxins or cell cultures, having all the following characteristics:
      1. a total filtration area equal to or greater than 1 square metre; **and**
      2. having any of the following characteristics:
         a. capable of being sterilized or disinfected *in-situ*; **or**
         b. using disposable or single-use filtration components.

   ***Note:***
   *This control excludes reverse osmosis and hemodialysis equipment, as specified by the manufacturer.*

b. Cross (tangential) flow filtration components (e.g. modules, elements, cassettes, cartridges, units or plates) with filtration area equal to or greater than 0.2 square metres for each component and designed for use in cross (tangential) flow filtration equipment as specified by 7-12.4.a.

***Technical Note:***

*In this control, 'sterilized' denotes the elimination of all viable microbes from the equipment through the use of either physical (e.g. steam) or chemical agents. 'Disinfected' denotes the destruction of potential microbial infectivity in the equipment through the use of chemical agents with a germicidal effect. 'Disinfection' and 'sterilization' are distinct from 'sanitization', the latter referring to cleaning procedures designed to lower the microbial content of equipment without necessarily achieving elimination of all microbial infectivity or viability.*

5. Freeze-drying Equipment

   Steam, gas or vapour sterilisable freeze-drying equipment with a condenser capacity of 10 kg of ice or greater in 24 hours and less than 1,000 kg of ice in 24 hours.

6. Spray-drying Equipment

   Spray drying equipment capable of drying toxins or pathogenic microorganisms having all of the following characteristics:

   a. a water evaporation capacity of ≥ 0.4 kg/h and ≤ 400 kg/h;
   b. the ability to generate a typical mean product particle size of ≤ 10 micrometers with existing fittings or by minimal modification of the spray-dryer with atomization nozzles enabling generation of the required particle size; **and**
   c. capable of being sterilized or disinfected in situ.

7. Protective and containment equipment as follows:

   a. Protective full or half suits, or hoods dependent upon a tethered external air supply and operating under positive pressure;

      ***Technical Note:***

      *This does not control suits designed to be worn with self-contained breathing apparatus.*

   b. Biocontainment chambers, isolators or biological safety cabinets having all of the following characteristics, for normal operation:

      1. Fully enclosed workspace where the operator is separated from the work by a physical barrier;
      2. Able to operate at negative pressure;
      3. Means to safely manipulate items in the workspace;
      4. Supply and exhaust air to and from the work space is HEPA filtered.

      ***Note 1:***

      *This control includes class III biosafety cabinets, as described in the latest edition of the WHO Laboratory Biosafety Manual or constructed in accordance with national standards, regulations or guidance.*

      ***Note 2:***

      *This control does not include isolators specially designed for barrier nursing or transportation of infected patients.*

8. Aerosol inhalation chambers

   Aerosol inhalation equipment designed for aerosol challenge testing with microorganisms, viruses or toxins as follows:

   a. Whole-body exposure chambers having a capacity of 1 cubic metre or greater.

b. Nose-only exposure apparatus utilising directed aerosol flow and having capacity for exposure of 12 or more rodents, or 2 or more animals other than rodents; and, closed animal restraint tubes designed for use with such apparatus.

9. Spraying or fogging systems and components therefore, as follows:

a. Complete spraying or fogging systems, specially designed or modified for fitting to aircraft, lighter than air vehicles or UAVs, capable of delivering, from a liquid suspension, an initial droplet "VMD" of less than 50 microns at a flow rate of greater than two litres per minute.

b. Spray booms or arrays of aerosol generating units, specially designed or modified for fitting to aircraft, lighter than air vehicles or UAVs, capable of delivering, from a liquid suspension, an initial droplet "VMD" of less than 50 microns at a flow rate of greater than two litres per minute.

c. Aerosol generating units specially designed for fitting to systems that fulfil all the criteria specified in paragraphs 7-12.9.a. and 7-12.9.b.

***Technical Notes:***

*Aerosol generating units are devices specially designed or modified for fitting to aircraft such as nozzles, rotary drum atomisers and similar devices.*

*This entry does not control spraying or fogging systems and components as specified in paragraph 7-12.9. above that are demonstrated not to be capable of delivering biological agents in the form of infectious aerosols.*

*Pending definition of international standards, the following guidelines should be followed:*

*Droplet size for spray equipment or nozzles specially designed for use on aircraft or UAVs should be measured using either of the following methods:*

*a. Doppler laser method;*

*b. Forward laser diffraction method.*

10. Nucleic acid assemblers and synthesizers

Nucleic acid assemblers and synthesizers, which are partly or entirely automated, and designed to generate continuous nucleic acids greater than 1.5 kilobases in length with error rates less than 5% in a single run.

*(Item 7-12. applies to all destinations except Argentina, Australia, Austria, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Republic of Cyprus, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States.)*

7-13. Materials

*(All destinations applies to all 7-13 Items)*

Biological Weapon Agents

7-13.1. Human and Animal Pathogens and Toxins, as follows:

a. Viruses:

1. African horse sickness virus
2. African swine fever virus
3. Andes virus
4. Avian influenza virus

***Note:***

*This includes only those Avian influenza viruses of high pathogenicity as defined by*

*competent international authorities or regulatory bodies such as the World Organization for Animal Health (OIE) or the European Union (EU).*

5. Bluetongue virus
6. Chapare virus
7. Chikungunya virus
8. Choclo virus
9. Classical swine fever virus (Hog cholera virus)
10. Crimean-Congo hemorrhagic fever virus
11. Dobrava-Belgrade virus
12. Eastern equine encephalitis virus
13. Ebolavirus: all members of the Ebolavirus genus
14. Foot-and-mouth disease virus
15. Goatpox virus
16. Guanarito virus
17. Hantaan virus
18. Hendra virus (Equine morbillivirus)
19. Japanese encephalitis virus
20. Junin virus
21. Kyasanur Forest disease virus
22. Laguna Negra virus
23. Lassa virus
24. Louping ill virus
25. Lujo virus
26. Lumpy skin disease virus
27. Lymphocytic choriomeningitis virus
28. Machupo virus
29. Marburgvirus: all members of the Marburgvirus genus
30. Monkeypox virus
31. Murray Valley encephalitis virus
32. Newcastle disease virus
33. Nipah virus
34. Omsk hemorrhagic fever virus
35. Oropouche virus
36. Peste-des-petits-ruminants virus
37. Porcine Teschovirus
38. Powassan virus
39. Rabies virus and other members of the Lyssavirus genus
40. Reconstructed 1918 influenza virus
41. Rift Valley fever virus
42. Rinderpest virus
43. Rocio virus
44. Sabia virus
45. Seoul virus
46. Severe acute respiratory syndrome-related coronavirus (SARS-related coronavirus)

47. Sheeppox virus
48. Sin Nombre virus
49. St. Louis encephalitis virus
50. Suid herpesvirus 1 (Pseudorabies virus; Aujeszky's disease)
51. Swine vesicular disease virus
52. Tick-borne encephalitis virus (Far Eastern subtype)
53. Variola virus
54. Venezuelan equine encephalitis virus
55. Vesicular stomatitis virus
56. Western equine encephalitis virus
57. Yellow fever virus

b. Not used since 2013

c. Bacteria:

1. Bacillus anthracis;
2. Brucella abortus;
3. Brucella melitensis;
4. Brucella suis;
5. Chlamydia psittaci (Chlamydophila psittaci);
6. Clostridium botulinum;
7. Clostridium argentinense (formerly known as Clostridium botulinum Type G), botulinum neurotoxin producing strains;
8. Clostridium baratii, botulinum neurotoxin producing strains;
9. Clostridium butyricum, botulinum neurotoxin producing strains;
10. Francisella tularensis;
11. Burkholderia mallei (Pseudomonas mallei);
12. Burkholderia pseudomallei (Pseudomonas pseudomallei);
13. Salmonella enterica subspecies enterica serovar Typhi (Salmonella typhi);
14. Shigella dysenteriae;
15. Vibrio cholerae;
16. Yersinia pestis;
17. Clostridium perfringens, epsilon toxin producing types;

    ***Note:***

    *It is understood that limiting this control to epsilon toxin producing strains of Clostridium perfringens therefore exempts from control the transfer of other Clostridium perfringens strains to be used as positive control cultures for food testing and quality control.*

18. Shiga toxin producing Escherichia coli (STEC) of serogroups O26, O45, O103, O104, O111, O121, O145, O157, and other shiga toxin producing serogroups;

    ***Note:***

    *Shiga toxin producing Escherichia (STEC) includes inter alia enterohaemorrhagic E.coli (EHEC), verotoxin producing E. coli (VTEC) or verocytotoxin producing E. coli (VTEC).*

19. Coxiella burnetii;
20. Rickettsia prowazekii;
21. Mycoplasma capricolum subspecies capripneumoniae ("strain F38")
22. Mycoplasma mycoides subspecies mycoides SC (small colony)

d. Toxins as follow and subunits thereof:

***Note:***

*Excluding immunotoxins.*

1. Botulinum toxins;

   ***Note:***

   *Excluding botulinum toxins in product form meeting all of the following criteria:*

   *a. pharmaceutical formulations designed for testing and human administration in the treatment of medical conditions;*

   *b. pre-packaged for distribution as clinical or medical products; and*

   *c. authorized by a state authority to be marketed as clinical or medical products.*

2. Clostridium perfringens alpha, beta 1, beta 2, epsilon and iota toxins;
3. Conotoxins;

   ***Note:***

   *Excluding conotoxins in product form meeting all of the following criteria:*

   *a. pharmaceutical formulations designed for testing and human administration in the treatment of medical conditions;*

   *b. pre-packaged for distribution as clinical or medical products;* ***and***

   *c. authorized by a state authority to be marketed as clinical or medical products.*

4. Ricin;
5. Saxitoxin;
6. Shiga toxins (shiga-like toxins, verotoxins, and verocytotoxins);
7. Staphylococcus aureus toxins, hemolysin alpha toxin, and toxic shock syndrome toxin (formerly known as Staphylococcus enterotoxin F);
8. Tetrodotoxin;
9. Microcystins (Cyanginosins);
10. Aflatoxins;
11. Abrin;
12. Cholera toxin;
13. Diacetoxyscirpenol;
14. T-2 toxin;
15. HT-2 toxin;
16. Modeccin;
17. Volkensin;
18. Viscumin (Viscum album lectin 1);

e. Fungi:

1. Coccidioides immitis;
2. Coccidioides posadasii;

***Note:***

*Biological agents and pathogens are controlled when they are an isolated live culture of a pathogen agent, or a preparation of a toxin agent which has been isolated or extracted from any source, or material including living material which has been deliberately inoculated or contaminated with the agent. Isolated live cultures of a pathogen agent include live cultures in dormant form or in dried preparations, whether the agent is natural, enhanced or modified.*

*An agent/pathogen is covered by item 7-13.1.a. to 7-13.1.e. except when it is in the form of a vaccine. A vaccine is a medicinal product in a pharmaceutical formulation licensed by, or having marketing or clinical trial authorization from, the regulatory authorities of either the country of manufacture or of use, which is intended to stimulate a protective immunological response in humans or animals in order to prevent disease in those to whom or to which it is administered.*

f. Genetic Elements and Genetically-modified Organisms:

Any 'genetically-modified organism' [1.] which contains, or 'genetic element' [2.] that codes for:

(a) any gene or genes specific to any listed virus in 7-13.1.a.; **or**

(b) any gene or genes specific to any listed bacterium in 7-13.1.c. or fungus in 7-13.1.e., and which

(i) in itself or through its transcribed or translated products represents a significant hazard to human, animal or plant health, **or**

(ii) could 'endow or enhance pathogenicity' [3.]; **or**

(c) any listed toxins 7-13.1.d. or their sub-units.

***Technical Notes:***

*1. 'Genetically-modified organisms' include organisms in which the nucleic acid sequences have been created or altered by deliberate molecular manipulation.*

*2. 'Genetic elements' include, inter alia: chromosomes, genomes, plasmids, transposons, vectors, and inactivated organisms containing recoverable nucleic acid fragments, whether genetically modified or unmodified, or chemically synthesized in whole or in part. For the purposes of the genetic elements control, nucleic acids from an inactivated organism, virus, or sample are considered 'recoverable' if the inactivation and preparation of the material is intended or known to facilitate isolation, purification, amplification, detection, or identification of nucleic acids.*

*3. 'Endow or enhance pathogenicity' is defined as when the insertion or integration of the nucleic acid sequence or sequences is/are likely to enable or increase a recipient organism's ability to be used to deliberately cause disease or death. This might include alterations to, inter alia: virulence, transmissibility, stability, route of infection, host range, reproducibility, ability to evade or suppress host immunity, resistance to countermeasures, or detectability.*

7-13.2. Animal Pathogens, as follows:

a. Not used since 2014

b. Not used since 2014

c. Not used since 2014

d. Not used since 2014

7-13.3. Plant Pathogens, as follows:

a. Viruses;

1. Andean potato latent virus (Potato Andean latent tymovirus);

2. Potato spindle tuber viroid;

b. Rickettsiae

None

c. Bacteria:

1. Xanthomonas albilineans;

2. Xanthomonas campestris pv.citri (Xanthomonas campestris pv. citri A) [Xanthomonas campestris pv. citri];

3. Xanthomonas oryzae pv.oryzae (Pseudomonas campestris pv. oryzae);

4. Clavibacter michiganensis subsp. sepedonicus (Coryne-bacterium michiganensis subsp. sepedonicum or Corynebacterium sepedonicum);

5. Ralstonia solanacearum, race 3; biovar 2;

d. Toxins

None

e. Fungi:

1. Colletotrichum kahawae (Colletotrichum coffeanum var. virulans);
2. Cochliobolus miyabeanus (Helminthospo-rium oryzae);
3. Microcyclus ulei (syn. Dothidella ulei);
4. Puccinia graminis ssp. graminis var. graminis/Puccinia graminis ssp. graminis var. stakmanii (Puccinia graminis) (syn. Puccinia graminis f.sp. tritici);
5. Puccinia striiformis (syn. Puccinia glumarum);
6. Magnaporthe oryzae (Pyricularia oryzae);
7. Peronosclerospora philippinensis (Peronosclerospora sacchari);
8. Sclerophthora rayssiae var. zeae;
9. Synchytrium endobioticum;
10. Tilletia indica;
11. Thecaphora solani;

f. Genetic Elements and Genetically-modified Organisms:

Any ‘genetically-modified organism’ [1.] which contains, or ‘genetic element’ [2.] that codes for:

(a) any gene or genes specific to any listed virus in 7-13.3.a.; or

(b) any gene or genes specific to any listed bacterium in 7-13.3.c. or fungus in 7-13.3.e., and which

(i) in itself or through its transcribed or translated products represents a significant hazard to human, animal or plant health, or

(ii) ‘could endow or enhance pathogenicity’ [3.].

***Technical Notes:***

*1. ‘Genetically-modified organisms’ include organisms in which the nucleic acid sequences have been created or altered by deliberate molecular manipulation.*

*2. ‘Genetic elements’ include, inter alia: chromosomes, genomes, plasmids, transposons, vectors, and inactivated organisms containing recoverable nucleic acid fragments, whether genetically modified or unmodified, or chemically synthesized in whole or in part. For the purposes of the genetic elements control, nucleic acids from an inactivated organism, virus, or sample are considered ‘recoverable’ if the inactivation and preparation of the material is intended or known to facilitate isolation, purification, amplification, detection, or identification of nucleic acids.*

*3. ‘Endow or enhance pathogenicity’ is defined as when the insertion or integration of the nucleic acid sequence or sequences is/are likely to enable or increase a recipient organism’s ability to be used to deliberately cause disease or death. This might include alterations to, inter alia: virulence, transmissibility, stability, route of infection, host range, reproducibility, ability to evade or suppress host immunity, resistance to countermeasures, or detectability.*

7-14. Software

Controls on “software” transfer only apply where specifically indicated in sections 7-12 above and 7-15 do not apply to “software” which is either:

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

b. Designed for installation by the user without further substantial support by the supplier; **or**

2. "In the public domain".

7-15. Technology

"Technology", including licenses, directly associated with

- AG-controlled biological agents specified by 7-13; **or**
- AG-controlled dual-use biological equipment items specified by 7-12.

This includes

a. transfer of "technology" (technical data) by any means, including electronic media, fax or telephone

b. transfer of "technology" in the form of "technical assistance".

***Notes:***

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

*2. The approval for export of any AG-controlled item of dual-use equipment also authorises the export to the same end-user of the minimum "technology" required for the installation, operation, maintenance, or repair of that item.*

## GROUP 7 – DEFINITIONS

"Basic scientific research"

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

"Development"

"Development" is related to all phases before "production" such as:

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

"In the public domain"

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

"Lighter than air vehicles"

Balloons and airships that rely on hot air or on lighter-than-air gases such as helium or hydrogen for their lift.

"Microprogram"

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

"Production"

Means all "production" phases such as:

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

"Program"

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

"Software"

A collection of one or more 'programs' or 'microprograms' fixed in any tangible medium of expression.

"Technical assistance"

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

"Technical data"

May take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.

"Technology"

Specific information necessary for the "development", "production" or "use" of a product. The information takes the form of "technical data" or "technical assistance".

"UAVs"

Unmanned Aerial Vehicles.

"Use"

Operation, installation (including on-site installation), maintenance (checking), repair, overhaul or refurbishing.

"VMD"

Volume Median Diameter.

*Note:* *For water-based systems, VMD equates to MMD - the Mass Median Diameter.*

# GROUP 8 – REPEALED - JANUARY 2006 (SOR/DORS/2006-16)

# GROUP 9 – ARMS TRADE TREATY

*(All destinations. All destinations applies to all Group 9 Items.)*

The goods referred to in items 9-1. to 9-9., whether or not included elsewhere on this List, the export of which Canada has agreed to control in accordance with its obligations under the *Arms Trade Treaty*.

9-1. Battle tanks that are tracked or wheeled self-propelled armoured fighting vehicles weighing at least 16.5 t unladen, with a direct fire main gun of at least 75 mm calibre.

9-2. Armoured combat vehicles as follows:

- a. tracked, semi-tracked or wheeled self-propelled vehicles with armoured protection and cross-country capability having any of the following characteristics:
  - i. designed or modified and equipped to transport a squad of four or more infantry soldiers,
  - ii. armed with an integral or organic weapon of at least 12.5 mm calibre,
  - iii. equipped with a missile launcher,
  - iv. equipped with organic technical means for observation, reconnaissance and target indication and designed to perform reconnaissance missions,
  - v. equipped with integral or organic technical means for command of troops,
  - vi. equipped with integral or organic electronic and technical means designed for electronic warfare; and
- b. armoured bridge-launching vehicles.

9-3. Large-calibre artillery systems as follows:

- a. guns, howitzers, mortars - and artillery pieces that combine the characteristics of a gun or howitzer - that are capable of engaging surface targets by delivering indirect fire and have
  - i. a calibre of at least 75 mm but not greater than 155 mm, or
  - ii. a calibre greater than 155 mm;
- b. multiple-launch rocket systems that are capable of engaging surface targets by delivering indirect fire and have a calibre of at least 75 mm; and
- c. gun carriers specially designed for towing artillery.

9-4. Military aircraft and related systems as follows:

- a. manned fixed-wing or variable-geometry wing aircraft that are designed, equipped or modified to
  - i. engage targets by employing guided missiles, unguided rockets, bombs, guns, cannons or other weapons of destruction, or
  - ii. perform reconnaissance, command-of-troops, electronic warfare, suppression of air-defence systems, refuelling or airdrop missions;
- b. unmanned fixed-wing or variable-geometry wing aircraft that are designed, equipped or modified to
  - i. engage targets by employing guided missiles, unguided rockets, bombs, guns, cannons or other weapons of destruction, or
  - ii. perform reconnaissance, electronic warfare or suppression of air-defence systems missions; and
- c. systems for the control and receiving of information from the unmanned aircraft referred to in paragraph 9-4.b.

9-5. Military helicopters and related systems as follows:

a. manned rotary-wing aircraft that are designed, equipped or modified to
   i. engage targets by employing guided or unguided anti-armour, air-to-surface, air-to-subsurface or air-to-air weapons for which the aircraft are equipped with an integrated fire control and aiming system, or
   ii. perform reconnaissance, electronic warfare, target acquisition (including anti-submarine warfare), communications, command-of-troops or minelaying missions;
b. unmanned rotary-wing aircraft that are designed, equipped or modified to
   i. engage targets by employing guided or unguided anti-armour, air-to-surface, air-to-subsurface or air-to-air weapons for which the aircraft are equipped with an integrated fire control and aiming system, or
   ii. perform reconnaissance, electronic warfare or suppression of air-defence systems missions; and
c. systems for the control and receiving of information from the unmanned aircraft referred to in paragraph 9-5.b.

9-6. Vessels and submarines that are armed and equipped for military use and that
a. have a standard displacement equal to or greater than 150 t; or
b. have a standard displacement of less than 150 t and are equipped for launching missiles or torpedoes with a range of 25 km or greater.

9-7. Missiles and missile launchers
1. Missiles and missile launchers, as follows:
   a. guided or unguided rockets and ballistic or cruise missiles that are capable of delivering a warhead or weapon of destruction to a range of 25 km or greater;
   b. launchers that are specially designed or modified for launching the missiles or rockets referred to in paragraph 9-7.1.a., if not included in any of items 9-1. to 9-6.; and
   c. Man-Portable Air-Defense Systems (MANPADS).
2. Paragraph 9-7.1.a. includes remotely piloted vehicles that have the characteristics of the missiles or rockets described in that subsection.

9-8. Small arms
1. Small arms that are destined for police or military end-use by individual members, as follows:
   a. handguns that
      i. are automatic or converted automatic in function,
      ii. are semi-automatic in function, or
      iii. are revolvers;
   b. rifles other than those specified in paragraph 9-8.1.d.;
   c. submachine guns that are automatic or converted automatic in function;
   d. assault rifles that are automatic or converted automatic in function; and
   e. light machine guns that
      i. are automatic or converted automatic in function, and
      ii. have a calibre of 12.7mm or less,
2. Subsection 9-8.1. does not include
   a. firearms that are specially designed for dummy or blank ammunition and are incapable of discharging a projectile or marking cartridges;
   b. firearms that are specially designed for marking or for force-on-force type training ammunition;

c. firearms that are specially designed to launch tethered projectiles having no high-explosive charge or communications link to a range of 500 m or less; or

d. *antique firearms* as defined in subsection 84(1) of the *Criminal Code*.

9-9. Light weapons

1. Light weapons destined for use by individual members of armed or security forces or by several members serving as a crew and delivering primarily direct fire as follows:
   a. heavy machine guns, other than the grenade launchers specified in paragraph 9-9.1.b., that
      i. are automatic or converted automatic in function, and
      ii. have a calibre greater than 12.7mm;
   b. hand-held grenade launchers, under-barrel-mounted grenade launchers and mounted grenade launchers;
   c. portable anti-tank guns;
   d. recoilless rifles;
   e. portable anti-tank missile launchers and rocket systems; and
   f. mortars that have a calibre less than 75 mm.
2. Subsection 9-9.1. does not include *antique firearms*, as defined in subsection 84(1) of the *Criminal Code*.

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