

## II

(Non-legislative acts)

## REGULATIONS

**COMMISSION DELEGATED REGULATION (EU) No 1382/2014**

**of 22 October 2014**

**amending Council Regulation (EC) No 428/2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items**

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Council Regulation (EC) No 428/2009 of 5 May 2009 setting up a Community regime for the control of exports, transfer, brokering and transit of dual-use items <sup>(1)</sup> and in particular Article 15(3) thereof,

Whereas:

- (1) Regulation (EC) No 428/2009 requires dual-use items to be subject to effective control when they are exported from or transit through the Union, or are delivered to a third country as a result of brokering services provided by a broker resident or established in the Union.
- (2) Annex I to Regulation (EC) No 428/2009 establishes the common list of dual-use items that are subject to controls in the Union. Decisions on the items subject to controls are taken within the framework of the Australia Group, the Missile Technology Control Regime, the Nuclear Suppliers Group, the Wassenaar Arrangement and the Chemical Weapons Convention.
- (3) The list of dual-use items set out in Annex I to Regulation (EC) No 428/2009 needs to be updated regularly so as to ensure full compliance with international security obligations, to guarantee transparency, and to maintain the competitiveness of exporters. In order to facilitate references for export control authorities and operators, an updated and consolidated version of Annex I to Regulation (EC) No 428/2009 should be published.
- (4) Regulation (EC) No 428/2009 empowers the Commission to update the list of dual-use items set out in Annex I by means of delegated acts, in conformity with the relevant obligations and commitments, and any modifications thereto, that Member States have accepted as members of the international non-proliferation regimes and export control arrangements, or by ratification of relevant international treaties.
- (5) Regulation (EC) No 428/2009 should therefore be amended accordingly,

HAS ADOPTED THIS REGULATION:

*Article 1*

Annex I to Regulation (EC) No 428/2009 is replaced by the text set out in the Annex to this Regulation.

*Article 2*

This Regulation shall enter into force on the day following that of its publication in the *Official Journal of the European Union*.

<sup>(1)</sup> OJ L 134, 29.5.2009, p. 1.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

Done at Brussels, 22 October 2014.

*For the Commission*

*The President*

José Manuel BARROSO

---

## ANNEX

## ANNEX I

**List referred to in Article 3 of this Regulation****LIST OF DUAL-USE ITEMS**

This list implements internationally agreed dual-use controls including the Wassenaar Arrangement, the Missile Technology Control Regime (MTCR), the Nuclear Suppliers' Group (NSG), the Australia Group and the Chemical Weapons Convention (CWC).

## CONTENTS

Notes

Acronyms and abbreviations

Definitions

Category 0 Nuclear materials, facilities and equipment

Category 1 Special materials and related equipment

Category 2 Materials processing

Category 3 Electronics

Category 4 Computers

Category 5 Telecommunications and "information security"

Category 6 Sensors and lasers

Category 7 Navigation and avionics

Category 8 Marine

Category 9 Aerospace and propulsion

## GENERAL NOTES TO ANNEX I

1. For control of goods which are designed or modified for military use, see the relevant list(s) of controls on military goods maintained by individual Member States. References in this Annex that state "SEE ALSO MILITARY GOODS CONTROLS" refer to the same lists.
2. The object of the controls contained in this Annex should not be defeated by the export of any non-controlled goods (including plant) containing one or more controlled components when the controlled component or components are the principal element of the goods 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, it is necessary to 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 goods being procured.*

3. Goods specified in this Annex include both new and used goods.
4. 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.

## NUCLEAR TECHNOLOGY NOTE (NTN)

(To be read in conjunction with section E of Category 0.)

The “technology” directly associated with any goods controlled in Category 0 is controlled according to the provisions of Category 0.

“Technology” for the “development”, “production” or “use” of goods under control remains under control even when applicable to non-controlled goods.

The approval of goods 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 goods.

Controls on “technology” transfer do not apply to information “in the public domain” or to “basic scientific research”.

## GENERAL TECHNOLOGY NOTE (GTN)

(To be read in conjunction with section E of Categories 1 to 9.)

The export of “technology” which is “required” for the “development”, “production” or “use” of goods controlled in Categories 1 to 9, is controlled according to the provisions of Categories 1 to 9.

“Technology” “required” for the “development”, “production” or “use” of goods under control remains under control even when applicable to non-controlled goods.

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

*N.B.: This does not release such “technology” specified in 1E002.e., 1E002.f., 8E002.a. and 8E002.b.*

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

## GENERAL SOFTWARE NOTE (GSN)

(This note overrides any control within section D of Categories 0 to 9.)

Categories 0 to 9 of this list do not control “software” which is any of the following:

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

*N.B.: Entry a. of the General Software Note does not release “software” specified in Category 5 — Part 2 (“Information Security”).*

- b. “In the public domain”; or
- c. The minimum necessary “object code” for the installation, operation, maintenance (checking) or repair of those items whose export has been authorised.

*N.B.: Entry c. of the General Software Note does not release “software” specified in Category 5 — Part 2 (“Information Security”).*

## EDITORIAL PRACTICES IN THE OFFICIAL JOURNAL OF THE EUROPEAN UNION

In accordance with the rules set out in paragraph 6.5 on page 108 of the Interinstitutional style guide (2011 edition), for texts in English published in the *Official Journal of the European Union*:

- a comma is used to separate whole number from decimals (e.g. 3,67 cm),
- a space is used to indicate thousands in whole numbers (e.g. 100 000).

The text reproduced in this annex follows the above-described practice.

## ACRONYMS AND ABBREVIATIONS USED IN THIS ANNEX

An acronym or abbreviation, when used as a defined term, will be found in 'Definitions of Terms used in this Annex'.

ACRONYM OR ABBREVIATION	MEANING
ABEC	Annular Bearing Engineers Committee
AGMA	American Gear Manufacturers' Association
AHRS	attitude and heading reference systems
AISI	American Iron and Steel Institute
ALU	arithmetic logic unit
ANSI	American National Standards Institute
ASTM	the American Society for Testing and Materials
ATC	air traffic control
AVLIS	atomic vapour laser isotope separation
CAD	computer-aided-design
CAS	Chemical Abstracts Service
CDU	control and display unit
CEP	circular error probable
CNTD	controlled nucleation thermal deposition
CRISLA	chemical reaction by isotope selective laser activation
CVD	chemical vapour deposition
CW	chemical warfare
CW (for lasers)	continuous wave
DME	distance measuring equipment
DS	directionally solidified
EB-PVD	electron beam physical vapour deposition
EBU	European Broadcasting Union
ECM	electro-chemical machining
ECR	electron cyclotron resonance
EDM	electrical discharge machines
EEPROMS	electrically erasable programmable read only memory
EIA	Electronic Industries Association
EMC	electromagnetic compatibility

ACRONYM OR ABBREVIATION	MEANING
ETSI	European Telecommunications Standards Institute
FFT	Fast Fourier Transform
GLONASS	global navigation satellite system
GPS	global positioning system
HBT	hetero-bipolar transistors
HDDR	high density digital recording
HEMT	high electron mobility transistors
ICAO	International Civil Aviation Organisation
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronic Engineers
IFOV	instantaneous-field-of-view
ILS	instrument landing system
IRIG	inter-range instrumentation group
ISA	international standard atmosphere
ISAR	inverse synthetic aperture radar
ISO	International Organization for Standardization
ITU	International Telecommunication Union
JIS	Japanese Industrial Standard
JT	Joule-Thomson
LIDAR	light detection and ranging
LRU	line replaceable unit
MAC	message authentication code
Mach	ratio of speed of an object to speed of sound (after Ernst Mach)
MLIS	molecular laser isotopic separation
MLS	microwave landing systems
MOCVD	metal organic chemical vapour deposition
MRI	magnetic resonance imaging
MTBF	mean-time-between-failures
Mtops	million theoretical operations per second
MTTF	mean-time-to-failure
NBC	Nuclear, Biological and Chemical
NDT	non-destructive test
PAR	precision approach radar
PIN	personal identification number
ppm	parts per million
PSD	power spectral density
QAM	quadrature-amplitude-modulation
RF	radio frequency
SACMA	Suppliers of Advanced Composite Materials Association

ACRONYM OR ABBREVIATION	MEANING
SAR	synthetic aperture radar
SC	single crystal
SLAR	sidelooking airborne radar
SMPTE	Society of Motion Picture and Television Engineers
SRA	shop replaceable assembly
SRAM	static random access memory
SRM	SACMA Recommended Methods
SSB	single sideband
SSR	secondary surveillance radar
TCSEC	trusted computer system evaluation criteria
TIR	total indicated reading
UV	ultraviolet
UTS	ultimate tensile strength
VOR	very high frequency omni-directional range
YAG	yttrium/aluminium garnet

## DEFINITIONS OF TERMS USED IN THIS ANNEX

Definitions of terms between 'single quotation marks' are given in a Technical Note to the relevant item.

Definitions of terms between "double quotation marks" are as follows:

*N.B.: Category references are given in brackets after the defined term.*

"Accuracy" (2 6), usually measured in terms of inaccuracy, means the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

"Active flight control systems" (7) are systems that 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" (6 8) is a minimum (single) element of the solid state array which has a photoelectric transfer function when exposed to light (electromagnetic) radiation.

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

"Adjusted Peak Performance" (4) is an adjusted peak rate at which "digital computers" perform 64-bit or larger floating point additions and multiplications, and is expressed in Weighted TeraFLOPS (WT) with units of  $10^{12}$  adjusted floating point operations per second.

*N.B.: See Category 4, Technical Note.*

"Aircraft" (1 7 9) means a fixed wing, swivel wing, rotary wing (helicopter), tilt rotor or tilt-wing airborne vehicle.

*N.B.: See also "civil aircraft".*

"Airship" (9) means 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” (2) 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” (3 5) means 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.*

“Angular position deviation” (2) means 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

“Angle random walk” (7) means the angular error build up with time that is due to white noise in angular rate. (IEEE STD 528-2001)

“APP” (4) is equivalent to “Adjusted Peak Performance”.

“Asymmetric algorithm” (5) means a cryptographic algorithm using different, mathematically-related keys for encryption and decryption.

*N.B.: A common use of “asymmetric algorithms” is key management.*

“Automatic target tracking” (6) means a processing technique that automatically determines and provides as output an extrapolated value of the most probable position of the target in real time.

“Average output power” (6) means 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” (3) means 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’.

*N.B. 1: “Basic gate propagation delay time” is not to be confused with the input/output delay time of a complex “monolithic integrated circuit”.*

*N.B. 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” (GTN NTN) means 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) (7) means 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 squared (g or m/s<sup>2</sup>). (IEEE Std 528-2001) (Micro g equals  $1 \times 10^{-6}$  g).

“Bias” (gyro) (7) means 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).

“Camming” (2) means 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).

“Carbon fibre preforms” (1) means 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”.

“CEP” (circle of equal probability) (7) is a measure of accuracy; the radius of the circle centred at the target, at a specific range, in which 50 % of the payloads impact.



“Chemical laser” (6) means a “laser” in which the excited species is produced by the output energy from a chemical reaction.

“Chemical mixture” (1) means a solid, liquid or gaseous product made up of two or more components which do not react together under the conditions under which the mixture is stored.

“Circulation-controlled anti-torque or circulation controlled direction control systems” (7) are systems that use air blown over aerodynamic surfaces to increase or control the forces generated by the surfaces.

“Civil aircraft” (1 3 4 7) means those “aircraft” listed by designation in published airworthiness certification lists by the civil aviation authorities to fly commercial civil internal and external routes or for legitimate civil, private or business use.

*N.B.: See also “aircraft”.*

“Commingled” (1) means filament to filament blending of thermoplastic fibres and reinforcement fibres in order to produce a fibre reinforcement “matrix” mix in total fibre form.

“Comminution” (1) means a process to reduce a material to particles by crushing or grinding.

“Communications channel controller” (4) means 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” (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” (1 2 6 8 9) means 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.

“Compound rotary table” (2) means a table allowing the workpiece to rotate and tilt about two non-parallel axes, which can be coordinated simultaneously for “contouring control”.

“III/V compounds” (3 6) means 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” (2) means 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” (1 3 5) (sometimes referred to as the transition temperature) of a specific “superconductive” material means the temperature at which the material loses all resistance to the flow of direct electrical current.

“Cryptographic activation” (5) means any technique that activates or enables cryptographic capability, via a secure mechanism that is implemented by the manufacturer of the item and is uniquely bound to the item or customer for which the cryptographic capability is being activated or enabled (e.g., a serial number-based licence key or an authentication instrument such as a digitally signed certificate).

*Technical Note:*

*“Cryptographic activation” techniques and mechanisms may be implemented as hardware, “software” or “technology”.*

“Cryptography” (5) means 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.

*Note: “Cryptography” does not include “fixed” data compression or coding techniques.*

*Technical Note:*

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

“CW laser” (6) means a “laser” that produces a nominally constant output energy for greater than 0,25 seconds.

“Data-Based Referenced Navigation” (“DBRN”) (7) Systems means 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.

“Deformable mirrors” (6) (also known as adaptive optic mirrors) means mirrors having:

- 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.

“Depleted uranium” (0) means uranium depleted in the isotope 235 below that occurring in nature.

“Development” (GTN NTN All) is related to all phases 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” (1 2 9) means 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” (4 5) means 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.

*N.B.: 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” (def) means the total bit rate of the information that is directly transferred on any type of medium.

*N.B.: See also “total digital transfer rate”.*

“Direct-acting hydraulic pressing” (2) means a deformation process which uses a fluid-filled flexible bladder in direct contact with the workpiece.

“Drift rate” (gyro) (7) means the component of gyro output that is functionally independent of input rotation. It is expressed as an angular rate. (IEEE STD 528-2001).

“Effective gramme” (0 1) of “special fissile material” means:

- a. For plutonium isotopes and uranium-233, the isotope weight in grammes;
- b. For uranium enriched 1 per cent or greater in the isotope uranium-235, the element weight in grammes multiplied by the square of its enrichment expressed as a decimal weight fraction;
- c. For uranium enriched below 1 per cent in the isotope uranium-235, the element weight in grammes multiplied by 0,0001;

“Electronic assembly” (2 3 4 5) means 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.

*N.B. 1: ‘Circuit element’: a single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.*

*N.B. 2: ‘Discrete component’: a separately packaged ‘circuit element’ with its own external connections.*

“Electronically steerable phased array antenna” (5 6) means 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 in azimuth or in elevation, or both, by application, both in transmission and reception, of an electrical signal.

“Energetic materials” (1) means substances or mixtures that react chemically to release energy required for their intended application. “Explosives”, “pyrotechnics” and “propellants” are subclasses of energetic materials.

“End-effectors” (2) means grippers, ‘active tooling units’ and any other tooling that is attached to the baseplate on the end of a “robot” manipulator arm.

*N.B.: ‘Active tooling unit’ means a device for applying motive power, process energy or sensing to the workpiece.*

“Equivalent Density” (6) means the mass of an optic per unit optical area projected onto the optical surface.

“Explosives” (1) means 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.

“FADEC Systems” (7 9) means 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” (0 1 8) 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” (3) means an array of ‘circuit elements’ and metallic interconnections formed by deposition of a thick or thin film on an insulating “substrate”.

*N.B.: ‘Circuit element’ is a single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.*

“Fixed” (5) means that the coding or compression algorithm cannot accept externally supplied parameters (e.g., cryptographic or key variables) and cannot be modified by the user.

“Flight control optical sensor array” (7) is a network of distributed optical sensors, using “laser” beams, to provide real-time flight control data for on-board processing.

“Flight path optimisation” (7) is a procedure that minimizes deviations from a four-dimensional (space and time) desired trajectory based on maximizing performance or effectiveness for mission tasks.

“Focal plane array” (6 8) means 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.

*N.B.: This is not intended to 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” (3 5) means the “instantaneous bandwidth” divided by the centre frequency, expressed as a percentage.

“Frequency hopping” (5) means 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 mask trigger” (3) for “signal analysers” 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.

“Frequency switching time” (3) means the time (i.e., delay) taken by a signal when switched from an initial specified output frequency, to arrive at or within  $\pm 0,05\%$  of a final specified output frequency. Items having a specified frequency range of less than  $\pm 0,05\%$  around their centre frequency are defined to be incapable of frequency switching.

“Frequency synthesiser” (3) means 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.

“Fuel cell” (8) is an electrochemical device that converts chemical energy directly into Direct Current (DC) electricity by consuming fuel from an external source.

“Fusible” (1) means 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).

“Gas Atomisation” (1) means a process to reduce a molten stream of metal alloy to droplets of 500 micrometre diameter or less by a high pressure gas stream.

“Geographically dispersed” (6) is where each location is distant from any other more than 1 500 m in any direction. Mobile sensors are always considered “geographically dispersed”.

“Guidance set” (7) means systems that integrate the process of measuring and computing a vehicles position and velocity (i.e. navigation) with that of computing and sending commands to the vehicles flight control systems to correct the trajectory.

“Hot isostatic densification” (2) means the 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.

“Hybrid integrated circuit” (3) means 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.

*N.B. 1: ‘Circuit element’: a single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.*

*N.B. 2: ‘Discrete component’: a separately packaged ‘circuit element’ with its own external connections.*

“Image enhancement” (4) means 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.

“Immunotoxin” (1) is a conjugate of one cell specific monoclonal antibody and a “toxin” or “sub-unit of toxin”, that selectively affects diseased cells.

“In the public domain” (GTN NTN GSN), as it applies herein, means “technology” or “software” which has been made available without restrictions upon its further dissemination (copyright restrictions do not remove “technology” or “software” from being “in the public domain”).

“Information security” (4 5) is 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.

*N.B.: ‘Cryptanalysis’: analysis of a cryptographic system or its inputs and outputs to derive confidential variables or sensitive data, including clear text.*

“Instantaneous bandwidth” (3 5 7) means the bandwidth over which output power remains constant within 3 dB without adjustment of other operating parameters.

“Instrumented range” (6) means the specified unambiguous display range of a radar.

“Insulation” (9) is applied to the components of a rocket motor, i.e. the case, nozzle, inlets, case closures, and 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.

“Interior lining” (9) is suited for the bond interface between the solid propellant and the case or insulating liner. Usually a liquid polymer based dispersion of refractory or insulating materials, e.g. carbon filled hydroxyl terminated polybutadiene (HTPB) or other polymer with added curing agents sprayed or screeded over a case interior.

“Intrinsic Magnetic Gradiometer” (6) is a single magnetic field gradient sensing element and associated electronics the output of which is a measure of magnetic field gradient.

*N.B.: See also “magnetic gradiometer”.*

“Intrusion software” (4) means “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.

“Isolated live cultures” (1) includes live cultures in dormant form and in dried preparations.

“Isostatic presses” (2) mean 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” (0 2 3 5 6 7 8 9) is an assembly of components which produce both spatially and temporally coherent light that is amplified by stimulated emission of radiation.

*N.B.: See also: “Chemical laser”;  
“Super High Power Laser”;  
“Transfer laser”.*

“Lighter-than-air vehicles” (9) means balloons and airships that rely on hot air or other lighter-than-air gases such as helium or hydrogen for their lift.

“Linearity” (2) (usually measured in terms of non-linearity) means 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.

“Local area network” (4 5) is 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).

N.B.: 'Data device' means equipment capable of transmitting or receiving sequences of digital information.

"Magnetic Gradiometers" (6) are instruments 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.

N.B.: See also "intrinsic magnetic gradiometer".

"Magnetometers" (6) are instruments 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.

"Main storage" (4) means 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.

"Materials resistant to corrosion by UF<sub>6</sub>" (0) include copper, copper alloys, stainless steel, aluminium, aluminium oxide, aluminium alloys, nickel or alloys containing 60 % or more nickel by weight and fluorinated hydrocarbon polymers.

"Matrix" (1 2 8 9) means a substantially continuous phase that fills the space between particles, whiskers or fibres.

"Measurement uncertainty" (2) is the characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95 %. It includes the uncorrected systematic deviations, the uncorrected backlash and the random deviations (ref. ISO 10360-2).

"Mechanical Alloying" (1) means 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.

"Melt Extraction" (1) means 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.

N.B.: 'Solidify rapidly': solidification of molten material at cooling rates exceeding 1 000 K/s.

"Melt Spinning" (1) means a process to 'solidify rapidly' a molten metal stream impinging upon a rotating chilled block, forming a flake, ribbon or rod-like product.

N.B.: 'Solidify rapidly': solidification of molten material at cooling rates exceeding 1 000 K/s.

"Microcomputer microcircuit" (3) means 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.

N.B.: The internal storage may be augmented by an external storage.

"Microprocessor microcircuit" (3) means 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.

N.B. 1: 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.

N.B. 2: This includes chip sets which are designed to operate together to provide the function of a "microprocessor microcircuit".

"Microorganisms" (1 2) means bacteria, viruses, mycoplasmas, rickettsiae, chlamydiae or fungi, whether natural, enhanced or modified, either in the form of "isolated live cultures" or as material including living material which has been deliberately inoculated or contaminated with such cultures.

"Missiles" (1 3 6 7 9) means complete rocket systems and unmanned aerial vehicle systems, capable of delivering at least 500 kg payload to a range of at least 300 km.

"Monofilament" (1) or filament is the smallest increment of fibre, usually several micrometres in diameter.

“Monolithic integrated circuit” (3) means 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 semi-conducting piece of material, a so-called ‘chip’;
- b. Can be considered as indivisibly associated; and
- c. Perform the function(s) of a circuit.

*N.B.: ‘Circuit element’ is a single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.*

“Monospectral imaging sensors” (6) are capable of acquisition of imaging data from one discrete spectral band.

“Multichip integrated circuit” (3) means two or more “monolithic integrated circuits” bonded to a common “substrate”.

“Multispectral imaging sensors” (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.

“Natural uranium” (0) means uranium containing the mixtures of isotopes occurring in nature.

“Network access controller” (4) means 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.

“Neural computer” (4) means a computational device designed or modified to mimic the behaviour of a neuron or a collection of neurons, i.e., a computational device which is distinguished by its hardware capability to modulate the weights and numbers of the interconnections of a multiplicity of computational components based on previous data.

“Nuclear reactor” (0) means a complete reactor capable of operation so as to maintain a controlled self-sustaining fission chain reaction. A “nuclear reactor” includes all 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, come into direct contact with or control the primary coolant of the reactor core.

“Numerical control” (2) means 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” (GSN) means an equipment executable form of a convenient expression of one or more processes (“source code” (source language)) which has been compiled by programming system.

“Optical amplification” (5), in optical communications, means an amplification technique that introduces a gain of optical signals that have been generated by a separate optical source, without conversion to electrical signals, i.e., using semiconductor optical amplifiers, optical fibre luminescent amplifiers.

“Optical computer” (4) means a computer designed or modified to use light to represent data and whose computational logic elements are based on directly coupled optical devices.

“Optical integrated circuit” (3) means 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” (5) means the routing of or switching of signals in optical form without conversion to electrical signals.

“Overall current density” (3) means 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.).

“Participating state” (7 9) is a state participating in the Wassenaar Arrangement. (See [www.wassenaar.org](http://www.wassenaar.org))

“Peak power” (6) means the highest power attained in the “pulse duration”.

“Personal area network” (5) means 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).

*Technical Note:*

‘Data device’ means equipment capable of transmitting or receiving sequences of digital information.

“Power management” (7) means 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.

“Previously separated” (0 1) means the application of any process intended to increase the concentration of the controlled isotope.

“Primary flight control” (7) means an “aircraft” stability or manoeuvring control using force/moment generators, i.e., aerodynamic control surfaces or propulsive thrust vectoring.

“Principal element” (4), as it applies in Category 4, 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” (GTN NTN All) means all production phases, such as: construction, production engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

“Production equipment” (1 7 9) 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” (7 9) means “production equipment” and specially designed software therefor integrated into installations for “development” or for one or more phases of “production”.

“Programme” (2 6) means a sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

“Pulse compression” (6) means 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” (6) is the duration of a “laser” pulse and means the time between the half-power points on the leading edge and trailing edge of an individual pulse.

“Pulsed laser” (6) means a “laser” having a “pulse duration” that is less than or equal to 0,25 seconds.

“Quantum cryptography” (5) means a family of techniques for the establishment of 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” (6) means 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” (6) means 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” (6) is Radiant sensitivity (mA/W) = 0,807 × (wavelength in nm) × 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 bandwidth” (3) for “signal analysers” 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 transformation that processes every incoming time point without gaps or windowing effects that causes a reduction of measured amplitude of more than 3 dB below the actual signal amplitude, while outputting or displaying the transformed data.

“Real time processing” (2 6 7) means 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” (7) means 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” (GTN 1-9), as applied to “technology”, refers to only that portion of “technology” which is peculiarly responsible for achieving or extending the controlled performance levels, characteristics or functions. Such “required” “technology” may be shared by different goods.

“Resolution” (2) means the least increment of a measuring device; on digital instruments, the least significant bit (ref. ANSI B-89.1.12).

“Riot control agent” (1) means 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.

Technical Note:

*Tear gases are a subset of “riot control agents”.*

“Robot” (2 8) means a manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use sensors, and has all the following characteristics:

- a. Is multifunctional;
- b. Is capable of positioning or orienting material, parts, tools or special devices through variable movements in three dimensional space;
- c. Incorporates three or more closed or open loop servo-devices which may include stepping motors; and
- d. Has “user accessible programmability” by means of teach/playback method or by means of an electronic computer which may be a programmable logic controller, i.e., without mechanical intervention.

N.B.: *The above definition does not include the following devices:*

1. Manipulation mechanisms which are only manually/teleoperator controllable;
2. Fixed sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic or electrical means;
3. Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is mechanically limited by fixed, but adjustable stops, such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed programme pattern. Variations or modifications of the programme pattern (e.g., changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;
4. Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The programme is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;
5. Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.

“Rotary atomisation” (1) means a process to reduce a stream or pool of molten metal to droplets to a diameter of 500 micrometre or less by centrifugal force.

“Roving” (1) is a bundle (typically 12-120) of approximately parallel ‘strands’.

*N.B.: ‘Strand’ is a bundle of “monofilaments” (typically over 200) arranged approximately parallel.*

“Run-out” (2) (out-of-true running) means 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).

“Scale factor” (gyro or accelerometer) (7) means 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” (3) means 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.

“SHPL” is equivalent to “super high power laser”.

“Signal analysers” (3) means apparatus capable of measuring and displaying basic properties of the single-frequency components of multi-frequency signals.

“Signal processing” (3 4 5 6) means 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” (GSN All) means a collection of one or more “programmes” or ‘microprogrammes’ fixed in any tangible medium of expression.

*N.B.: ‘Microprogramme’ means 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.*

“Source code” (or source language) (6 7 9) is 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” (7 9) means active and passive satellites and space probes.

“Space-qualified” (3 6 7) means designed, manufactured or qualified through successful testing, for operation at altitudes greater than 100 km above the surface of the Earth.

*N.B.: 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.*

“Special fissile material” (0) means plutonium-239, uranium-233, “uranium enriched in the isotopes 235 or 233”, and any material containing the foregoing.

“Specific modulus” (0 1 9) is Young’s modulus in pascals, equivalent to  $N/m^2$  divided by specific weight in  $N/m^3$ , measured at a temperature of  $(296 \pm 2)$  K  $((23 \pm 2)^\circ C)$  and a relative humidity of  $(50 \pm 5)$  %.

“Specific tensile strength” (0 1 9) is ultimate tensile strength in pascals, equivalent to  $N/m^2$  divided by specific weight in  $N/m^3$ , measured at a temperature of  $(296 \pm 2)$  K  $((23 \pm 2)^\circ C)$  and a relative humidity of  $(50 \pm 5)$  %.

“Spinning mass gyros” (7) means gyros which use a continually rotating mass to sense angular motion.

“Splat Quenching” (1) means a process to ‘solidify rapidly’ a molten metal stream impinging upon a chilled block, forming a flake-like product.

*N.B.: ‘Solidify rapidly’ solidification of molten material at cooling rates exceeding 1 000 K/s.*

“Spread spectrum” (5) means the technique whereby energy in a relatively narrow-band communication channel is spread over a much wider energy spectrum.

“Spread spectrum” radar (6) - see “Radar spread spectrum”

“Stability” (7) means the 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.

“States (not) Party to the Chemical Weapon Convention” (1) are those states for which the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons has (not) entered into force. (See [www.opcw.org](http://www.opcw.org))

“Substrate” (3) means 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.

*N.B. 1: ‘Discrete component’: a separately packaged ‘circuit element’ with its own external connections.*

*N.B. 2: ‘Circuit element’: a single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.*

“Substrate blanks” (3 6) means monolithic compounds with dimensions suitable for the production of optical elements such as mirrors or optical windows.

“Sub-unit of toxin” (1) is a structurally and functionally discrete component of a whole “toxin”.

“Superalloys” (2 9) means 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” (1 3 5 6 8) means 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.

*N.B.: 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”) (6) means 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” (1 2) means 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” (5) means a cryptographic algorithm using an identical key for both encryption and decryption.

*N.B.: A common use of “symmetric algorithms” is confidentiality of data.*

“System tracks” (6) means processed, correlated (fusion of radar target data to flight plan position) and updated aircraft flight position report available to the Air Traffic Control centre controllers.

“Systolic array computer” (4) means a computer where the flow and modification of the data is dynamically controllable at the logic gate level by the user.

“Tape” (1) is a material constructed of interlaced or unidirectional “monofilaments”, ‘strands’, “rovings”, “tows”, or “yarns”, etc., usually pre-impregnated with resin.

*N.B.: ‘Strand’ is a bundle of “monofilaments” (typically over 200) arranged approximately parallel.*

“Technology” (GTN NTN All) means specific information necessary for the “development”, “production” or “use” of goods. This information takes the form of ‘technical data’ or ‘technical assistance’.

*N.B. 1: ‘Technical assistance’ may take forms such as instructions, skills, training, working knowledge and consulting services and may involve the transfer of ‘technical data’.*

*N.B. 2: ‘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.*

“Three dimensional integrated circuit” (3) means a collection of semiconductor die, integrated together, and having vias passing completely through at least one die to establish interconnections between die.

“Tilting spindle” (2) means 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” (6) is 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” (9) means 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” (7) means an 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” (5) means the number of bits, including line coding, overhead and so forth per unit time passing between corresponding equipment in a digital transmission system.

*N.B.:* See also “digital transfer rate”.

“Tow” (1) is a bundle of “monofilaments”, usually approximately parallel.

“Toxins” (1 2) means toxins in the form of deliberately isolated preparations or mixtures, no matter how produced, other than toxins present as contaminants of other materials such as pathological specimens, crops, foodstuffs or seed stocks of “microorganisms”.

“Transfer laser” (6) means a “laser” in which the lasing species is excited through the transfer of energy by collision of a non-lasing atom or molecule with a lasing atom or molecule species.

“Tunable” (6) means 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”.

“Unmanned Aerial Vehicle” (“UAV”) (9) means any aircraft capable of initiating flight and sustaining controlled flight and navigation without any human presence on board.

“Uranium enriched in the isotopes 235 or 233” (0) means uranium containing the isotopes 235 or 233, or both, in an amount such that the abundance ratio of the sum of these isotopes to the isotope 238 is more than the ratio of the isotope 235 to the isotope 238 occurring in nature (isotopic ratio 0,71 per cent).

“Use” (GTN NTN All) means operation, installation (including on-site installation), maintenance (checking), repair, overhaul and refurbishing.

“User accessible programmability” (6) means the facility allowing a user to insert, modify or replace “programmes” by means other than:

- a. A physical change in wiring or interconnections; or
- b. The setting of function controls including entry of parameters.

“Vaccine” (1) is a medicinal product in a pharmaceutical formulation licensed by, or having marketing or clinical trial authorisation 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.

“Vacuum Atomisation” (1) means a process to reduce a molten stream of metal to droplets of a diameter of 500 micrometre or less by the rapid evolution of a dissolved gas upon exposure to a vacuum.

“Variable geometry airfoils” (7) means the use of trailing edge flaps or tabs, or leading edge slats or pivoted nose droop, the position of which can be controlled in flight.

“Yarn” (1) is a bundle of twisted ‘strands’.

*N.B.:* ‘Strand’ is a bundle of “monofilaments” (typically over 200) arranged approximately parallel.

**CATEGORY 0 — NUCLEAR MATERIALS, FACILITIES, AND EQUIPMENT****0A Systems, Equipment and Components**

0A001 “Nuclear reactors” and specially designed or prepared equipment and components therefor, as follows:

- a. “Nuclear reactors”;
- b. Metal vessels, or major shop-fabricated parts therefor, including the reactor vessel head for a reactor pressure vessel, specially designed or prepared to contain the core of a “nuclear reactor”;
- c. Manipulative equipment specially designed or prepared for inserting or removing fuel in a “nuclear reactor”;
- d. Control rods specially designed or prepared for the control of the fission process in a “nuclear reactor”, support or suspension structures therefor, rod drive mechanisms and rod guide tubes;
- e. Pressure tubes specially designed or prepared to contain both fuel elements and the primary coolant in a “nuclear reactor”;
- f. Zirconium metal tubes or zirconium alloy tubes (or assemblies of tubes) specially designed or prepared for use as fuel cladding in a “nuclear reactor”, and in quantities exceeding 10 kg;

*N.B.: For zirconium pressure tubes see 0A001.e. and for calandria tubes see 0A001.h.*

- g. Coolant pumps or circulators specially designed or prepared for circulating the primary coolant of “nuclear reactors”;
- h. ‘Nuclear reactor internals’ specially designed or prepared for use in a “nuclear reactor”, including support columns for the core, fuel channels, calandria tubes, thermal shields, baffles, core grid plates, and diffuser plates;

*Technical Note:*

*In 0A001.h. ‘nuclear reactor internals’ means any major structure within a reactor vessel which has 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.*

- i. Heat exchangers as follows:
    1. Steam generators specially designed or prepared for the primary, or intermediate, coolant circuit of a “nuclear reactor”;
    2. Other heat exchangers specially designed or prepared for use in the primary coolant circuit of a “nuclear reactor”;
- Note: 0A001.i. does not control heat exchangers for the supporting systems of the reactor, e.g., the emergency cooling system or the decay heat cooling system.*
- j. Neutron detectors specially designed or prepared for determining neutron flux levels within the core of a “nuclear reactor”;
  - k. ‘External thermal shields’ specially designed or prepared for use in a “nuclear reactor” for the reduction of heat loss and also for the containment vessel protection.

*Technical Note:*

*In 0A001.k. ‘external thermal shields’ means major structures placed over the reactor vessel which reduce heat loss from the reactor and reduce temperature within the containment vessel.*

**OB Test, Inspection and Production Equipment**

OB001 Plant for the separation of isotopes of “natural uranium”, “depleted uranium” and “special fissile materials”, and specially designed or prepared equipment and components therefor, as follows:

- a. Plant specially designed for separating isotopes of “natural uranium”, “depleted uranium”, and “special fissile materials”, as follows:
  1. Gas centrifuge separation plant;
  2. Gaseous diffusion separation plant;
  3. Aerodynamic separation plant;
  4. Chemical exchange separation plant;
  5. Ion-exchange separation plant;
  6. Atomic vapour “laser” isotope separation (AVLIS) plant;
  7. Molecular “laser” isotope separation (MLIS) plant;
  8. Plasma separation plant;
  9. Electro magnetic separation plant;
- b. Gas centrifuges and assemblies and components, specially designed or prepared for gas centrifuge separation process, as follows:

Technical Note:

In OB001.b. ‘high strength-to-density ratio material’ means any of the following:

1. Maraging steel capable of an ultimate tensile strength of 1,95 GPa or more;
  2. Aluminium alloys capable of an ultimate tensile strength of 0,46 GPa or more; or
  3. “Fibrous or filamentary materials” with a “specific modulus” of more than  $3,18 \times 10^6$  m and a “specific tensile strength” greater than  $7,62 \times 10^4$  m;
1. Gas centrifuges;
  2. Complete rotor assemblies;
  3. Rotor tube cylinders with a wall thickness of 12 mm or less, a diameter of between 75 mm and 650 mm, made from ‘high strength-to-density ratio materials’;
  4. Rings or bellows with a wall thickness of 3 mm or less and a diameter of between 75 mm and 650 mm and designed to give local support to a rotor tube or to join a number together, made from ‘high strength-to-density ratio materials’;
  5. Baffles of between 75 mm and 650 mm diameter for mounting inside a rotor tube, made from ‘high strength-to-density ratio materials’.
  6. Top or bottom caps of between 75 mm and 650 mm diameter to fit the ends of a rotor tube, made from ‘high strength-to-density ratio materials’;
  7. Magnetic suspension bearings as follows:
    - a. Bearing assemblies consisting of an annular magnet suspended within a housing made of or protected by “materials resistant to corrosion by  $UF_6$ ” containing a damping medium and having the magnet coupling with a pole piece or second magnet fitted to the top cap of the rotor;
    - b. Active magnetic bearings specially designed or prepared for use with gas centrifuges.
  8. Specially prepared bearings comprising a pivot-cup assembly mounted on a damper;

OB001 b. (continued)

9. Molecular pumps comprised of cylinders having internally machined or extruded helical grooves and internally machined bores;
  10. Ring-shaped motor stators for multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuum at a frequency of 600 Hz or more and a power of 40 VA or more;
  11. Centrifuge housing/recipients to contain the rotor tube assembly of a gas centrifuge, consisting of a rigid cylinder of wall thickness up to 30 mm with precision machined ends that are parallel to each other and perpendicular to the cylinder's longitudinal axis to within 0,05 degrees or less;
  12. Scoops consisting of specially designed or prepared tubes for the extraction of UF<sub>6</sub> gas from within the rotor tube by a Pitot tube action and capable of being fixed to the central gas extraction system;
  13. Frequency changers (converters or inverters) specially designed or prepared to supply motor stators for gas centrifuge enrichment, having all of the following characteristics, and specially designed components therefor:
    - a. A multiphase frequency output of 600 Hz or greater; and
    - b. High stability (with frequency control better than 0,2 %);
  14. Shut-off and control valves as follows:
    - a. Shut-off valves specially designed or prepared to act on the feed, product or tails UF<sub>6</sub> gaseous streams of an individual gas centrifuge;
    - b. Bellows-sealed valves, shut-off or control, made of or protected by "materials resistant to corrosion by UF<sub>6</sub>", with an inside diameter of 10 mm to 160 mm, specially designed or prepared for use in main or auxiliary systems of gas centrifuge enrichment plants;
- c. Equipment and components, specially designed or prepared for gaseous diffusion separation process, as follows:
1. Gaseous diffusion barriers made of porous metallic, polymer or ceramic "materials resistant to corrosion by UF<sub>6</sub>" with a pore size of 10 to 100 nm, a thickness of 5 mm or less, and, for tubular forms, a diameter of 25 mm or less;
  2. Gaseous diffuser housings made of or protected by "materials resistant to corrosion by UF<sub>6</sub>";
  3. Compressors or gas blowers with a suction volume capacity of 1 m<sup>3</sup>/min or more of UF<sub>6</sub>, discharge pressure up to 500 kPa and having a pressure ratio of 10:1 or less, and made of or protected by "materials resistant to corrosion by UF<sub>6</sub>";
  4. Rotary shaft seals for compressors or blowers specified in OB001.c.3. and designed for a buffer gas in-leakage rate of less than 1 000 cm<sup>3</sup>/min.;
  5. Heat exchangers made of or protected by "materials resistant to corrosion by UF<sub>6</sub>", and designed for a leakage pressure rate of less than 10 Pa per hour under a pressure differential of 100 kPa;
  6. Bellows-sealed valves, manual or automated, shut-off or control, made of or protected by "materials resistant to corrosion by UF<sub>6</sub>";
- d. Equipment and components, specially designed or prepared for aerodynamic separation process, as follows:
1. Separation nozzles consisting of slit-shaped, curved channels having a radius of curvature less than 1 mm, resistant to corrosion by UF<sub>6</sub>, and having a knife-edge contained within the nozzle which separates the gas flowing through the nozzle into two streams;

OB001 d. (continued)

2. Cylindrical or conical tubes, (vortex tubes), made of or protected by “materials resistant to corrosion by  $\text{UF}_6$ ” and with one or more tangential inlets;
  3. Compressors or gas blowers made of or protected by “materials resistant to corrosion by  $\text{UF}_6$ ”, and rotary shaft seals therefor;
  4. Heat exchangers made of or protected by “materials resistant to corrosion by  $\text{UF}_6$ ”;
  5. Separation element housings, made of or protected by “materials resistant to corrosion by  $\text{UF}_6$ ” to contain vortex tubes or separation nozzles;
  6. Bellows-sealed valves, manual or automated, shut-off or control, made of or protected by “materials resistant to corrosion by  $\text{UF}_6$ ”, with a diameter of 40 mm or more;
  7. Process systems for separating  $\text{UF}_6$  from carrier gas (hydrogen or helium) to 1 ppm  $\text{UF}_6$  content or less, including:
    - 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  $\text{UF}_6$  from carrier gas;
    - d.  $\text{UF}_6$  cold traps capable of freezing out  $\text{UF}_6$ ;
- e. Equipment and components, specially designed or prepared for chemical exchange separation process, as follows:
1. Fast-exchange liquid-liquid pulse columns with stage residence time of 30 seconds or less and resistant to concentrated hydrochloric acid (e.g. made of or protected by suitable plastic materials such as fluorinated hydrocarbon polymers or glass);
  2. Fast-exchange liquid-liquid centrifugal contactors with stage residence time of 30 seconds or less and resistant to concentrated hydrochloric acid (e.g. made of or protected by suitable plastic materials such as fluorinated hydrocarbon polymers or glass);
  3. Electrochemical reduction cells resistant to concentrated hydrochloric acid solutions, for reduction of uranium from one valence state to another;
  4. Electrochemical reduction cells feed equipment to take  $\text{U}^{+4}$  from the organic stream and, for those parts in contact with the process stream, made of or protected by suitable materials (e.g. glass, fluorocarbon polymers, polyphenyl sulphate, polyether sulfone and resin-impregnated graphite);
  5. Feed preparation systems for producing high purity uranium chloride solution consisting of dissolution, solvent extraction and/or ion exchange equipment for purification and electrolytic cells for reducing the uranium  $\text{U}^{+6}$  or  $\text{U}^{+4}$  to  $\text{U}^{+3}$ ;
  6. Uranium oxidation systems for oxidation of  $\text{U}^{+3}$  to  $\text{U}^{+4}$ ;
- f. Equipment and components, specially designed or prepared for ion-exchange separation process, as follows:
1. Fast reacting ion-exchange resins, pellicular or porous macro-reticulated resins 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, with diameters of 0,2 mm or less, resistant to concentrated hydrochloric acid and designed to have an exchange rate half-time of less than 10 seconds and capable of operating at temperatures in the range of 373 K (100 °C) to 473 K (200 °C);



OB001 f. (continued)

2. Ion exchange columns (cylindrical) with a diameter greater than 1 000 mm, made of or protected by materials resistant to concentrated hydrochloric acid (e.g. titanium or fluorocarbon plastics) and capable of operating at temperatures in the range of 373 K (100 °C) to 473 K (200 °C) and pressures above 0,7 MPa;
  3. Ion exchange reflux systems (chemical or electrochemical oxidation or reduction systems) for regeneration of the chemical reducing or oxidizing agents used in ion exchange enrichment cascades;
- g. Equipment and components, specially designed or prepared for atomic vapour based methods, as follows:
1. Uranium metal vaporization systems designed to achieve a delivered power of 1 kW or more on the target for use in laser enrichment;
  2. Liquid or vapour uranium metal handling systems specially designed or prepared for handling molten uranium, molten uranium alloys or uranium metal vapour for use in laser enrichment, and specially designed components therefor;  
N.B.: SEE ALSO 2A225.
  3. Product and tails collector assemblies for uranium metal in liquid or solid form, made of or protected by materials resistant to the heat and corrosion of uranium metal vapour or liquid, such as yttria-coated graphite or tantalum;
  4. Separator module housings (cylindrical or rectangular vessels) for containing the uranium metal vapour source, the electron beam gun and the product and tails collectors;
  5. "Lasers" or "laser" systems specially designed or prepared for the separation of uranium isotopes with a spectrum frequency stabilisation for operation over extended periods of time;  
N.B.: SEE ALSO 6A005 AND 6A205.
- h. Equipment and components, specially designed or prepared for molecular based methods or laser systems, as follows:
1. Supersonic expansion nozzles for cooling mixtures of  $\text{UF}_6$  and carrier gas to 150 K (– 123 °C) or less and made from "materials resistant to corrosion by  $\text{UF}_6$ ";
  2. Product or tails collector components or devices specially designed or prepared for collecting uranium material or uranium tails material following illumination with laser light, made of "materials resistant to corrosion by  $\text{UF}_6$ ";
  3. Compressors made of or protected by "materials resistant to corrosion by  $\text{UF}_6$ ", and rotary shaft seals therefor;
  4. Equipment for fluorinating  $\text{UF}_5$  (solid) to  $\text{UF}_6$  (gas);
  5. Process systems for separating  $\text{UF}_6$  from carrier gas (e.g. nitrogen, argon or other gas) including:
    - 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.  $\text{UF}_6$  cold traps capable of freezing out  $\text{UF}_6$ ;
  6. "Lasers" or "laser" systems specially designed or prepared for the separation of uranium isotopes with a spectrum frequency stabilisation for operation over extended periods of time;  
N.B.: SEE ALSO 6A005 AND 6A205.

OB001 (continued)

- i. Equipment and components, specially designed or prepared for plasma separation process, as follows:
1. Microwave power sources and antennae for producing or accelerating ions, with an output frequency greater than 30 GHz and mean power output greater than 50 kW;
  2. 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;
  4. Not used;
  5. Product and tails collector assemblies for uranium metal in solid form, made of or protected by materials resistant to the heat and corrosion of uranium vapour such as yttria-coated graphite or tantalum;
  6. Separator module housings (cylindrical) for containing the uranium plasma source, radio-frequency drive coil and the product and tails collectors and made of a suitable non-magnetic material (e.g. stainless steel);
- j. Equipment and components, specially designed or prepared for electromagnetic separation process, as follows:
1. Ion sources, single or multiple, consisting of a vapour source, ioniser, and beam accelerator made of suitable non-magnetic materials (e.g. graphite, stainless steel, or copper) and capable of providing a total ion beam current of 50 mA or greater;
  2. Ion collector plates for collection of enriched or depleted uranium ion beams, consisting of two or more slits and pockets and made of suitable non-magnetic materials (e.g. graphite or stainless steel);
  3. Vacuum housings for uranium electromagnetic separators made of non-magnetic materials (e.g. stainless steel) and designed to operate at pressures of 0,1 Pa or lower;
  4. Magnet pole pieces with a diameter greater than 2 m;
  5. High voltage power supplies for ion sources, having all of the following characteristics:
    - a. Capable of continuous operation;
    - b. Output voltage of 20 000 V or greater;
    - c. Output current of 1 A or greater; and
    - d. Voltage regulation of better than 0,01 % over a period of 8 hours;

N.B.: SEE ALSO 3A227.
  6. Magnet power supplies (high power, direct current) having all of the following characteristics:
    - a. Capable of continuous operation with a current output of 500 A or greater at a voltage of 100 V or greater; and
    - b. Current or voltage regulation better than 0,01 % over a period of 8 hours.

N.B.: SEE ALSO 3A226.

- 0B002 Specially designed or prepared auxiliary systems, equipment and components as follows, for isotope separation plant specified in 0B001, made of or protected by "materials resistant to corrosion by  $\text{UF}_6$ ":
- a. Feed autoclaves, ovens or systems used for passing  $\text{UF}_6$  to the enrichment process;
  - b. Desublimers or cold traps, used to remove  $\text{UF}_6$  from the enrichment process for subsequent transfer upon heating;
  - c. Product and tails stations for transferring  $\text{UF}_6$  into containers;
  - d. Liquefaction or solidification stations used to remove  $\text{UF}_6$  from the enrichment process by compressing, cooling and converting  $\text{UF}_6$  to a liquid or solid form;
  - e. Piping systems and header systems specially designed or prepared for handling  $\text{UF}_6$  within gaseous diffusion, centrifuge or aerodynamic cascades;
  - f. Vacuum systems and pumps as follows:
    1. Vacuum manifolds, vacuum headers or vacuum pumps having a suction capacity of  $5 \text{ m}^3/\text{minute}$  or more;
    2. Vacuum pumps specially designed for use in  $\text{UF}_6$  bearing atmospheres made of, or protected by, "materials resistant to corrosion by  $\text{UF}_6$ "; or
    3. Vacuum systems consisting of vacuum manifolds, vacuum headers and vacuum pumps, and designed for service in  $\text{UF}_6$ -bearing atmospheres;
  - g.  $\text{UF}_6$  mass spectrometers/ion sources capable of taking on-line samples from  $\text{UF}_6$  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 % or more by weight, or nickel-chrome alloys;
    3. Electron bombardment ionisation sources; and
    4. Having a collector system suitable for isotopic analysis.
- 0B003 Plant for the conversion of uranium and equipment specially designed or prepared therefor, as follows:
- a. Systems for the conversion of uranium ore concentrates to  $\text{UO}_3$ ;
  - b. Systems for the conversion of  $\text{UO}_3$  to  $\text{UF}_6$ ;
  - c. Systems for the conversion of  $\text{UO}_3$  to  $\text{UO}_2$ ;
  - d. Systems for the conversion of  $\text{UO}_2$  to  $\text{UF}_4$ ;
  - e. Systems for the conversion of  $\text{UF}_4$  to  $\text{UF}_6$ ;
  - f. Systems for the conversion of  $\text{UF}_4$  to uranium metal;
  - g. Systems for the conversion of  $\text{UF}_6$  to  $\text{UO}_2$ ;
  - h. Systems for the conversion of  $\text{UF}_6$  to  $\text{UF}_4$ ;
  - i. Systems for the conversion of  $\text{UO}_2$  to  $\text{UCl}_4$ .
- 0B004 Plant for the production or concentration of heavy water, deuterium and deuterium compounds and specially designed or prepared equipment and components therefor, as follows:
- a. Plant for the production of heavy water, deuterium or deuterium compounds, as follows:
    1. Water-hydrogen sulphide exchange plants;
    2. Ammonia-hydrogen exchange plants;

OB004 (continued)

b. Equipment and components, as follows:

1. Water-hydrogen sulphide exchange towers with diameters of 1,5 m or more, capable of operating at pressures greater than or equal to 2 MPa;
2. 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 % H<sub>2</sub>S) with a throughput capacity greater than or equal to 56 m<sup>3</sup>/second when operating at pressures greater than or equal to 1,8 MPa suction and having seals designed for wet H<sub>2</sub>S service;
3. 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;
4. Tower internals, including stage contactors, and stage pumps, including those which are submersible, for heavy water production utilizing the ammonia-hydrogen exchange process;
5. Ammonia crackers with operating pressures greater than or equal to 3 MPa for heavy water production utilizing the ammonia-hydrogen exchange process;
6. Infrared absorption analysers capable of on-line hydrogen/deuterium ratio analysis where deuterium concentrations are equal to or greater than 90 %;
7. Catalytic burners for the conversion of enriched deuterium gas into heavy water utilizing the ammonia-hydrogen exchange process;
8. Complete heavy water upgrade systems, or columns therefor, for the upgrade of heavy water to reactor-grade deuterium concentration;
9. Ammonia synthesis converters or synthesis units specially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process.

OB005 Plant specially designed for the fabrication of "nuclear reactor" fuel elements and specially designed or prepared equipment therefor.

Technical Note:

*A plant for the fabrication of "nuclear reactor" fuel elements includes equipment which:*

1. *Normally comes into direct contact with or directly processes or controls the production flow of nuclear materials;*
2. *Seals the nuclear materials within the cladding;*
3. *Checks the integrity of the cladding or the seal;*
4. *Checks the finish treatment of the sealed fuel; or*
5. *Is used for assembling reactor elements.*

OB006 Plant for the reprocessing of irradiated "nuclear reactor" fuel elements, and specially designed or prepared equipment and components therefor.

Note: OB006 includes:

- a. *Plant for the reprocessing of irradiated "nuclear reactor" fuel elements including equipment and components which normally come into direct contact with and directly control the irradiated fuel and the major nuclear material and fission product processing streams;*
- b. *Fuel element chopping or shredding machines, i.e. remotely operated equipment to cut, chop or shear irradiated "nuclear reactor" fuel assemblies, bundles or rods;*
- c. *Dissolvers, critically safe tanks (e.g. small diameter, annular or slab tanks) specially designed or prepared for the dissolution of irradiated "nuclear reactor" fuel, which are capable of withstanding hot, highly corrosive liquids, and which can be remotely loaded and maintained;*

OB006 Note: (continued)

d. Solvent extractors, such as packed or pulsed columns, mixer settlers or centrifugal contractors, resistant to the corrosive effects of nitric acid and specially designed or prepared for use in a plant for the reprocessing of irradiated "natural uranium", "depleted uranium" or "special fissile materials";

e. Holding or storage vessels specially designed to be critically safe and resistant to the corrosive effects of nitric acid;

Technical Note:

Holding or storage vessels may have the following features:

1. Walls or internal structures with a boron equivalent (calculated for all constituent elements as defined in the note to OC004) of at least two per cent;

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.

f. Neutron measurement systems specially designed or prepared for integration and use with automated process control systems in a plant for the reprocessing of irradiated "natural uranium", "depleted uranium" or "special fissile materials".

OB007 Plant for the conversion of plutonium and equipment specially designed or prepared therefor, as follows:

a. Systems for the conversion of plutonium nitrate to oxide;

b. Systems for plutonium metal production.

**OC Materials**

OC001 "Natural uranium" or "depleted uranium" or thorium in the form of metal, alloy, chemical compound or concentrate and any other material containing one or more of the foregoing;

Note: OC001 does not control the following:

a. Four grammes or less of "natural uranium" or "depleted uranium" when contained in a sensing component in instruments;

b. "Depleted uranium" specially fabricated for the following civil non-nuclear applications:

1. Shielding;

2. Packaging;

3. Ballasts having a mass not greater than 100 kg;

4. Counter-weights having a mass not greater than 100 kg;

c. Alloys containing less than 5 % thorium;

d. Ceramic products containing thorium, which have been manufactured for non-nuclear use.

OC002 "Special fissile materials"

Note: OC002 does not control four "effective grammes" or less when contained in a sensing component in instruments.

OC003 Deuterium, heavy water (deuterium oxide) and other compounds of deuterium, and mixtures and solutions containing deuterium, in which the isotopic ratio of deuterium to hydrogen exceeds 1:5 000.

0C004 Graphite having a purity level better than 5 parts per million 'boron equivalent' and with a density greater than 1,50 g/cm<sup>3</sup> for use in a "nuclear reactor", in quantities exceeding 1 kg.

N.B.: SEE ALSO 1C107

Note 1: For the purpose of export control, the competent authorities of the Member State in which the exporter is established will determine whether or not the exports of graphite meeting the above specifications are for "nuclear reactor" use.

Note 2: In 0C004, 'boron equivalent' (BE) is defined as the sum of BE<sub>Z</sub> for impurities (excluding BE<sub>carbon</sub> since carbon is not considered an impurity) including boron, where:

BE<sub>Z</sub> (ppm) = CF × concentration of element Z in ppm;

where CF is the conversion factor =  $\frac{\sigma_Z A_B}{\sigma_B A_Z}$

and  $\sigma_B$  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.

0C005 Specially prepared compounds or powders for the manufacture of gaseous diffusion barriers, resistant to corrosion by UF<sub>6</sub> (e.g. nickel or alloy containing 60 weight per cent or more nickel, aluminium oxide and fully fluorinated hydrocarbon polymers), having a purity of 99,9 % by weight or more and a particle size less than 10 µm measured by American Society for Testing and Materials (ASTM) B330 standard and a high degree of particle size uniformity.

#### 0D Software

0D001 "Software" specially designed or modified for the "development", "production" or "use" of goods specified in this Category.

#### 0E Technology

0E001 "Technology" according to the Nuclear Technology Note for the "development", "production" or "use" of goods specified in this Category.

### CATEGORY 1 — SPECIAL MATERIALS AND RELATED EQUIPMENT

#### 1A Systems, Equipment and Components

1A001 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 in 1C009.b. or 1C009.c.;
- b. Piezoelectric polymers and copolymers, made from vinylidene fluoride (CAS 75-38-7) materials, specified in 1C009.a., having all of the following:
  1. In sheet or film form; and
  2. With a thickness exceeding 200 µm;
- c. Seals, gaskets, valve seats, bladders or diaphragms, having all of the following:
  1. Made from fluoroelastomers containing at least one vinyl ether group as a constitutional unit; and
  2. Specially designed for "aircraft", aerospace or 'missile' use.

Note: In 1A001.c., 'missile' means complete rocket systems and unmanned aerial vehicle systems.

1A002 “Composite” structures or laminates, having any of the following:

N.B.: SEE ALSO 1A202, 9A010 and 9A110

- a. Consisting of an organic “matrix” and materials specified in 1C010.c., 1C010.d. or 1C010.e.; or
- b. Consisting of 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  $10,15 \times 10^6$  m; and
    - b. A “specific tensile strength” exceeding  $17,7 \times 10^4$  m; or
  2. Materials specified in 1C010.c.

Note 1: 1A002 does not control composite structures or laminates made from epoxy resin impregnated carbon “fibrous or filamentary materials” for the repair of “civil aircraft” structures or laminates, having all of the following:

- a. An area not exceeding 1 m<sup>2</sup>;
- b. A length not exceeding 2,5 m; and
- c. A width exceeding 15 mm.

Note 2: 1A002 does not control 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: 1A002.b.1. does not control 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: 1A002 does not control finished items specially designed for a specific application.

1A003 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: 1A003 does not control 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 1C008.a.3.

1A004 Protective and detection equipment and components not specially designed for military use, as follows:

N.B.: SEE ALSO MILITARY GOODS CONTROLS, 2B351 AND 2B352.

## 1A004 (continued)

- 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:* 1A004.a. includes Powered Air Purifying Respirators (PAPR) that are designed or modified for defence against agents or materials, listed in 1A004.a.

*Technical Note:*

For the purposes of 1A004.a.:

1. Full face masks are also known as gas masks.
2. Filter canisters include filter cartridges.
1. Biological agents “adapted for use in war”;
2. Radioactive materials “adapted for use in war”;
3. Chemical warfare (CW) agents; or
4. “Riot control agents”, including:
  - a.  $\alpha$ -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, Phenylacetyl chloride ( $\omega$ -chloroacetophenone) (CN) (CAS 532-27-4);
  - d. Dibenz-(b,f)-1,4-oxazaphine (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 “adapted for use in war”;
  2. Radioactive materials “adapted for use in war”; 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 “adapted for use in war”;
  2. Radioactive materials “adapted for use in war”; 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:* 1A004.d. does not control equipment specially designed for laboratory use.

*Note 2:* 1A004.d. does not control non-contact walk-through security portals.



1A004 (continued)

Note: 1A004 does not control:

- 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. 1A004 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 “adapted for use in war”, biological agents “adapted for use in war”, 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’ is a substance or material that is used in place of toxic agent (chemical or biological) in training, research, testing or evaluation.

1A005 Body armour and components therefor, as follows:

N.B.: SEE ALSO MILITARY GOODS CONTROLS.

- 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.: For “fibrous or filamentary materials” used in the manufacture of body armour, see 1C010.

Note 1: 1A005 does not control body armour when accompanying its user for the user’s own personal protection.

Note 2: 1A005 does not control body armour designed to provide frontal protection only from both fragment and blast from non-military explosive devices.

Note 3: 1A005 does not control body armour designed to provide protection only from knife, spike, needle or blunt trauma.

1A006 Equipment, specially designed or modified for the disposal of improvised explosive devices, as follows, and specially designed components and accessories therefor:

N.B.: SEE ALSO MILITARY GOODS CONTROLS.

- a. Remotely operated vehicles;
- b. 'Disruptors'.

Technical Note:

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

Note: 1A006 does not control equipment when accompanying its operator.

1A007 Equipment and devices, specially designed to initiate charges and devices containing "energetic materials", by electrical means, as follows:

N.B.: SEE ALSO MILITARY GOODS CONTROLS, 3A229 AND 3A232.

- a. Explosive detonator firing sets designed to drive explosive detonators specified in 1A007.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 1A007.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 vaporization of the electrical conductor drives a flyer or slapper across a gap, and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by magnetic force. The term exploding foil detonator may refer to either an EB or a slapper-type detonator.

1A008 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 in 1A008.b., and severing tools, having a Net Explosive Quantity (NEQ) greater than 3,5 kg.

Technical Note:

'Shaped charges' are explosive charges shaped to focus the effects of the explosive blast.

1A102 Resaturated pyrolyzed carbon-carbon components designed for space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

1A202 Composite structures, other than those specified in 1A002, in the form of tubes and having both of the following characteristics:

*N.B.: SEE ALSO 9A010 AND 9A110.*

- a. An inside diameter of between 75 mm and 400 mm; and
- b. Made with any of the “fibrous or filamentary materials” specified in 1C010.a. or b. or 1C210.a. or with carbon prepreg materials specified in 1C210.c.

1A225 Platinized catalysts specially designed or prepared for promoting the hydrogen isotope exchange reaction between hydrogen and water for the recovery of tritium from heavy water or for the production of heavy water.

1A226 Specialized packings which may be used in separating heavy water from ordinary water, having both of the following characteristics:

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

1A227 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<sup>2</sup>;
- b. A density greater than 3 g/cm<sup>3</sup>; and
- c. A thickness of 100 m or greater.

*Technical Note:*

*In 1A227 the term ‘cold area’ means the viewing area of the window exposed to the lowest level of radiation in the design application.*

## **1B Test, Inspection and Production Equipment**

1B001 Equipment for the production or inspection of “composite” structures or laminates specified in 1A002 or “fibrous or filamentary materials” specified in 1C010, as follows, and specially designed components and accessories therefor:

*N.B.: SEE ALSO 1B101 AND 1B201.*

- 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;

*Note: In 1B001.b. ‘missile’ means complete rocket systems and unmanned aerial vehicle systems.*

*Technical Note:*

*For the purposes of 1B001.b., ‘tape-laying machines’ have the ability to lay one or more ‘filament bands’ limited to widths greater than 25 mm and less than or equal to 305 mm, and to cut and restart individual ‘filament band’ courses during the laying process.*

1B001 (continued)

- 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 1B001.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 preregs specified in 1C010.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 1B001.g., ‘tow-placement machines’ have the ability to place one or more ‘filament bands’ having widths less than or equal to 25 mm, and to cut and restart individual ‘filament band’ courses during the placement process.*

*Technical Note:*

1. *For the purpose of 1B001, ‘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 1B001., a ‘filament band’ is a single continuous width of fully or partially resin-impregnated tape, tow or fibre.*

1B002 Equipment for producing metal alloys, metal alloy powder or alloyed materials, specially designed to avoid contamination and specially designed for use in one of the processes specified in 1C002.c.2.

N.B.: SEE ALSO 1B102.

- 1B003 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 in 1B003.a. or for engines specified in 1B003.b.

- 1B101 Equipment, other than that specified in 1B001, for the “production” of structural composites as follows; and specially designed components and accessories therefor:

N.B.: SEE ALSO 1B201.

Note: Components and accessories specified in 1B101 include moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.

- a. Filament winding machines or fibre placement machines, of which the motions for positioning, wrapping and winding fibres can be coordinated and programmed in three or more axes, designed to fabricate composite structures or laminates from fibrous or filamentary materials, and coordinating and programming controls;
- b. Tape-laying machines of which the motions for positioning and laying tape and sheets can be coordinated and programmed in two or more axes, designed for the manufacture of composite airframe and “missile” structures;
- c. 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);
- d. Equipment designed or modified for special fibre surface treatment or for producing prepregs and preforms specified in entry 9C110.

Note: 1B101.d. includes rollers, tension stretchers, coating equipment, cutting equipment and clicker dies.

- 1B102 Metal powder “production equipment”, other than that specified in 1B002, and components as follows:

N.B.: SEE ALSO 1B115.b.

- a. Metal powder “production equipment” usable for the “production”, in a controlled environment, of spherical, spheroidal or atomised materials specified in 1C011.a., 1C011.b., 1C111.a.1., 1C111.a.2. or in the Military Goods Controls.
- b. Specially designed components for “production equipment” specified in 1B002 or 1B102.a.

Note: 1B102 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. Electrobust 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).

- 1B115 Equipment, other than that specified in 1B002 or 1B102, for the production of propellant and propellant constituents, as follows, and specially designed components therefor:
- a. "Production equipment" for the "production", handling or acceptance testing of liquid propellants or propellant constituents specified in 1C011.a., 1C011.b., 1C111 or in the Military Goods Controls;
  - b. "Production equipment" for the "production", handling, mixing, curing, casting, pressing, machining, extruding or acceptance testing of solid propellants or propellant constituents specified in 1C011.a., 1C011.b., 1C111 or in the Military Goods Controls.
- Note:* 1B115.b. does not control batch mixers, continuous mixers or fluid energy mills. For the control of batch mixers, continuous mixers and fluid energy mills see 1B117, 1B118 and 1B119.
- Note 1:* For equipment specially designed for the production of military goods, see the Military Goods Controls.
- Note 2:* 1B115 does not control equipment for the "production", handling and acceptance testing of boron carbide.
- 1B116 Specially designed nozzles for producing pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1 573 K (1 300 °C) to 3 173 K (2 900 °C) temperature range at pressures of 130 Pa to 20 kPa.
- 1B117 Batch mixers with provision for mixing under vacuum in the range of zero to 13,326 kPa and with temperature control capability of the mixing chamber and having all of the following, and specially designed components therefor:
- a. A total volumetric capacity of 110 litres or more; and
  - b. At least one 'mixing/kneading shaft' mounted off centre.
- Note:* In 1B117.b. the term 'mixing/kneading shaft' does not refer to deagglomerators or knife-spindles.
- 1B118 Continuous mixers with provision for mixing under vacuum in the range of zero to 13,326 kPa and with a temperature control capability of the mixing chamber having any of the following, and specially designed components therefor:
- a. Two or more mixing/kneading shafts; or
  - b. A single rotating shaft which oscillates and having kneading teeth/pins on the shaft as well as inside the casing of the mixing chamber.
- 1B119 Fluid energy mills usable for grinding or milling substances specified in 1C011.a., 1C011.b., 1C111 or in the Military Goods Controls, and specially designed components therefor.
- 1B201 Filament winding machines, other than those specified in 1B001 or 1B101, 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 1B201.a.;
  - c. Precision mandrels for the filament winding machines specified in 1B201.a.

- 1B225 Electrolytic cells for fluorine production with an output capacity greater than 250 g of fluorine per hour.
- 1B226 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.

*Note:* 1B226 includes separators:

- a. Capable of enriching stable isotopes;
- b. With the ion sources and collectors both in the magnetic field and those configurations in which they are external to the field.

- 1B228 Hydrogen-cryogenic distillation columns having all of the following characteristics:
- a. Designed for operation with internal temperatures of 35 K (– 238 °C) or less;
  - b. Designed for operation at an internal pressure of 0,5 to 5 MPa;
  - c. Constructed of either:
    1. Stainless steel of the 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 H<sub>2</sub>-compatible; and
  - d. With internal diameters of 30 cm or greater and 'effective lengths' of 4 m or greater.

*Technical Note:*

*In 1B228 'effective length' means the active height of packing material in a packed-type column, or the active height of internal contactor plates in a plate-type column.*

- 1B229 Water-hydrogen sulphide exchange tray columns and 'internal contactors', as follows:

*N.B.:* For columns which are specially designed or prepared for the production of heavy water see OBO04.

- a. Water-hydrogen sulphide exchange tray columns, having all of the following characteristics:
  1. Can operate at pressures of 2 MPa or greater;
  2. Constructed of carbon steel having an austenitic ASTM (or equivalent standard) grain size number of 5 or greater; and
  3. With a diameter of 1,8 m or greater;
- b. 'Internal contactors' for the water-hydrogen sulphide exchange tray columns specified in 1B229.a.

*Technical Note:*

*'Internal contactors' of the columns are segmented trays which have an effective assembled diameter of 1,8 m or greater, are designed to facilitate countercurrent contacting and are constructed of stainless steels with a carbon content of 0,03 % or less. These may be sieve trays, valve trays, bubble cap trays, or turbogrid trays.*

- 1B230 Pumps capable of circulating solutions of concentrated or dilute potassium amide catalyst in liquid ammonia (KNH<sub>2</sub>/NH<sub>3</sub>), having all of the following characteristics:
- a. Airtight (i.e., hermetically sealed);
  - b. A capacity greater than 8,5 m<sup>3</sup>/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.

- 1B231 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 purification systems using metal hydrides as the storage or purification medium.
- 1B232 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.
- 1B233 Lithium isotope separation facilities or plants, and systems and equipment therefor, as follows:
- 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 components therefor;
  - d. Chemical exchange systems (employing crown ethers, cryptands, or lariat ethers), specially designed for lithium isotope separation, and specially designed components therefor.
- 1B234 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:
- N.B.: SEE ALSO MILITARY GOODS CONTROLS.
- a. Designed to fully contain an explosion equivalent to 2 kg of TNT or greater; and
  - b. Having design elements or features enabling real time or delayed transfer of diagnostic or measurement information.

## 1C **Materials**

### Technical Note:

#### *Metals and alloys:*

*Unless provision to the contrary is made, the words 'metals' and 'alloys' in 1C001 to 1C012 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):*



**1C** (continued)

- 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.

1C001 Materials specially designed for use as absorbers of electromagnetic waves, or intrinsically conductive polymers, as follows:

N.B.: SEE ALSO 1C101.

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

Note 1: 1C001.a. does not control:

- a. Hair type absorbers, constructed of natural or synthetic fibres, with non-magnetic loading to provide absorption;
- b. Absorbers having no magnetic loss and whose incident surface is non-planar in shape, including pyramids, cones, wedges and convoluted surfaces;
- c. Planar absorbers, having all of the following:
  1. Made from any of the following:
    - a. Plastic foam materials (flexible or non-flexible) with carbon-loading, or organic materials, including binders, providing more than 5 % echo compared with metal over a bandwidth exceeding  $\pm 15$  % of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 450 K (177 °C); or
    - b. Ceramic materials providing more than 20 % echo compared with metal over a bandwidth exceeding  $\pm 15$  % of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 800 K (527 °C);

Technical Note:

Absorption test samples for 1C001.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  $7 \times 10^6$  N/m<sup>2</sup>; and
3. Compressive strength less than  $14 \times 10^6$  N/m<sup>2</sup>;
- 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).

Note 2: Nothing in Note 1 to 1C001.a. releases magnetic materials to provide absorption when contained in paint.

## 1C001 (continued)

- b. Materials for absorbing frequencies exceeding  $1,5 \times 10^{14}$  Hz but less than  $3,7 \times 10^{14}$  Hz and not transparent to visible light;

*Note:* 1C001.b. does not control 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.

*Note:* 1C001.c. does not control materials in a liquid form.

Technical Note:

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

## 1C002 Metal alloys, metal alloy powder and alloyed materials, as follows:

N.B.: SEE ALSO 1C202.

*Note:* 1C002 does not control metal alloys, metal alloy powder and alloyed materials for coating substrates.

Technical Notes:

1. The metal alloys in 1C002 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 (Kt) 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 in 1C002.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;

- 1C002    b. (*continued*)
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<sup>9</sup> 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"; or
    - g. "Mechanical alloying"; and
  3. Capable of forming materials specified in 1C002.a. or 1C002.b.;

1C002 (continued)

- d. Alloyed materials having all of the following:
1. Made from any of the composition systems specified in 1C002.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".

1C003 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 1C003.c. are those materials having a crystal grain size of 50 nm or less, as determined by X-ray diffraction.*

1C004 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<sup>3</sup>;
- b. An elastic limit exceeding 880 MPa;
- c. An ultimate tensile strength exceeding 1 270 MPa; and
- d. An elongation exceeding 8 %.

1C005 "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  $0,28 \times 10^{-4}$  mm<sup>2</sup> (6  $\mu$ m in diameter for circular 'filaments');

1C005 (continued)

- 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<sup>2</sup> 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 1C005 'filaments' may be in wire, cylinder, film, tape or ribbon form.*

1C006 Fluids and lubricating materials, as follows:

- a. Hydraulic fluids containing, as their principal ingredients, any of the following:

1. Synthetic 'silahydrocarbon oils' having all of the following:

Technical Note:

*For the purpose of 1C006.a.1., 'silahydrocarbon oils' contain exclusively silicon, hydrogen and carbon.*

- a. A 'flash point' exceeding 477 K (204 °C);
- b. A 'pour point' at 239 K (- 34 °C) or less;
- c. A 'viscosity index' of 75 or more; and
- d. A 'thermal stability' at 616 K (343 °C); or

2. 'Chlorofluorocarbons' having all of the following:

Technical Note:

*For the purpose of 1C006.a.2., 'chlorofluorocarbons' contain exclusively carbon, fluorine and chlorine.*

- a. No 'flash point';
- b. An 'autogenous ignition temperature' exceeding 977 K (704 °C);
- c. A 'pour point' at 219 K (- 54 °C) or less;
- d. A 'viscosity index' of 80 or more; and
- e. A boiling point at 473 K (200 °C) or higher;

- b. Lubricating materials containing, as their principal ingredients, any of the following:

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<sup>2</sup>/s (5 000 centistokes) measured at 298 K (25 °C);

1C006 (continued)

- 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:* 1C006.d. does not control materials specified and packaged as medical products.

Technical Note:

For the purpose of 1C006:

1. 'Flash point' is determined using the Cleveland Open Cup Method described in ASTM D-92 or national equivalents;
2. 'Pour point' is determined using the method described in ASTM D-97 or national equivalents;
3. 'Viscosity index' is determined using the method described in ASTM D-2270 or national equivalents;
4. 'Thermal stability' is determined by the following test procedure or national equivalents:

Twenty ml of the fluid under test is placed in a 46 ml type 317 stainless steel chamber containing one each of 12,5 mm (nominal) diameter balls of M-10 tool steel, 52100 steel and naval bronze (60 % Cu, 39 % Zn, 0,75 % Sn);

The chamber is purged with nitrogen, sealed at atmospheric pressure and the temperature raised to and maintained at  $644 \pm 6$  K ( $371 \pm 6$  °C) for six hours;

The specimen will be considered thermally stable if, on completion of the above procedure, all of the following conditions are met:

  - a. The loss in weight of each ball is less than 10 mg/mm<sup>2</sup> of ball surface;
  - b. The change in original viscosity as determined at 311 K (38 °C) is less than 25%; and
  - c. The total acid or base number is less than 0,40;
5. 'Autogenous ignition' temperature is determined using the method described in ASTM E-659 or national equivalents.

1C007 Ceramic base materials, non-“composite” ceramic materials, ceramic-“matrix”, “composite” materials and precursor materials, as follows:

*N.B.: SEE ALSO 1C107.*

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

*Note: 1C007.b. does not control abrasives.*

c. Ceramic-ceramic “composite” materials with a glass or oxide-“matrix” and reinforced with fibres having all of the following:

1. Made from any of the following materials:

- a. Si-N;
- b. Si-C;
- c. Si-Al-O-N; or
- d. Si-O-N; and

2. Having a “specific tensile strength” exceeding  $12,7 \times 10^3$  m;

d. Ceramic-ceramic “composite” materials, with or without a continuous metallic phase, incorporating particles, whiskers or fibres, where carbides or nitrides of silicon, zirconium or boron form the “matrix”;

e. Precursor materials (i.e., special purpose polymeric or metallo-organic materials) for producing any phase or phases of the materials specified in 1C007.c., as follows:

1. Polydiorganosilanes (for producing silicon carbide);
2. Polysilazanes (for producing silicon nitride);
3. Polycarbosilazanes (for producing ceramics with silicon, carbon and nitrogen components);

f. Ceramic-ceramic “composite” materials with an oxide or glass “matrix” reinforced with continuous fibres from any of the following systems:

1. Al<sub>2</sub>O<sub>3</sub> (CAS 1344-28-1); or
2. Si-C-N.

*Note: 1C007.f. does not control “composites” containing fibres from these systems with a fibre tensile strength of less than 700 MPa at 1 273 K (1 000 °C) or fibre tensile creep resistance of more than 1 % creep strain at 100 MPa load and 1 273 K (1 000 °C) for 100 hours.*

1C008 Non-fluorinated polymeric substances as follows:

a. Imides, as follows:

1. Bismaleimides;
2. Aromatic polyamide-imides (PAI) having a ‘glass transition temperature (T<sub>g</sub>)’ exceeding 563 K (290 °C);
3. Aromatic polyimides having a ‘glass transition temperature (T<sub>g</sub>)’ exceeding 505 K (232 °C);

## 1C008 a. (continued)

4. Aromatic polyetherimides having a 'glass transition temperature ( $T_g$ )' exceeding 563 K (290 °C);

Note: 1C008.a. controls 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 1A003.

b. Thermoplastic liquid crystal copolymers having a heat distortion temperature exceeding 523 K (250 °C) measured according to ISO 75-2 (2004), method A or national equivalents, with a load of 1,80 N/mm<sup>2</sup> and composed of:

1. Any of the following compounds:

a. Phenylene, biphenylene or naphthalene; or

b. Methyl, tertiary-butyl or phenyl substituted phenylene, biphenylene or naphthalene; and

2. Any of the following acids:

a. Terephthalic acid (CAS 100-21-0);

b. 6-hydroxy-2 naphthoic acid (CAS 16712-64-4); or

c. 4-hydroxybenzoic acid (CAS 99-96-7);

c. Not used;

d. Polyarylene ketones;

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

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

Technical Note:

1. The 'glass transition temperature ( $T_g$ )' for 1C008.a.2. thermoplastic materials and 1C008.a.4. materials is determined using the method described in ISO 11357-2 (1999) or national equivalents

2. The 'glass transition temperature ( $T_g$ )' for 1C008.a.2. thermosetting materials and 1C008.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  $T_g$ .

## 1C009 Unprocessed fluorinated compounds as follows:

a. Copolymers of vinylidene fluoride having 75 % or more beta crystalline structure without stretching;

b. Fluorinated polyimides containing 10 % by weight or more of combined fluorine;

c. Fluorinated phosphazene elastomers containing 30 % by weight or more of combined fluorine.

## 1C010 "Fibrous or filamentary materials", as follows:

N.B.: SEE ALSO 1C210 AND 9C110.

a. Organic "fibrous or filamentary materials", having all of the following:

1. "Specific modulus" exceeding  $12,7 \times 10^6$  m; and

2. "Specific tensile strength" exceeding  $23,5 \times 10^4$  m;

Note: 1C010.a. does not control polyethylene.



1C010 (continued)

b. Carbon “fibrous or filamentary materials”, having all of the following:

1. “Specific modulus” exceeding  $14,65 \times 10^6$  m; and
2. “Specific tensile strength” exceeding  $26,82 \times 10^4$  m;

Note: 1C010.b. does not control:

- a. “Fibrous or filamentary materials”, for the repair of “civil aircraft” structures or laminates, having all of the following:
  1. An area not exceeding  $1 \text{ m}^2$ ;
  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  $2,54 \times 10^6$  m; and
2. Melting, softening, decomposition or sublimation point exceeding 1 922 K (1 649 °C) in an inert environment;

Note: 1C010.c. does not control:

- 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  $10 \times 10^6$  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.

Technical Notes:

1. For the purpose of calculating “specific tensile strength”, “specific modulus” or specific weight of “fibrous or filamentary materials” in 1C010.a., 1C010.b. or 1C010.c., 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 1C010. 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”.
- d. “Fibrous or filamentary materials”, having any of the following:
1. Composed of any of the following:
    - a. Polyetherimides specified in 1C008.a.; or
    - b. Materials specified in 1C008.b. to 1C008.f.; or
  2. Composed of materials specified in 1C010.d.1.a. or 1C010.d.1.b. and “commingled” with other fibres specified in 1C010.a., 1C010.b. or 1C010.c.;

## 1C010 (continued)

- 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 in 1C010.c.; or
    - b. Organic or carbon “fibrous or filamentary materials”, having all of the following:
      1. “Specific modulus” exceeding  $10,15 \times 10^6$  m; and
      2. “Specific tensile strength” exceeding  $17,7 \times 10^4$  m; and
  2. Having any of the following:
    - a. Resin or pitch, specified in 1C008 or 1C009.b.;
    - b. ‘Dynamic Mechanical Analysis glass transition temperature (DMA T<sub>g</sub>)’ equal to or exceeding 453 K (180 °C) and having a phenolic resin; or
    - c. ‘Dynamic Mechanical Analysis glass transition temperature (DMA T<sub>g</sub>)’ equal to or exceeding 505 K (232 °C) and having a resin or pitch, not specified in 1C008 or 1C009.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 1C010.a., 1C010.b. or 1C010.c.

Note 2: 1C010.e. does not control:

- a. Epoxy resin “matrix” impregnated carbon “fibrous or filamentary materials” (prepregs) for the repair of “civil aircraft” structures or laminates, having all the following:
  1. An area not exceeding 1 m<sup>2</sup>;
  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 1C008 or 1C009.b.

Technical Note:

The ‘Dynamic Mechanical Analysis glass transition temperature (DMA T<sub>g</sub>)’ for materials specified by 1C010.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.

## 1C011 Metals and compounds, as follows:

N.B.: SEE ALSO MILITARY GOODS CONTROLS and 1C111.

- 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;

1C011 a. (continued)

Technical Note:

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

Note: The metals or alloys specified in 1C011.a. are controlled whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.

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 in 1C011.b. are controlled whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.

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

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

N.B.: See also Military Goods Controls for metal powders mixed with other substances to form a mixture formulated for military purposes.

1C012 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: 1C012.a. does not control:

- a. Shipments with a plutonium content of 1 g or less;
- b. Shipments of 3 “effective grammes” or less when contained in a sensing component in instruments.

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

Note: 1C012.b. does not control shipments with a neptunium-237 content of 1 g or less.

1C101 Materials and devices for reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures, other than those specified in 1C001, usable in ‘missiles’, “missile” subsystems or unmanned aerial vehicles specified in 9A012.

Note 1: 1C101 includes:

- a. Structural materials and coatings specially designed for reduced radar reflectivity;
- b. Coatings, including paints, specially designed for reduced or tailored reflectivity or emissivity in the microwave, infrared or ultraviolet regions of the electromagnetic spectrum.

Note 2: 1C101 does not include coatings when specially used for the thermal control of satellites.

Technical Note:

In 1C101 ‘missile’ means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

1C102 Resaturated pyrolyzed carbon-carbon materials designed for space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

1C107 Graphite and ceramic materials, other than those specified in 1C007, as follows:

a. Fine grain graphites with a bulk density of 1,72 g/cm<sup>3</sup> or greater, measured at 288 K (15 °C), and having a grain size of 100 µm or less, usable for rocket nozzles and re-entry vehicle nose tips, which can be machined to any of the following products:

1. Cylinders having a diameter of 120 mm or greater and a length of 50 mm or greater;
2. 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
3. Blocks having a size of 120 mm × 120 mm × 50 mm or greater;

N.B.: See also 0C004

b. Pyrolytic or fibrous reinforced graphites, usable for rocket nozzles and reentry vehicle nose tips usable in “missiles”, space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;

N.B.: See also 0C004

c. Ceramic composite materials (dielectric constant less than 6 at any frequency from 100 MHz to 100 GHz) for use in radomes usable in “missiles”, space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;

d. Bulk machinable silicon-carbide reinforced unfired ceramic, usable for nose tips usable in “missiles”, space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;

e. Reinforced silicon-carbide ceramic composites, usable for nose tips, reentry vehicles and nozzle flaps usable in “missiles”, space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

1C111 Propellants and constituent chemicals for propellants, other than those specified in 1C011, as follows:

a. Propulsive substances:

1. Spherical or spheroidal aluminium powder, other than that specified in the Military Goods Controls, in particle size of less than 200 µm and an aluminium content of 97 % by weight or more, if at least 10 % of the total weight is made up of particles of less than 63 µm, according to ISO 2591:1988 or national equivalents;

Technical Note:

*A particle size of 63 µm (ISO R-565) corresponds to 250 mesh (Tyler) or 230 mesh (ASTM standard E-11).*

2. Metal powders, other than that specified in the Military Goods Controls, as follows:

a. Metal powders of zirconium, beryllium or magnesium, or alloys of these metals, if at least 90 % of the total particles by particle volume or weight are made up of particles of less than 60 µm (determined by measurement techniques such as using a sieve, laser diffraction or optical scanning), whether spherical, atomized, spheroidal, flaked or ground, consisting 97 % by weight or more of any of the following:

1. Zirconium;
2. Beryllium; or
3. Magnesium;

Technical Note:

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

1C111 a. 2. (continued)

- b. Metal powders of either boron 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 60 µm (determined by measurement techniques such as using a sieve, laser diffraction or optical scanning), whether spherical, atomised, spheroidal, flaked or ground;

*Note: 1C111a.2.a. and 1C111a.2.b. controls powder mixtures with a multimodal particle distribution (e.g. mixtures of different grain sizes) if one or more modes are controlled.*

3. Oxidiser substances usable in liquid propellant rocket engines as follows:

- a. Dinitrogen trioxide (CAS 10544-73-7);
- b. Nitrogen dioxide (CAS 10102-44-0)/dinitrogen tetroxide (CAS 10544-72-6);
- c. Dinitrogen pentoxide (CAS 10102-03-1);
- d. Mixed Oxides of Nitrogen (MON);

*Technical Note:*

*Mixed Oxides of Nitrogen (MON) are solutions of Nitric Oxide (NO) in Dinitrogen Tetroxide/Nitrogen Dioxide (N<sub>2</sub>O<sub>4</sub>/NO<sub>2</sub>) that can be used in missile systems. There are a range of compositions that can be denoted as MON<sub>i</sub> or MON<sub>ij</sub>, where i and j are integers representing the percentage of Nitric Oxide in the mixture (e.g., MON<sub>3</sub> contains 3 % Nitric Oxide, MON<sub>25</sub> 25 % Nitric Oxide. An upper limit is MON<sub>40</sub>, 40 % by weight).*

- e. SEE MILITARY GOODS CONTROLS for Inhibited Red Fuming Nitric Acid (IRFNA);
- f. SEE MILITARY GOODS CONTROLS AND 1C238 for compounds composed of fluorine and one or more of other halogens, oxygen or nitrogen.

4. Hydrazine derivatives as follows:

*N.B.: SEE ALSO MILITARY GOODS CONTROLS.*

- a. Trimethylhydrazine (CAS 1741-01-1);
- b. Tetramethylhydrazine (CAS 6415-12-9);
- c. N,N diallylhydrazine;
- d. Allylhydrazine (CAS 7422-78-8);
- e. Ethylene dihydrazine;
- f. Monomethylhydrazine dinitrate;
- g. Unsymmetrical dimethylhydrazine nitrate;
- h. Hydrazinium azide (CAS 14546-44-2);
- i. Dimethylhydrazinium azide;
- j. Hydrazinium dinitrate;
- k. Diimido oxalic acid dihydrazine (CAS 3457-37-2);
- l. 2-hydroxyethylhydrazine nitrate (HEHN);
- m. See Military Goods Controls for Hydrazinium perchlorate;
- n. Hydrazinium diperchlorate (CAS 13812-39-0);

- 1C111 a. 4. (continued)
- o. Methylhydrazine nitrate (MHN);
  - p. Diethylhydrazine nitrate (DEHN);
  - q. 3,6-dihydrazino tetrazine nitrate (1,4-dihydrazine nitrate) (DHTN);
5. High energy density materials, other than that specified in the Military Goods Controls, usable in 'missiles' or unmanned aerial vehicles specified in 9A012;
- a. Mixed fuel that incorporate both solid and liquid fuels, such as boron slurry, having a mass-based energy density of  $40 \times 10^6$  J/kg or greater;
  - b. Other high energy density fuels and fuel additives (e.g., cubane, ionic solutions, JP-10) having a volume-based energy density of  $37,5 \times 10^9$  J/m<sup>3</sup> or greater, measured at 20 °C and one atmosphere (101,325 kPa) pressure;  
*Note: 1C111.a.5.b. does not control fossil refined fuels and biofuels produced from vegetables, including fuels for engines certified for use in civil aviation, unless specially formulated for 'missiles' or unmanned aerial vehicles specified in 9A012.*
- Technical Note:  
In 1C111.a.5. 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.
- b. Polymeric substances:
- 1. Carboxy-terminated polybutadiene (including carboxyl-terminated polybutadiene) (CTPB);
  - 2. Hydroxy-terminated polybutadiene (included hydroxyl-terminated polybutadiene) (HTPB), other than that specified in the Military Goods Controls;
  - 3. Polybutadiene-acrylic acid (PBAA);
  - 4. Polybutadiene-acrylic acid-acrylonitrile (PBAN);
  - 5. Polytetrahydrofuran polyethylene glycol (TPEG);  
Technical Note:  
Polytetrahydrofuran polyethylene glycol (TPEG) is a block co-polymer of poly 1,4-Butanediol and polyethylene glycol (PEG).
- c. Other propellant additives and agents:
- 1. SEE MILITARY GOODS CONTROLS FOR Carboranes, decaboranes, pentaboranes and derivatives thereof;
  - 2. Triethylene glycol dinitrate (TEGDN) (CAS 111-22-8);
  - 3. 2-Nitrodiphenylamine (CAS 119-75-5);
  - 4. Trimethylolethane trinitrate (TMETN) (CAS 3032-55-1);
  - 5. Diethylene glycol dinitrate (DEGDN) (CAS 693-21-0);
  - 6. Ferrocene derivatives as follows:
    - a. See Military Goods Controls for catocene;
    - b. Ethyl ferrocene (CAS 1273-89-8);
    - c. Propyl ferrocene;

- 1C111 c. 6. (continued)
- d. See Military Goods Controls for n-butyl ferrocene;
  - e. Pentyl ferrocene (CAS 1274-00-6);
  - f. Dicyclopentyl ferrocene;
  - 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. See Military Goods Controls for ferrocene Carboxylic acids;
  - n. See Military Goods Controls for butacene;
  - o. Other ferrocene derivatives usable as rocket propellant burning rate modifiers, other than those specified in the Military Goods Controls.  
*Note: 1C111.c.6.o. does not control ferrocene derivatives that contain a six carbon aromatic functional group attached to the ferrocene molecule.*
7. 4,5 diazidomethyl-2-methyl-1,2,3-triazole (iso- DAMTR), other than that specified in the Military Goods Controls.

*Note: For propellants and constituent chemicals for propellants not specified in 1C111, see the Military Goods Controls.*

1C116 Maraging steels, useable in 'missiles', having all of the following:

N.B.: SEE ALSO 1C216.

- a. Having an ultimate tensile strength, measured at 293 K (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;
  - 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 1:

*Maraging steels are iron alloy:*

- 1. Generally characterised by high nickel, very low carbon content and the use of substitutional elements or precipitates to produce strengthening and age-hardening of the alloy; and
- 2. Subjected to heat treatment cycles to facilitate the martensitic transformation process (solution annealed stage) and subsequently age hardened (precipitation hardened stage).

Technical Note 2:

*In 1C116 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.*

- 1C117 Materials for the fabrication of 'missiles' components as follows:
- a. Tungsten and alloys in particulate form with a tungsten content of 97 % by weight or more and a particle size of  $50 \times 10^{-6}$  m (50  $\mu$ m) or less;
  - b. Molybdenum and alloys in particulate form with a molybdenum content of 97 % by weight or more and a particle size of  $50 \times 10^{-6}$  m (50  $\mu$ m) or less;
  - c. Tungsten materials in 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 by 120 mm by 50 mm or greater.

*Technical Note:*

*In 1C117 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.*

- 1C118 Titanium-stabilised duplex stainless steel (Ti-DSS) having all of the following:
- a. Having all of the following characteristics:
    1. Containing 17,0 - 23,0 weight percent chromium and 4,5 - 7,0 weight percent nickel;
    2. Having a titanium content of greater than 0,10 weight percent; and
    3. A ferritic-austenitic microstructure (also referred to as a two-phase microstructure) of which at least 10 percent is austenite by volume (according to ASTM E-1181-87 or national equivalents); and
  - b. Having 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.
- 1C202 Alloys, other than those specified in 1C002.b.3. or .b.4., as follows:
- a. Aluminium alloys having both of the following characteristics:
    1. 'Capable of' an ultimate tensile strength of 460 MPa or more at 293 K (20 °C); and
    2. In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm;
  - b. Titanium alloys having both of the following characteristics:
    1. 'Capable of' an ultimate tensile strength of 900 MPa or more at 293 K (20 °C); and
    2. In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.

*Technical Note:*

*The phrase alloys 'capable of' encompasses alloys before or after heat treatment.*



1C210 'Fibrous or filamentary materials' or prepregs, other than those specified in 1C010.a., b. or e., as follows:

a. Carbon or aramid 'fibrous or filamentary materials' having either of the following characteristics:

1. A "specific modulus" of  $12,7 \times 10^6$  m or greater; or
2. A "specific tensile strength" of  $23,5 \times 10^4$  m or greater;

*Note:* 1C210.a. does not control aramid 'fibrous or filamentary materials' having 0,25 % by weight or more of an ester based fibre surface modifier;

b. Glass 'fibrous or filamentary materials' having both of the following characteristics:

1. A "specific modulus" of  $3,18 \times 10^6$  m or greater; and
2. A "specific tensile strength" of  $7,62 \times 10^4$  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 1C210.a. or b.

*Technical Note:*

*The resin forms the matrix of the composite.*

*Note:* In 1C210, 'fibrous or filamentary materials' is restricted to continuous "monofilaments", "yarns", "rovings", "tows" or "tapes".

1C216 Maraging steel, other than that specified in 1C116, 'capable of' an ultimate tensile strength of 1 950 MPa or more, at 293 K (20 °C).

*Note:* 1C216 does not control forms in which all linear dimensions are 75 mm or less.

*Technical Note:*

*The phrase maraging steel 'capable of' encompasses maraging steel before or after heat treatment.*

1C225 Boron enriched in the boron-10 ( $^{10}\text{B}$ ) 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 1C225 mixtures containing boron include boron loaded materials.

*Technical Note:*

*The natural isotopic abundance of boron-10 is approximately 18,5 weight per cent (20 atom per cent).*

1C226 Tungsten, tungsten carbide, and alloys containing more than 90 % tungsten by weight, other than that specified by 1C117, having both of the following characteristics:

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

*Note:* 1C226 does not control manufactures specially designed as weights or gamma-ray collimators.

- 1C227 Calcium having both of the following characteristics:
- Containing less than 1 000 parts per million by weight of metallic impurities other than magnesium; and
  - Containing less than 10 parts per million by weight of boron.
- 1C228 Magnesium having both of the following characteristics:
- Containing less than 200 parts per million by weight of metallic impurities other than calcium; and
  - Containing less than 10 parts per million by weight of boron.
- 1C229 Bismuth having both of the following characteristics:
- A purity of 99,99 % or greater by weight; and
  - Containing less than 10 ppm (parts per million) by weight of silver.
- 1C230 Beryllium metal, alloys containing more than 50 % beryllium by weight, beryllium compounds, manufactures thereof, and waste or scrap of any of the foregoing, other than that specified in the Military Goods Controls.
- N.B.: SEE ALSO MILITARY GOODS CONTROLS.
- Note: 1C230 does not control the following:
- Metal windows for X-ray machines, or for bore-hole logging devices;
  - Oxide shapes in fabricated or semi-fabricated forms specially designed for electronic component parts or as substrates for electronic circuits;
  - Beryl (silicate of beryllium and aluminium) in the form of emeralds or aquamarines.
- 1C231 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.
- 1C232 Helium-3 (<sup>3</sup>He), mixtures containing helium-3, and products or devices containing any of the foregoing.
- Note: 1C232 does not control a product or device containing less than 1 g of helium-3.
- 1C233 Lithium enriched in the lithium-6 (<sup>6</sup>Li) isotope to greater than its natural isotopic abundance, and products or devices containing enriched lithium, as follows: elemental lithium, alloys, compounds, mixtures containing lithium, manufactures thereof, waste or scrap of any of the foregoing.
- Note: 1C233 does not control thermoluminescent dosimeters.
- Technical Note:
- The natural isotopic abundance of lithium-6 is approximately 6,5 weight per cent (7,5 atom per cent).
- 1C234 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, other than those specified in 0A001.f.
- Note: 1C234 does not control zirconium in the form of foil having a thickness of 0,10 mm or less.
- 1C235 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: 1C235 does not control a product or device containing less than  $1,48 \times 10^3$  GBq (40 Ci) of tritium.

1C236 'Radionuclides' appropriate for making neutron sources based on alpha-n reaction, other than those specified in 0C001 and 1C012.a., in the following forms:

- a. Elemental;
- b. Compounds having a total activity of 37 GBq/kg (1 Ci/kg) or greater;
- c. Mixtures having a total activity of 37 GBq/kg (1 Ci/kg) or greater;
- d. Products or devices containing any of the foregoing.

*Note:* 1C236 does not control a product or device containing less than 3,7 GBq (100 millicuries) of activity.

Technical Note:

In 1C236 'radionuclides' are any of the following:

- Actinium-225 (Ac-225)
- Actinium-227 (Ac-227)
- Californium-253 (Cf-253)
- Curium-240 (Cm-240)
- Curium-241 (Cm-241)
- Curium-242 (Cm-242)
- Curium-243 (Cm-243)
- Curium-244 (Cm-244)
- Einsteinium-253 (Es-253)
- Einsteinium-254 (Es-254)
- Gadolinium-148 (Gd-148)
- Plutonium-236 (Pu-236)
- Plutonium-238 (Pu-238)
- Polonium-208 (Po-208)
- Polonium-209 (Po-209)
- Polonium-210 (Po-210)
- Radium-223 (Ra-223)
- Thorium-227 (Th-227)
- Thorium-228 (Th-228)
- Uranium-230 (U-230)
- Uranium-232 (U-232)

1C237 Radium-226 (<sup>226</sup>Ra), radium-226 alloys, radium-226 compounds, mixtures containing radium-226, manufactures thereof, and products or devices containing any of the foregoing.

*Note:* 1C237 does not control the following:

- a. Medical applicators;
- b. A product or device containing less than 0,37 GBq (10 millicuries) of radium-226.

1C238 Chlorine trifluoride (ClF<sub>3</sub>).

1C239 High explosives, other than those specified in the Military Goods Controls, or substances or mixtures containing more than 2 % by weight thereof, with a crystal density greater than 1,8 g/cm<sup>3</sup> and having a detonation velocity greater than 8 000 m/s.

1C240 Nickel powder and porous nickel metal, other than those specified in 0C005, as follows:

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 American Society for Testing and Materials (ASTM) B330 standard;

b. Porous nickel metal produced from materials specified in 1C240.a.

Note: 1C240 does not control the following:

a. Filamentary nickel powders;

b. Single porous nickel sheets with an area of 1 000 cm<sup>2</sup> per sheet or less.

Technical Note:

1C240.b. refers to porous metal formed by compacting and sintering the materials in 1C240.a. to form a metal material with fine pores interconnected throughout the structure.

1C241 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.

1C350 Chemicals, which may be used as precursors for toxic chemical agents, as follows, and “chemical mixtures” containing one or more thereof:

N.B.: SEE ALSO MILITARY GOODS CONTROLS AND 1C450.

1. Thiodiglycol (111-48-8);
2. Phosphorus oxychloride (10025-87-3);
3. Dimethyl methylphosphonate (756-79-6);
4. SEE MILITARY GOODS CONTROLS for Methyl phosphonyl difluoride (676-99-3);
5. Methyl phosphonyl dichloride (676-97-1);
6. Dimethyl phosphite (DMP) (868-85-9);
7. Phosphorus trichloride (7719-12-2);
8. Trimethyl phosphite (TMP) (121-45-9);
9. Thionyl chloride (7719-09-7);
10. 3-Hydroxy-1-methylpiperidine (3554-74-3);
11. N,N-Diisopropyl-(beta)-aminoethyl chloride (96-79-7);
12. N,N-Diisopropyl-(beta)-aminoethane thiol (5842-07-9);

1C350 (continued)

13. 3-Quinuclidinol (1619-34-7);
14. Potassium fluoride (7789-23-3);
15. 2-Chloroethanol (107-07-3);
16. Dimethylamine (124-40-3);
17. Diethyl ethylphosphonate (78-38-6);
18. Diethyl-N,N-dimethylphosphoramidate (2404-03-7);
19. Diethyl phosphite (762-04-9);
20. Dimethylamine hydrochloride (506-59-2);
21. Ethyl phosphinyl dichloride (1498-40-4);
22. Ethyl phosphonyl dichloride (1066-50-8);
23. SEE MILITARY GOODS CONTROLS for Ethyl phosphonyl difluoride (753-98-0);
24. Hydrogen fluoride (7664-39-3);
25. Methyl benzilate (76-89-1);
26. Methyl phosphinyl dichloride (676-83-5);
27. N,N-Diisopropyl-(beta)-amino ethanol (96-80-0);
28. Pinacolyl alcohol (464-07-3);
29. SEE MILITARY GOODS CONTROLS for O-Ethyl-2-diisopropylaminoethyl methyl phosphonite (QL) (57856-11-8);
30. Triethyl phosphite (122-52-1);
31. Arsenic trichloride (7784-34-1);
32. Benzilic acid (76-93-7);
33. Diethyl methylphosphonite (15715-41-0);
34. Dimethyl ethylphosphonate (6163-75-3);
35. Ethyl phosphinyl difluoride (430-78-4);
36. Methyl phosphinyl difluoride (753-59-3);
37. 3-Quinuclidone (3731-38-2);
38. Phosphorus pentachloride (10026-13-8);
39. Pinacolone (75-97-8);
40. Potassium cyanide (151-50-8);
41. Potassium bifluoride (7789-29-9);
42. Ammonium hydrogen fluoride or ammonium bifluoride (1341-49-7);
43. Sodium fluoride (7681-49-4);

1C350 (continued)

44. Sodium bifluoride (1333-83-1);
45. Sodium cyanide (143-33-9);
46. Triethanolamine (102-71-6);
47. Phosphorus pentasulphide (1314-80-3);
48. Di-isopropylamine (108-18-9);
49. Diethylaminoethanol (100-37-8);
50. Sodium sulphide (1313-82-2);
51. Sulphur monochloride (10025-67-9);
52. Sulphur dichloride (10545-99-0);
53. Triethanolamine hydrochloride (637-39-8);
54. N,N-Diisopropyl-(Beta)-aminoethyl chloride hydrochloride (4261-68-1);
55. Methylphosphonic acid (993-13-5);
56. Diethyl methylphosphonate (683-08-9);
57. N,N-Dimethylaminophosphoryl dichloride (677-43-0);
58. Triisopropyl phosphite (116-17-6);
59. Ethyldiethanolamine (139-87-7);
60. O,O-Diethyl phosphorothioate (2465-65-8);
61. O,O-Diethyl phosphorodithioate (298-06-6);
62. Sodium hexafluorosilicate (16893-85-9);
63. Methylphosphonothioic dichloride (676-98-2).

Note 1: For exports to "States not Party to the Chemical Weapons Convention", 1C350 does not control "chemical mixtures" containing one or more of the chemicals specified in entries 1C350.1, .3, .5, .11, .12, .13, .17, .18, .21, .22, .26, .27, .28, .31, .32, .33, .34, .35, .36, .54, .55, .56, .57 and .63 in which no individually specified chemical constitutes more than 10% by the weight of the mixture.

Note 2: For exports to "States Party to the Chemical Weapons Convention", 1C350 does not control "chemical mixtures" containing one or more of the chemicals specified in entries 1C350.1, .3, .5, .11, .12, .13, .17, .18, .21, .22, .26, .27, .28, .31, .32, .33, .34, .35, .36, .54, .55, .56, .57 and .63 in which no individually specified chemical constitutes more than 30% by the weight of the mixture.

Note 3: 1C350 does not control "chemical mixtures" containing one or more of the chemicals specified in entries 1C350.2, .6, .7, .8, .9, .10, .14, .15, .16, .19, .20, .24, .25, .30, .37, .38, .39, .40, .41, .42, .43, .44, .45, .46, .47, .48, .49, .50, .51, .52, .53, .58, .59, .60, .61 and .62 in which no individually specified chemical constitutes more than 30% by the weight of the mixture.

Note 4: 1C350 does not control products identified as consumer goods packaged for retail sale for personal use or packaged for individual use.

1C351 Human and animal pathogens and “toxins”, as follows:

- a. Viruses, whether natural, enhanced or modified, either in the form of “isolated live cultures” or as material including living material which has been deliberately inoculated or contaminated with such cultures, as follows:
  1. African horse sickness virus;
  2. African swine fever virus;
  3. Andes virus;
  4. Avian influenza virus, which are:
    - a. Uncharacterised; or
    - b. Defined in Annex I(2) EC Directive 2005/94/EC (O.J. L 10 14.1.2006, p. 16) as having high pathogenicity, as follows:
      1. Type A viruses with an IVPI (intravenous pathogenicity index) in 6 week old chickens of greater than 1,2; or
      2. Type A viruses of the subtypes H5 or H7 with genome sequences codified for multiple basic amino acids at the cleavage site of the haemagglutinin molecule similar to that observed for other HPAI viruses, indicating that the haemagglutinin molecule can be cleaved by a host ubiquitous protease;
  5. Bluetongue virus;
  6. Chapare virus;
  7. Chikungunya virus;
  8. Choclo virus;
  9. Congo-Crimean haemorrhagic fever virus;
  10. Dengue fever virus;
  11. Dobrava-Belgrade virus;
  12. Eastern equine encephalitis virus;
  13. Ebola virus;
  14. Foot and mouth disease virus;
  15. Goat pox virus;
  16. Guanarito virus;
  17. Hantaan virus;
  18. Hendra virus (Equine morbillivirus);
  19. Herpes virus (Aujeszky's disease);
  20. Hog cholera virus (swine fever virus);
  21. Japanese encephalitis virus;
  22. Junin virus;
  23. Kyasanur Forest virus;
  24. Laguna Negra virus;
  25. Lassa fever virus;

- 1C351 a. (*continued*)
26. Louping ill virus;
  27. Lujo virus;
  28. Lumpy skin disease virus;
  29. Lymphocytic choriomeningitis virus;
  30. Machupo virus;
  31. Marburg virus;
  32. Monkey pox virus;
  33. Murray Valley encephalitis virus;
  34. Newcastle disease virus;
  35. Nipah virus;
  36. Omsk haemorrhagic fever virus;
  37. Oropouche virus;
  38. Peste des petits ruminants virus;
  39. Porcine enterovirus type 9 (swine vesicular disease virus);
  40. Powassan virus;
  41. Rabies virus and all other members of the Lyssavirus genus;
  42. Rift Valley fever virus;
  43. Rinderpest virus;
  44. Rocio virus;
  45. Sabia virus;
  46. Seoul virus;
  47. Sheep pox virus;
  48. Sin nombre virus;
  49. St Louis encephalitis virus;
  50. Teschen disease virus;
  51. Tick-borne encephalitis virus (Russian Spring-Summer encephalitis virus);
  52. Variola virus;
  53. Venezuelan equine encephalitis virus;
  54. Vesicular stomatitis virus;
  55. Western equine encephalitis virus;
  56. Yellow fever virus;
- b. Not used;



1C351 (continued)

- c. Bacteria, whether natural, enhanced or modified, either in the form of “isolated live cultures” or as material including living material which has been deliberately inoculated or contaminated with such cultures, as follows:
1. *Bacillus anthracis*;
  2. *Brucella abortus*;
  3. *Brucella melitensis*;
  4. *Brucella suis*;
  5. *Burkholderia mallei* (*Pseudomonas mallei*);
  6. *Burkholderia pseudomallei* (*Pseudomonas pseudomallei*);
  7. *Chlamydophila psittaci* (formally known as *Chlamydia psittaci*);
  8. *Clostridium argentinense* (formerly known as *Clostridium botulinum* Type G), botulinum neurotoxin producing strains;
  9. *Clostridium baratii*, botulinum neurotoxin producing strains;
  10. *Clostridium botulinum*;
  11. *Clostridium butyricum*, botulinum neurotoxin producing strains;
  12. *Clostridium perfringens* epsilon toxin producing types;
  13. *Coxiella burnetii*;
  14. *Francisella tularensis*;
  15. *Mycoplasma capricolum* subspecies *capripneumoniae* (strain F38);
  16. *Mycoplasma mycoides* subspecies *mycoides* SC (small colony);
  17. *Rickettsia prowasecki*;
  18. *Salmonella typhi*;
  19. Shiga toxin producing *Escherichia coli* (STEC) of serogroups O26, O45, O103, O104, O111, O121, O145, O157, and other shiga toxin producing serogroups;
  20. *Shigella dysenteriae*;
  21. *Vibrio cholerae*;
  22. *Yersinia pestis*;
- d. “Toxins”, as follows, and “sub-unit of toxins” thereof:
1. Botulinum toxins;
  2. *Clostridium perfringens* alpha, beta 1, beta 2, epsilon and iota toxins;
  3. Conotoxin;
  4. Ricin;
  5. Saxitoxin;

## 1C351 d. (continued)

## 6. Shiga toxin;

*Technical Note:*

*Shiga toxin producing Escherichia coli (STEC) is also known as enterohaemorrhagic E. coli (EHEC) or verocytotoxin producing E. coli (VTEC).*

## 7. Staphylococcus aureus enterotoxins, hemolysin alpha toxin, and toxic shock syndrome toxin (formerly known as Staphylococcus enterotoxin F);

## 8. Tetrodotoxin;

## 9. Verotoxin and shiga-like ribosome inactivating proteins;

## 10. Microcystin (Cyanginosin);

## 11. Aflatoxins;

## 12. Abrin;

## 13. Cholera toxin;

## 14. Diacetoxyscirpenol toxin;

## 15. T-2 toxin;

## 16. HT-2 toxin;

## 17. Modeccin;

## 18. Volkensin;

## 19. Viscum album Lectin 1 (Viscumin);

*Note: 1C351.d. does not control botulinum toxins or conotoxins in product form meeting all of the following criteria:*

*1. Are pharmaceutical formulations designed for human administration in the treatment of medical conditions;*

*2. Are pre-packaged for distribution as medical products;*

*3. Are authorised by a state authority to be marketed as medical products.*

## e. Fungi, whether natural, enhanced or modified, either in the form of "isolated live cultures" or as material including living material which has been deliberately inoculated or contaminated with such cultures, as follows:

1. *Coccidioides immitis*;2. *Coccidioides posadasii*.

*Note: 1C351 does not control "vaccines" or "immunotoxins".*

## 1C352 Not used

## 1C353 Genetic elements and genetically modified organisms, as follows:

## a. Genetically modified organisms or genetic elements that contain nucleic acid sequences associated with pathogenicity of organisms specified in 1C351.a., 1C351.c, 1C351.e. or 1C354;

1C353 (continued)

- b. Genetically modified organisms or genetic elements that contain nucleic acid sequences coding for any of the “toxins” specified in 1C351.d. or “sub-units of toxins” thereof.

Technical Notes:

1. Genetically-modified organisms includes organisms in which the genetic material (nucleic acid sequences) has been altered in a way that does not occur naturally by mating and/or natural recombination, and encompasses those produced artificially in whole or in part.
2. Genetic elements include, inter alia, chromosomes, genomes, plasmids, transposons, and vectors whether genetically modified or unmodified, or chemically synthesized in whole or in part.
3. Nucleic acid sequences associated with the pathogenicity of any of the micro-organisms specified in 1C351.a., 1C351.c., 1C351.e. or 1C354 means any sequence specific to the specified micro-organism that:
  - a. In itself or through its transcribed or translated products represents a significant hazard to human, animal or plant health; or
  - b. Is known to enhance the ability of a specified micro-organism, or any other organism into which it may be inserted or otherwise integrated, to cause serious harm to humans, animals or plant health.

Note: 1C353 does not control nucleic acid sequences associated with the pathogenicity of enterohaemorrhagic *Escherichia coli*, serotype O157 and other verotoxin producing strains, other than those coding for the verotoxin, or for its sub-units.

1C354 Plant pathogens, as follows:

- a. Viruses, whether natural, enhanced or modified, either in the form of “isolated live cultures” or as material including living material which has been deliberately inoculated or contaminated with such cultures, as follows:
  1. Andean potato latent virus (Potato Andean latent tymovirus);
  2. Potato spindle tuber viroid;
- b. Bacteria, whether natural, enhanced or modified, either in the form of “isolated live cultures” or as material which has been deliberately inoculated or contaminated with such cultures, as follows:
  1. *Xanthomonas albilineans*;
  2. *Xanthomonas axonopodis* 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* (*Corynebacterium michiganensis* subsp. *sepedonicum* or *Corynebacterium sepedonicum*);
  5. *Ralstonia solanacearum*, race 3, biovar 2;
- c. Fungi, whether natural, enhanced or modified, either in the form of “isolated live cultures” or as material which has been deliberately inoculated or contaminated with such cultures, as follows:
  1. *Colletotrichum kahawae* (*Colletotrichum coffeanum* var. *virulans*);
  2. *Cochliobolus miyabeanus* (*Helminthosporium 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*]);

## 1C354 c. (continued)

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*.

## 1C450 Toxic chemicals and toxic chemical precursors, as follows, and “chemical mixtures” containing one or more thereof:

N.B.: SEE ALSO ENTRY 1C350, 1C351.d. AND MILITARY GOODS CONTROLS.

## a. Toxic chemicals, as follows:

1. Amiton: O,O-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate (78-53-5) and corresponding alkylated or protonated salts;
2. PFIB: 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene (382-21-8);
3. SEE MILITARY GOODS CONTROLS for BZ: 3-Quinuclidinyl benzilate (6581-06-2);
4. Phosgene: Carbonyl dichloride (75-44-5);
5. Cyanogen chloride (506-77-4);
6. Hydrogen cyanide (74-90-8);
7. Chloropicrin: Trichloronitromethane (76-06-2);

Note 1: For exports to “States not Party to the Chemical Weapons Convention”, 1C450 does not control “chemical mixtures” containing one or more of the chemicals specified in entries 1C450.a.1. and .a.2. in which no individually specified chemical constitutes more than 1 % by the weight of the mixture.

Note 2: For exports to “States Party to the Chemical Weapons Convention”, 1C450 does not control “chemical mixtures” containing one or more of the chemicals specified in entries 1C450.a.1. and .a.2. in which no individually specified chemical constitutes more than 30 % by the weight of the mixture.

Note 3: 1C450 does not control “chemical mixtures” containing one or more of the chemicals specified in entries 1C450.a.4., .a.5., .a.6. and .a.7. in which no individually specified chemical constitutes more than 30 % by the weight of the mixture.

Note 4: 1C450 does not control products identified as consumer goods packaged for retail sale for personal use or packaged for individual use.

## b. Toxic chemical precursors, as follows:

1. Chemicals, other than those specified in the Military Goods Controls or in 1C350, containing a phosphorus atom to which is bonded one methyl, ethyl or propyl (normal or iso) group but not further carbon atoms;

Note: 1C450.b.1 does not control Fonofos: O-Ethyl S-phenyl ethylphosphonothiothionate (944-22-9);

## 1C450 b. (continued)

2. N,N-Dialkyl [methyl, ethyl or propyl (normal or iso)] phosphoramidic dihalides, other than N,N-Dimethylaminophosphoryl dichloride;  
*N.B.:* See 1C350.57. for N,N-Dimethylaminophosphoryl dichloride.
3. Dialkyl [methyl, ethyl or propyl (normal or iso)] N,N-dialkyl [methyl, ethyl or propyl (normal or iso)]-phosphoramidates, other than Diethyl-N,N-dimethylphosphoramidate which is specified in 1C350;
4. N,N-Dialkyl [methyl, ethyl or propyl (normal or iso)] aminoethyl-2-chlorides and corresponding protonated salts, other than N,N-Diisopropyl-(beta)-aminoethyl chloride or N,N-Diisopropyl-(beta)-aminoethyl chloride hydrochloride which are specified in 1C350;
5. N-Dialkyl [methyl, ethyl or propyl (normal or iso)] aminoethane-2-ols and corresponding protonated salts, other than N,N-Diisopropyl-(beta)-aminoethanol (96-80-0) and N,N-Diethylaminoethanol (100-37-8) which are specified in 1C350;  
*Note:* 1C450.b.5. does not control the following:
  - a. N,N-Dimethylaminoethanol (108-01-0) and corresponding protonated salts;
  - b. Protonated salts of N,N-Diethylaminoethanol (100-37-8);
6. N,N-Dialkyl [methyl, ethyl or propyl (normal or iso)] aminoethane-2-thiols and corresponding protonated salts, other than N,N-Diisopropyl-(beta)-aminoethane thiol which is specified in 1C350;
7. See 1C350 for ethyldiethanolamine (139-87-7);
8. Methyldiethanolamine (105-59-9).

*Note 1:* For exports to “States not Party to the Chemical Weapons Convention”, 1C450 does not control “chemical mixtures” containing one or more of the chemicals specified in entries 1C450.b.1., .b.2., .b.3., .b.4., .b.5. and .b.6. in which no individually specified chemical constitutes more than 10 % by the weight of the mixture.

*Note 2:* For exports to “States Party to the Chemical Weapons Convention”, 1C450 does not control “chemical mixtures” containing one or more of the chemicals specified in entries 1C450.b.1., .b.2., .b.3., .b.4., .b.5. and .b.6. in which no individually specified chemical constitutes more than 30 % by the weight of the mixture.

*Note 3:* 1C450 does not control “chemical mixtures” containing one or more of the chemicals specified in entry 1C450.b.8. in which no individually specified chemical constitutes more than 30 % by the weight of the mixture.

*Note 4:* 1C450 does not control products identified as consumer goods packaged for retail sale for personal use or packaged for individual use.

**1D Software**

- 1D001 “Software” specially designed or modified for the “development”, “production” or “use” of equipment specified in 1B001 to 1B003.
- 1D002 “Software” for the “development” of organic “matrix”, metal “matrix” or carbon “matrix” laminates or “composites”.
- 1D003 “Software” specially designed or modified to enable equipment to perform the functions of equipment specified in 1A004.c. or 1A004.d.
- 1D101 “Software” specially designed or modified for the operation or maintenance of goods specified in 1B101, 1B102, 1B115, 1B117, 1B118 or 1B119.

1D103 “Software” specially designed for analysis of reduced observables such as radar reflectivity, ultraviolet/infrared signatures and acoustic signatures.

1D201 “Software” specially designed for the “use” of goods specified in 1B201.

**1E Technology**

1E001 “Technology” according to the General Technology Note for the “development” or “production” of equipment or materials specified in 1A001.b., 1A001.c., 1A002 to 1A005, 1A006.b., 1A007, 1B or 1C.

1E002 Other “technology” as follows:

- a. “Technology” for the “development” or “production” of polybenzothiazoles or polybenzoxazoles;
- b. “Technology” for the “development” or “production” of fluoroelastomer compounds containing at least one vinyl ether monomer;
- c. “Technology” for the design or “production” of the following base materials or non-“composite” ceramic materials:

1. Base materials having all of the following:

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

2. Non-“composite” ceramic materials composed of the materials specified in 1E002.c.1;

*Note: 1E002.c.2. does not control “technology” for the design or production of abrasives.*

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

1E002 (continued)

- e. "Technology" for the installation, maintenance or repair of materials specified in 1C001;
- f. "Technology" for the repair of "composite" structures, laminates or materials specified in 1A002, 1C007.c. or 1C007.d.;

*Note: 1E002.f. does not control "technology" for the repair of "civil aircraft" structures using carbon "fibrous or filamentary materials" and epoxy resins, contained in aircraft manufacturers' manuals.*

- g. 'Libraries (parametric technical databases)' specially designed or modified to enable equipment to perform the functions of equipment specified in 1A004.c. or 1A004.d.

Technical Note:

*For the purpose of 1E002.g., 'library (parametric technical database)' means a collection of technical information, reference to which may enhance the performance of relevant equipment or systems.*

1E101 "Technology" according to the General Technology Note for the "use" of goods specified in 1A102, 1B001, 1B101, 1B102, 1B115 to 1B119, 1C001, 1C101, 1C107, 1C111 to 1C118, 1D101 or 1D103.

1E102 "Technology" according to the General Technology Note for the "development" of "software" specified in 1D001, 1D101 or 1D103.

1E103 "Technology" for the regulation of temperature, pressure or atmosphere in autoclaves or hydroclaves, when used for the "production" of "composites" or partially processed "composites".

1E104 "Technology" relating to the "production" of pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1 573 K (1 300 °C) to 3 173 K (2 900 °C) temperature range at pressures of 130 Pa to 20 kPa.

*Note: 1E104 includes "technology" for the composition of precursor gases, flow-rates and process control schedules and parameters.*

1E201 "Technology" according to the General Technology Note for the "use" of goods specified in 1A002, 1A007, 1A202, 1A225 to 1A227, 1B201, 1B225 to 1B234, 1C002.b.3. or .b.4., 1C010.b., 1C202, 1C210, 1C216, 1C225 to 1C241 or 1D201.

1E202 "Technology" according to the General Technology Note for the "development" or "production" of goods specified in 1A007, 1A202 or 1A225 to 1A227.

1E203 "Technology" according to the General Technology Note for the "development" of "software" specified in 1D201.

## CATEGORY 2 — MATERIALS PROCESSING

### 2A Systems, Equipment and Components

*N.B.: For quiet running bearings, see the Military Goods Controls.*

2A001 Anti-friction bearings and bearing systems, as follows, and components therefor:

*N.B.: SEE ALSO 2A101.*

*Note: 2A001 does not control balls with tolerances specified by the manufacturer in accordance with ISO 3290 as grade 5 or worse.*

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

*Note: 2A001.a. does not control tapered roller bearings.*

2A001 (continued)

- b. Not used;
- 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.

2A101 Radial ball bearings, other than those specified in 2A001, 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 mm and 50 mm;
- b. An outer ring outside diameter between 25 mm and 100 mm; and
- c. A width between 10 mm and 20 mm.

2A225 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<sup>3</sup> and 8 000 cm<sup>3</sup>; 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<sub>2</sub>);
    - b. Calcium zirconate (metazirconate) (CaZrO<sub>3</sub>);
    - c. Cerium sulphide (Ce<sub>2</sub>S<sub>3</sub>);
    - d. Erbium oxide (erbia) (Er<sub>2</sub>O<sub>3</sub>);
    - e. Hafnium oxide (hafnia) (HfO<sub>2</sub>);
    - f. Magnesium oxide (MgO);
    - g. Nitrided niobium-titanium-tungsten alloy (approximately 50 % Nb, 30 % Ti, 20 % W);
    - h. Yttrium oxide (yttria) (Y<sub>2</sub>O<sub>3</sub>); or
    - i. Zirconium oxide (zirconia) (ZrO<sub>2</sub>);
- b. Crucibles having both of the following characteristics:
  - 1. A volume of between 50 cm<sup>3</sup> and 2 000 cm<sup>3</sup>; 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<sup>3</sup> and 2 000 cm<sup>3</sup>;
  - 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.



- 2A226 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 diameters, the 'nominal size' in 2A226 refers to the smallest diameter.

**2B 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 2B, 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 movement within the machine are performed such as:
  - a. Wheel-dressing systems in grinding machines;
  - b. Parallel rotary axes designed for mounting of separate workpieces;
  - c. Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.
3. Axis nomenclature shall be in accordance with International Standard ISO 841, 'Numerical Control Machines — Axis and Motion Nomenclature'.
4. For the purposes of 2B001 to 2B009 a "tilting spindle" is counted as a rotary axis.
5. 'Stated positioning accuracy' derived from measurements made according to ISO 230/2 or national equivalents may be used for each machine tool model as an alternative to individual machine tests. 'Stated positioning accuracy' means the accuracy value provided to the competent authorities of the Member State in which the exporter is established as representative of the accuracy of a specific machine model.

Determination of 'Stated Positioning Accuracy'

- a. Select five machines of a model to be evaluated;
  - b. Measure the linear axis accuracies according to ISO 230/2;
  - c. Determine the A-values for each axis of each machine. The method of calculating the A-value is described in the ISO standard;
  - d. Determine the mean value of the A-value of each axis. This mean value  $\hat{A}$  becomes the stated value of each axis for the model ( $\hat{A}_x \hat{A}_y \dots$ );
  - e. Since the Category 2 list refers to each linear axis there will be as many stated values as there are linear axes;
  - f. If any axis of a machine model not controlled by 2B001.a. to 2B001.c. or 2B201 has a stated accuracy  $\hat{A}$  equal to or less than the specified positioning accuracy of each machine tool model plus 2  $\mu\text{m}$ , the manufacturer should be required to reaffirm the accuracy level once every eighteen months.
6. For the purposes of 2B001.a. to 2B001.c., measurement uncertainty for the positioning accuracy of machine tools, as defined in the International Standard ISO 230/2 (2006) <sup>(1)</sup> or national equivalents, shall not be considered.

<sup>(1)</sup> such as in 2B001.a.1.

2B001 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:

N.B.: SEE ALSO 2B201.

Note 1: 2B001 does not control special purpose machine tools limited to the manufacture of gears. For such machines see 2B003.

Note 2: 2B001 does not control special purpose machine tools limited to the manufacture of any of the following:

- a. Crankshafts or camshafts;
- b. Tools or cutters;
- c. Extruder worms;
- d. Engraved or faceted 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 2B001.a., b. or c.

N.B.: For optical finishing machines, see 2B002.

a. Machine tools for turning having all of the following:

1. Positioning accuracy with “all compensations available” equal to or less (better) than 3,0 µm according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents along one or more linear axis; and
2. Two or more axes which can be coordinated simultaneously for “contouring control”;

Note: 2B001.a. does not control 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.

b. Machine tools for milling having any of the following:

1. Having all of the following:
  - a. Positioning accuracy with “all compensations available” equal to or less (better) than 3,0 µm according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents along one or more linear axis; and
  - b. Three linear axes plus one rotary axis which can be coordinated simultaneously for “contouring control”;
2. Five or more axes which can be coordinated simultaneously for “contouring control” having any of the following;

N.B.: ‘Parallel mechanism machine tools’ are specified in 2B001.b.2.d.

- a. Positioning accuracy with “all compensations available” equal to or less (better) than 3,0 µm according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents along one or more linear axis with a travel length less than 1 m;

<sup>(1)</sup> Manufacturers calculating positioning accuracy in accordance with ISO 230/2 (1988) or (1997) should consult the competent authorities of the Member State in which they are established.

2B001 b. 2. (continued)

- b. Positioning accuracy with “all compensations available” equal to or less (better) than  $4,5 \mu\text{m}$  according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents along one or more linear axis with a travel length equal to or greater than 1 m and less than 2 m;
- c. Positioning accuracy with “all compensations available” equal to or less (better) than  $4,5 + 7(L-2) \mu\text{m}$  (L is the travel length in meters) according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents along one or more linear axis with a travel length equal to or greater than 2 m; or
- d. Being a ‘parallel mechanism machine tool’;

Technical Note:

A ‘parallel mechanism machine tool’ is a machine tool having multiple rods which are linked with a platform and actuators; each of the actuators operates the respective rod simultaneously and independently.

- 3. A positioning accuracy for jig boring machines, with “all compensations available”, equal to or less (better) than  $3,0 \mu\text{m}$  according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents 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  $0,0004 \text{ mm TIR}$ ; 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. Positioning accuracy with “all compensations available” equal to or less (better) than  $3,0 \mu\text{m}$  according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents along one or more linear axis; and
    - b. Three or more axes which can be coordinated simultaneously for “contouring control”; or
  - 2. Five or more axes which can be coordinated simultaneously for “contouring control”;

Note: 2B001.c. does not control grinding machine 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 positioning accuracy with “all compensations available” less (better) than  $3,0 \mu\text{m}$  according to ISO 230/2 (2006) <sup>(1)</sup> or national equivalents.
- 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”;

<sup>(1)</sup> Manufacturers calculating positioning accuracy in accordance with ISO 230/2 (1988) or (1997) should consult the competent authorities of the Member State in which they are established.

2B001 (continued)

- 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.

2B002 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 2B002:*

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.

2B003 “Numerically controlled” or manual machine tools, and specially designed components, controls and accessories therefor, specially designed for the shaving, finishing, grinding or honing of hardened (Rc = 40 or more) spur, helical and double-helical gears with a pitch diameter exceeding 1 250 mm and a face width of 15 % of pitch diameter or larger finished to a quality of AGMA 14 or better (equivalent to ISO 1328 class 3).

2B004 Hot "isostatic presses" having all of the following, and specially designed components and accessories therefor:

N.B.: SEE ALSO 2B104 and 2B204.

- 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 1B003, 9B009 and the Military Goods Controls.

2B005 Equipment specially designed for the deposition, processing and in-process control of inorganic overlays, coatings and surface modifications, as follows, for non-electronic substrates, by processes shown in the Table and associated Notes following 2E003.f., and specially designed automated handling, positioning, manipulation and control components therefor:

- a. Chemical vapour deposition (CVD) production equipment having all of the following:

N.B.: SEE ALSO 2B105.

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;

2B005 (continued)

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<sup>2</sup> 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 the *in situ* measurement of any of the following:

1. Coating thickness on the substrate and rate control; or
2. Optical characteristics.

Note: 2B005 does not control chemical vapour deposition, cathodic arc, sputter deposition, ion plating or ion implantation equipment, specially designed for cutting or machining tools.

2B006 Dimensional inspection or measuring systems, equipment and “electronic assemblies”, as follows:

a. Computer controlled or “numerically 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.

N.B.: SEE ALSO 2B206.

b. Linear and angular displacement measuring instruments, as follows:

1. ‘Linear displacement’ measuring instruments having any of the following:

Note: Displacement measuring “laser” interferometers are only controlled in 2B006.b.1.c.

Technical Note:

For the purpose of 2B006.b.1. ‘linear displacement’ means the change of distance between the measuring probe and the measured object.

a. Non-contact type measuring systems with a “resolution” equal to or less (better) than 0,2 µm within a measuring range up to 0,2 mm;

2B006 b. 1. (continued)

b. Linear Variable Differential Transformer (LVDT) systems having all of the following:

1. Having any of the following:

- a. "Linearity" equal to or less (better) than 0,1 % measured from 0 to the 'full operating range', for LVDTs with a 'full operating range' up to and including  $\pm 5$  mm; or
- b. "Linearity" equal to or less (better) than 0,1 % measured from 0 to 5 mm for LVDTs with a 'full operating range' greater than  $\pm 5$  mm; and

2. Drift equal to or less (better) than 0,1 % per day at a standard ambient test room temperature  $\pm 1$  K;

*Technical Note:*

*For the purposes of 2B006.b.1.b., 'full operating range' is half of the total possible linear displacement of the LVDT. For example, LVDTs with a 'full operating range' up to and including  $\pm 5$  mm can measure a total possible linear displacement of 10 mm.*

c. Measuring systems having all of the following:

1. Containing a "laser"; and

2. Maintaining, for at least 12 hours, at a temperature of  $20 \pm 1$  °C, all of the following:

- a. A "resolution" over their full scale of  $0,1 \mu\text{m}$  or less (better); and
- b. Capable of achieving a "measurement uncertainty" equal to or less (better) than  $(0,2 + L/2\ 000) \mu\text{m}$  (L is the measured length in mm) at any point within a measuring range, when compensated for the refractive index of air; or

d. "Electronic assemblies" specially designed to provide feedback capability in systems specified in 2B006.b.1.c.;

*Note: 2B006.b.1. does not control measuring interferometer systems, with an automatic control system that is designed to use no feedback techniques, containing a "laser" to measure slide movement errors of machine-tools, dimensional inspection machines or similar equipment.*

2. Angular displacement measuring instruments having an angular position "accuracy" equal to or less (better) than  $0,00025^\circ$ ;

*Note: 2B006.b.2. does not control optical instruments, such as autocollimators, using collimated light (e.g., laser light) to detect angular displacement of a mirror.*

c. Equipment for measuring surface roughness (including surface defects), by measuring optical scatter with a sensitivity of  $0,5$  nm or less (better).

*Note: 2B006 includes machine tools, other than those specified by 2B001, that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function.*

2B007 "Robots" having any of the following characteristics and specially designed controllers and "end-effectors" therefor:

N.B.: SEE ALSO 2B207.

a. Capable in real time of full three-dimensional image processing or full three-dimensional 'scene analysis' to generate or modify "programmes" or to generate or modify numerical programme data;

*Technical Note:*

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

- 2B007 (continued)
- b. Specially designed to comply with national safety standards applicable to potentially explosive munitions environments;
- Note:* 2B007.b. does not control “robots” specially designed for paint-spraying booths.
- c. Specially designed or rated as radiation-hardened to withstand a total radiation dose greater than  $5 \times 10^3$  Gy (silicon) without operational degradation; or
- 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.
- d. Specially designed to operate at altitudes exceeding 30 000 m.
- 2B008 Assemblies or units, specially designed for machine tools, or dimensional inspection or measuring systems and equipment, as follows:
- a. Linear position feedback units having an overall “accuracy” less (better) than  $(800 + (600 \times L/1\ 000))$  nm (L equals the effective length in mm);
- N.B.:* For “laser” systems see also Note to 2B006.b.1.c. and d.
- b. Rotary position feedback units having an “accuracy” less (better) than 0,00025°;
- N.B.:* For “laser” systems see also Note to 2B006.b.2.
- Note:* 2B008.a. and 2B008.b. control units, which are designed to determine the positioning information for feedback control, such as inductive type devices, graduated scales, infrared systems or “laser” systems.
- c. “Compound rotary tables” and “tilting spindles”, capable of upgrading, according to the manufacturer’s specifications, machine tools to or above the levels specified in 2B.
- 2B009 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:
- N.B.:* SEE ALSO 2B109 AND 2B209.
- 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 2B009, machines combining the function of spin-forming and flow-forming are regarded as flow-forming machines.
- 2B104 “Isostatic presses”, other than those specified in 2B004, having all of the following:
- N.B.:* SEE ALSO 2B204.
- a. Maximum working pressure of 69 MPa or greater;
- b. Designed to achieve and maintain a controlled thermal environment of 873 K (600 °C) or greater; and
- c. Possessing a chamber cavity with an inside diameter of 254 mm or greater.
- 2B105 Chemical vapour deposition (CVD) furnaces, other than those specified in 2B005.a., designed or modified for the densification of carbon-carbon composites.



2B109 Flow-forming machines, other than those specified in 2B009, and specially designed components as follows:

N.B.: SEE ALSO 2B209.

a. Flow-forming machines having all of the following:

1. According to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control, even when not equipped with such units; and
2. With more than two axes which can be coordinated simultaneously for "contouring control".

b. Specially designed components for flow-forming machines specified in 2B009 or 2B109.a.

Note: 2B109 does not control machines that are not usable in the production of propulsion components and equipment (e.g. motor cases) for systems specified in 9A005, 9A007.a. or 9A105.a.

Technical Note:

*Machines combining the function of spin-forming and flow-forming are for the purpose of 2B109 regarded as flow-forming machines.*

2B116 Vibration test systems, equipment 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 designed for use with vibration test systems specified in 2B116.a.;

Technical Note:

*In 2B116.b., 'real-time control bandwidth' means 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 2B116.a.;
- d. Test piece support structures and electronic units designed to combine multiple shaker units in a system capable of providing an effective combined force equal to or greater than 50 kN, measured 'bare table', and usable in vibration systems specified in 2B116.a.

Technical Note:

*In 2B116, 'bare table' means a flat table, or surface, with no fixture or fittings.*

2B117 Equipment and process controls, other than those specified in 2B004, 2B005.a., 2B104 or 2B105, designed or modified for densification and pyrolysis of structural composite rocket nozzles and reentry vehicle nose tips.

2B119 Balancing machines and related equipment, as follows:

N.B.: SEE ALSO 2B219.

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;

2B119 a. (continued)

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;

*Note:* 2B119.a. does not control balancing machines designed or modified for dental or other medical equipment.

b. Indicator heads designed or modified for use with machines specified in 2B119.a.

*Technical Note:*

*Indicator heads are sometimes known as balancing instrumentation.*

2B120 Motion simulators or rate tables having all of the following characteristics:

- a. Two axes or more;
- b. Designed or modified to incorporate slip rings or integrated non-contact devices capable of transferring electrical power, signal information, or both; and
- c. Having any of the following characteristics:
  1. For any single axis having all of the following:
    - a. Capable of rates of 400 degrees/s or more, or 30 degrees/s or less; and
    - b. A rate resolution equal to or less than 6 degrees/s and an accuracy equal to or less than 0,6 degrees/s;
  2. Having a worst-case rate stability equal to or better (less) than plus or minus 0,05 % averaged over 10 degrees or more; or
  3. A positioning "accuracy" equal to or less (better) than 5 arc second.

*Note 1:* 2B120 does not control rotary tables designed or modified for machine tools or for medical equipment. For controls on machine tool rotary tables see 2B008.

*Note 2:* Motion simulators or rate tables specified in 2B120 remain controlled whether or not slip rings or integrated non-contact devices are fitted at time of export.

2B121 Positioning tables (equipment capable of precise rotary positioning in any axes), other than those specified in 2B120, having all the following characteristics:

- a. Two axes or more; and
- b. A positioning "accuracy" equal to or less (better) than 5 arc second.

*Note:* 2B121 does not control rotary tables designed or modified for machine tools or for medical equipment. For controls on machine tool rotary tables see 2B008.

2B122 Centrifuges capable of imparting accelerations above 100 g and designed or modified to incorporate slip rings or integrated non-contact devices capable of transferring electrical power, signal information, or both.

*Note:* Centrifuges specified in 2B122 remain controlled whether or not slip rings or integrated non-contact devices are fitted at time of export.

2B201 Machine tools and any combination thereof, other than those specified in 2B001, as follows, for removing or cutting metals, ceramics or “composites”, which, according to the manufacturer’s technical specification, can be equipped with electronic devices for simultaneous “contouring control” in two or more axes:

a. Machine tools for milling, having any of the following characteristics:

1. Positioning accuracies with “all compensations available” equal to or less (better) than 6 µm according to ISO 230/2 (1988) <sup>(1)</sup> or national equivalents along any linear axis; or
2. Two or more contouring rotary axes;

Note: 2B201.a. does not control milling machines having the following characteristics:

- a. X-axis travel greater than 2 m; and
- b. Overall positioning accuracy on the x-axis more (worse) than 30 µm.

b. Machine tools for grinding, having any of the following characteristics:

1. Positioning accuracies with “all compensations available” equal to or less (better) than 4 µm according to ISO 230/2 (1988) <sup>(1)</sup> or national equivalents along any linear axis; or
2. Two or more contouring rotary axes.

Note: 2B201.b. does not control the following grinding machines:

- a. Cylindrical external, internal, and external-internal grinding machines having all of the following characteristics:
  1. Limited to a maximum workpiece capacity of 150 mm outside diameter or length; and
  2. Axes limited to x, z and c;
- b. 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) <sup>(1)</sup> or national equivalents.

Note 1: 2B201 does not control special purpose machine tools limited to the manufacture of any of the following parts:

- a. Gears;
- b. Crankshafts or camshafts;
- c. Tools or cutters;
- d. Extruder worms.

Note 2: 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 2B001.a. or 2B201.a. or b.

2B204 “Isostatic presses”, other than those specified in 2B004 or 2B104, 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;

<sup>(1)</sup> Manufacturers calculating positioning accuracy in accordance with ISO 230/2 (1997) or (2006) should consult the competent authorities of the Member State in which they are established.

2B204 (continued)

- b. Dies, moulds and controls, specially designed for “isostatic presses” specified in 2B204.a.

Technical Note:

*In 2B204 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.*

2B206 Dimensional inspection machines, instruments or systems, other than those specified in 2B006, 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  $(1,25 + L/1\,000) \mu\text{m}$  (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  $(1,7 + L/800) \mu\text{m}$  (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, environments) and with all compensations available shall be compared to the  $1,7 + L/800 \mu\text{m}$  threshold.*

- b. Systems for simultaneous linear-angular inspection of hemishells, having both of the following characteristics:
1. “Measurement uncertainty” along any linear axis equal to or less (better) than  $3,5 \mu\text{m}$  per 5 mm; and
  2. “Angular position deviation” equal to or less than  $0,02^\circ$ .

Note 1: Machine tools that can be used as measuring machines are controlled if they meet or exceed the criteria specified for the machine tool function or the measuring machine function.

Note 2: A machine specified in 2B206 is controlled if it exceeds the control threshold anywhere within its operating range.

Technical Notes:

All parameters of measurement values in 2B206 represent plus/minus i.e., not total band.

2B207 “Robots”, “end-effectors” and control units, other than those specified in 2B007, as follows:

- a. “Robots” or “end-effectors” specially designed to comply with national safety standards applicable to handling high explosives (for example, meeting electrical code ratings for high explosives);
- b. Control units specially designed for any of the “robots” or “end-effectors” specified in 2B207.a.

- 2B209 Flow forming machines, spin forming machines capable of flow forming functions, other than those specified in 2B009 or 2B109, 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 mm and 400 mm.

*Note:* 2B209.a. 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.

- 2B219 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 r.p.m.;
  - b. Centrifugal balancing machines designed for balancing hollow cylindrical rotor components and having all of the following characteristics:
    1. Journal diameter greater than 75 mm;
    2. Mass capability of from 0,9 to 23 kg;
    3. Capable of balancing to a residual imbalance equal to or less than 0,01 kg × mm/kg per plane; and
    4. Belt drive type.

- 2B225 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 'master/slave' type or operated by joystick or keypad.*

- 2B226 Controlled atmosphere (vacuum or inert gas) induction furnaces, and power supplies therefor, as follows:
- N.B.: SEE ALSO 3B.
- a. Furnaces having all of the following characteristics:
    1. Capable of operation 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;
  - b. Power supplies, with a specified power output of 5 kW or more, specially designed for furnaces specified in 2B226.a.

*Note:* 2B226.a. does not control furnaces designed for the processing of semiconductor wafers.

- 2B227 Vacuum or other controlled atmosphere metallurgical melting and casting furnaces and related equipment as follows:
- a. Arc remelt and casting furnaces having both of the following characteristics:
    1. Consumable electrode capacities between 1 000 cm<sup>3</sup> and 20 000 cm<sup>3</sup>; and
    2. Capable of operating with melting temperatures above 1 973 K (1 700 °C);
  - b. Electron beam melting furnaces and plasma atomization and melting furnaces, having both of the following characteristics:
    1. A power of 50 kW or greater; and
    2. Capable of operating with melting temperatures above 1 473 K (1 200 °C).
  - c. Computer control and monitoring systems specially configured for any of the furnaces specified in 2B227.a. or b.
- 2B228 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: 2B228.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 2B228.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:*  
*In 2B228.c. the bellows have all of the following characteristics:*
    1. Inside diameter between 75 mm 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”.
- 2B230 All types of ‘pressure transducers’ capable of measuring absolute pressures and having all of the following:
- 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, aluminum oxide (alumina or sapphire), nickel, nickel alloy with more than 60 % nickel by weight, or fully fluorinated hydrocarbon polymers; and

2B230 (continued)

c. Having either of the following characteristics:

1. A full scale of less than 13 kPa and an 'accuracy' of better than  $\pm 1\%$  of full-scale; or
2. A full scale of 13 kPa or greater and an 'accuracy' of better than  $\pm 130$  Pa when measured at 13 kPa.

*Technical Notes:*

1. In 2B230 'pressure transducer' means a device that converts a pressure measurement into a signal.
2. For the purposes of 2B230, 'accuracy' includes non-linearity, hysteresis and repeatability at ambient temperature.

2B231 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  $15 \text{ m}^3/\text{s}$ ; and
- c. Capable of producing an ultimate vacuum better than 13 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.

2B232 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.

N.B.: SEE ALSO MILITARY GOODS CONTROLS.

2B233 Bellows-sealed scroll-type compressors and bellows-sealed scroll-type vacuum pumps having all of the following:

N.B.: SEE ALSO 2B350.i.

- a. Capable of an inlet volume flow rate of  $50 \text{ m}^3/\text{h}$  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.

2B350 Chemical manufacturing facilities, equipment and components, as follows:

- a. Reaction vessels or reactors, with or without agitators, with total internal (geometric) volume greater than  $0,1 \text{ m}^3$  (100 litres) and less than  $20 \text{ m}^3$  (20 000 litres), where all surfaces that come in direct contact with the chemical(s) being processed or contained are made from any of the following materials:
  1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
  2. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);

- 2B350 a. (*continued*)
3. Glass (including vitrified or enamelled coating or glass lining);
  4. Nickel or 'alloys' with more than 40 % nickel by weight;
  5. Tantalum or tantalum 'alloys';
  6. Titanium or titanium 'alloys';
  7. Zirconium or zirconium 'alloys'; or
  8. Niobium (columbium) or niobium 'alloys';
- b. Agitators designed for use in reaction vessels or reactors specified in 2B350.a.; 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. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
  2. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);
  3. Glass (including vitrified or enamelled coatings or glass lining);
  4. Nickel or 'alloys' with more than 40 % nickel by weight;
  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<sup>3</sup> (100 litres) where all surfaces that come in direct contact with the chemical(s) being processed or contained are made from any of the following materials:
1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
  2. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);
  3. Glass (including vitrified or enamelled coatings or glass lining);
  4. Nickel or 'alloys' with more than 40 % nickel by weight;
  5. Tantalum or tantalum 'alloys';
  6. Titanium or titanium 'alloys';
  7. Zirconium or zirconium 'alloys'; or
  8. Niobium (columbium) or niobium 'alloys';
- d. Heat exchangers or condensers with a heat transfer surface area greater than 0,15 m<sup>2</sup>, and less than 20 m<sup>2</sup>; 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 any of the following materials:
1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
  2. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);
  3. Glass (including vitrified or enamelled coatings or glass lining);
  4. Graphite or 'carbon graphite';



- 2B350 d. (*continued*)
5. Nickel or 'alloys' with more than 40 % nickel by weight;
  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';
- 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 any of the following materials:
1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
  2. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);
  3. Glass (including vitrified or enamelled coatings or glass lining);
  4. Graphite or 'carbon graphite';
  5. Nickel or 'alloys' with more than 40 % nickel by weight;
  6. Tantalum or tantalum 'alloys';
  7. Titanium or titanium 'alloys';
  8. Zirconium or zirconium 'alloys'; or
  9. Niobium (columbium) or niobium 'alloys';
- f. Remotely operated filling equipment in which all surfaces that come in direct contact with the chemical(s) being processed are made from any of the following materials:
1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight; or
  2. Nickel or 'alloys' with more than 40 % nickel by weight;
- g. Valves and components, as follows:
1. Valves, having both of the following:
    - a. A 'nominal size' greater than 10 mm (3/8"); and
    - b. All surfaces that come in direct contact with the chemical(s) being produced, processed, or contained are made from 'corrosion resistant materials';
  2. Valves, other than those specified in 2B350.g.1., having all of the following:
    - a. A 'nominal size' equal to or greater than 25,4 mm (1") and equal to or less than 101,6 mm (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 'corrosion resistant materials';

2B350 g. (continued)

3. Components, designed for valves specified in 2B350.g.1 or 2B350.g.2., in which all surfaces that come in direct contact with the chemical(s) being produced, processed, or contained are made from 'corrosion resistant materials', as follows:

- a. Casings (valve bodies);
- b. Preformed casing liners;

Technical Notes:

1. For the purposes of 2B350.g., 'corrosion resistant materials' means any of the following materials:

- a. Nickel or alloys with more than 40 % nickel by weight;
- b. Alloys with more than 25 % nickel and 20 % chromium by weight;
- c. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);
- d. Glass or glass-lined (including vitrified or enamelled coating);
- e. Tantalum or tantalum alloys;
- f. Titanium or titanium alloys;
- g. Zirconium or zirconium alloys;
- h. Niobium (columbium) or niobium alloys; or
- i. Ceramic materials as follows:
  1. Silicon carbide with a purity of 80 % or more by weight;
  2. Aluminium oxide (alumina) with a purity of 99,9 % or more by weight;
  3. Zirconium oxide (zirconia).

2. The 'nominal size' is defined as the smaller of the inlet and outlet diameters.

h. 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 any of the following materials:

1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
2. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);
3. Glass (including vitrified or enamelled coatings or glass lining);
4. Graphite or 'carbon graphite';
5. Nickel or 'alloys' with more than 40 % nickel by weight;
6. Tantalum or tantalum 'alloys';
7. Titanium or titanium 'alloys';
8. Zirconium or zirconium 'alloys'; or
9. Niobium (columbium) or niobium 'alloys';

## 2B350 (continued)

- i. Multiple-seal and seal-less pumps, with manufacturer's specified maximum flow-rate greater than 0,6 m<sup>3</sup>/hour, or vacuum pumps with manufacturer's specified maximum flow-rate greater than 5 m<sup>3</sup>/hour (under standard temperature (273 K (0 °C)) and pressure (101,3 kPa) conditions), other than those specified in 2B233; and casings (pump bodies), preformed casing liners, impellers, rotors or jet pump nozzles designed for such pumps, in which all surfaces that come in direct contact with the chemical(s) being processed are made from any of the following materials:
1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
  2. Ceramics;
  3. Ferrosilicon (high silicon iron alloys);
  4. Fluoropolymers (polymeric or elastomeric materials with more than 35 % fluorine by weight);
  5. Glass (including vitrified or enamelled coatings or glass lining);
  6. Graphite or 'carbon graphite';
  7. Nickel or 'alloys' with more than 40 % nickel by weight;
  8. Tantalum or tantalum 'alloys';
  9. Titanium or titanium 'alloys';
  10. Zirconium or zirconium 'alloys'; or
  11. Niobium (columbium) or niobium 'alloys';

Technical Note:

*In 2B350.i., the term seal refers to only those seals that 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.*

- j. Incinerators designed to destroy chemicals specified in entry 1C350, having specially designed waste supply systems, special handling facilities and an average combustion chamber temperature greater than 1 273 K (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 any of the following materials:
1. 'Alloys' with more than 25 % nickel and 20 % chromium by weight;
  2. Ceramics; or
  3. Nickel or 'alloys' with more than 40 % nickel by weight.

Note: For the purposes of 2B350, the materials used for gaskets, packing, seals, screws, washers or other materials performing a sealing function do not determine the status of control, provided that such components are designed to be interchangeable.

Technical Notes:

1. 'Carbon graphite' is a composition consisting of amorphous carbon and graphite, in which the graphite content is eight percent or more by weight.
2. For the listed materials in the above entries, 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.

## 2B351 Toxic gas monitoring systems and their dedicated detecting components, other than those specified in 1A004, as follows; and detectors; sensor devices; and replaceable sensor cartridges therefor:

- a. Designed for continuous operation and usable for the detection of chemical warfare agents or chemicals specified in 1C350, at concentrations of less than 0,3 mg/m<sup>3</sup>; or
- b. Designed for the detection of cholinesterase-inhibiting activity.

2B352 Equipment capable of use in handling biological materials, as follows:

a. Complete biological containment facilities at P3, P4 containment level;

Technical Note:

*P3 or P4 (BL3, BL4, L3, L4) containment levels are as specified in the WHO Laboratory Biosafety manual (3rd edition Geneva 2004).*

b. Fermenters and components as follows:

1. Fermenters capable of cultivation of pathogenic "microorganisms" or of live cells for the production of pathogenic viruses or toxins, without the propagation of aerosols, having a total capacity of 20 litres or more;
2. Components designed for fermenters in 2B352.b.1. as follows:
  - a. Cultivation chambers designed to be sterilised or disinfected *in situ*;
  - b. Cultivation chamber holding devices;
  - c. 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);

Technical Note:

*For the purposes of 2B352.b. fermenters include bioreactors, single-use (disposable) bioreactors, chemostats and continuous-flow systems.*

c. Centrifugal separators, capable of continuous separation without the propagation of aerosols, having all the following characteristics:

1. Flow rate exceeding 100 litres per hour;
2. Components of polished stainless steel or titanium;
3. One or more sealing joints within the steam containment area; and
4. Capable of *in situ* steam sterilisation in a closed state;

Technical Note:

*Centrifugal separators include decanters.*

d. Cross (tangential) flow filtration equipment and components as follows:

1. Cross (tangential) flow filtration equipment capable of separation of pathogenic micro-organisms, viruses, toxins or cell cultures having all of the following characteristics:
  - a. A total filtration area equal to or greater than 1 m<sup>2</sup>; and
  - b. Having any of the following characteristics:
    1. Capable of being sterilised or disinfected *in-situ*; or
    2. Using disposable or single-use filtration components;

Technical Note:

*In 2B352.d.1.b. sterilised 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 sterilisation are distinct from sanitisation, the latter referring to cleaning procedures designed to lower the microbial content of equipment without necessarily achieving elimination of all microbial infectivity or viability.*

Note: 2B352.d. does not control reverse osmosis equipment, as specified by the manufacturer.

2B352 d. (continued)

2. Cross (tangential) flow filtration components (e.g. modules, elements, cassettes, cartridges, units or plates) with filtration area equal to or greater than 0,2 m<sup>2</sup> for each component and designed for use in cross (tangential) flow filtration equipment specified in 2B352.d.;
- e. Steam sterilisable freeze drying equipment with a condenser capacity exceeding 10 kg of ice in 24 hours and less than 1 000 kg of ice in 24 hours;
- f. Protective and containment equipment, as follows:
1. Protective full or half suits, or hoods dependent upon a tethered external air supply and operating under positive pressure;  
*Note: 2B352.f.1. does not control suits designed to be worn with self-contained breathing apparatus.*
  2. Class III biological safety cabinets or isolators with similar performance standards;  
*Note: In 2B352.f.2., isolators include flexible isolators, dry boxes, anaerobic chambers, glove boxes and laminar flow hoods (closed with vertical flow).*
- g. Chambers designed for aerosol challenge testing with “microorganisms”, viruses or “toxins” and having a capacity of 1 m<sup>3</sup> or greater;
- h. Spray drying equipment capable of drying toxins or pathogenic microorganisms having all of the following:
1. A water evaporation capacity of  $\geq 0,4$  kg/h and  $\leq 400$  kg/h;
  2. The ability to generate a typical mean product particle size of  $\leq 10$   $\mu\text{m}$  with existing fittings or by minimal modification of the spray-dryer with atomization nozzles enabling generation of the required particle size; and
  3. Capable of being sterilised or disinfected *in situ*.

## 2C Materials

None.

## 2D Software

2D001 “Software”, other than that specified in 2D002, as follows:

- a. “Software” specially designed or modified for the “development” or “production” of equipment specified in 2A001 or 2B001
- b. “Software” specially designed or modified for the “use” of equipment specified in 2A001.c, 2B001 or 2B003 to 2B009.

*Note: 2D001 does not control part programming “software” that generates “numerical control” codes for machining various parts.*

2D002 “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 coordinating simultaneously more than four axes for “contouring control”.

*Note 1: 2D002 does not control “software” specially designed or modified for the operation of items not specified in Category 2.*

*Note 2: 2D002 does not control “software” for items specified in 2B002. See 2D001 and 2D003 for “software” for items specified in 2B002.*

*Note 3: 2D002 does not control “software” that is exported with, and the minimum necessary for the operation of, items not specified by Category 2.*

2D003 “Software”, designed or modified for the operation of equipment specified in 2B002, that converts optical design, workpiece measurements and material removal functions into “numerical control” commands to achieve the desired workpiece form.

2D101 “Software” specially designed or modified for the “use” of equipment specified in 2B104, 2B105, 2B109, 2B116, 2B117 or 2B119 to 2B122.

N.B.: SEE ALSO 9D004.

2D201 “Software” specially designed for the “use” of equipment specified in 2B204, 2B206, 2B207, 2B209, 2B219 or 2B227.

2D202 “Software” specially designed or modified for the “development”, “production” or “use” of equipment specified in 2B201.

Note: 2D202 does not control part programming “software” that generates “numerical control” command codes but does not allow direct use of equipment for machining various parts.

2D351 “Software”, other than that specified in 1D003, specially designed for “use” of equipment specified in 2B351.

## **2E Technology**

2E001 “Technology” according to the General Technology Note for the “development” of equipment or “software” specified in 2A, 2B or 2D.

Note: 2E001 includes “technology” for the integration of probe systems into coordinate measurement machines specified in 2B006.a.

2E002 “Technology” according to the General Technology Note for the “production” of equipment specified in 2A or 2B.

2E003 Other “technology”, as follows:

a. “Technology” for the “development” of interactive graphics as an integrated part in “numerical control” units for preparation or modification of part programmes;

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

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

a. “Superplastic forming”;

b. “Diffusion bonding”; or

c. “Direct-acting hydraulic pressing”;

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

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

1. Surface preparation;

2. Strain rate;

3. Temperature;

4. Pressure;

- 2E003      b. 2. (*continued*)
- b. “Diffusion bonding” of “superalloys” or titanium alloys:
    1. Surface preparation;
    2. Temperature;
    3. Pressure;
  - c. “Direct-acting hydraulic pressing” of aluminium alloys or titanium alloys:
    1. Pressure;
    2. Cycle time;
  - d. “Hot isostatic densification” of titanium alloys, aluminium alloys or “superalloys”:
    1. Temperature;
    2. Pressure;
    3. Cycle time;
  - c. “Technology” for the “development” or “production” of hydraulic stretch-forming machines and dies therefor, for the manufacture of airframe structures;
  - d. “Technology” for the “development” of generators of machine tool instructions (e.g., part programmes) from design data residing inside “numerical control” units;
  - e. “Technology” for the “development” of integration “software” for incorporation of expert systems for advanced decision support of shop floor operations into “numerical control” units;
  - f. “Technology” for the application of inorganic overlay coatings or inorganic surface modification coatings (specified in column 3 of the following table) to non-electronic substrates (specified in column 2 of the following table), by processes specified in column 1 of the following table and defined in the Technical Note.

*Note:* The table and Technical Note appear after entry 2E301.

*N.B.:* This table should be read to specify the technology of a particular Coating Process only when the Resultant Coating in column 3 is in a paragraph directly across from the relevant Substrate under column 2. For example, Chemical Vapour Deposition (CVD) coating process technical data are 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).

- 2E101      “Technology” according to the General Technology Note for the “use” of equipment or “software” specified in 2B004, 2B009, 2B104, 2B109, 2B116, 2B119 to 2B122 or 2D101.
- 2E201      “Technology” according to the General Technology Note for the “use” of equipment or “software” specified in 2A225, 2A226, 2B001, 2B006, 2B007.b., 2B007.c., 2B008, 2B009, 2B201, 2B204, 2B206, 2B207, 2B209, 2B225 to 2B233, 2D201 or 2D202.
- 2E301      “Technology” according to the General Technology Note for the “use” of goods specified in 2B350 to 2B352.

*Table*  
**Deposition techniques**

1. Coating Process (1) (*)	2. Substrate	3. Resultant Coating
A. Chemical Vapour Deposition (CVD)	“Superalloys”	Aluminides for internal passages
	Ceramics (19) and Low-expansion glasses (14)	Silicides Carbides Dielectric layers (15) Diamond Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal “matrix” “composites”	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Aluminides Alloyed aluminides (2) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Diamond Diamond-like carbon (17)
	Sensor window materials (9)	Dielectric layers (15) Diamond Diamond-like carbon (17)
B. Thermal-Evaporation Physical Vapour Deposition (TE-PVD)		
B.1. Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD)	“Superalloys”	Alloyed silicides Alloyed aluminides (2) MCrAlX (5) Modified zirconia (12) Silicides Aluminides Mixtures thereof (4)



1. Coating Process (1) (*)	2. Substrate	3. Resultant Coating
	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15)
	Corrosion resistant steel (7)	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4)
	Carbon-carbon, Ceramic and Metal “matrix” “composites”	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Borides Beryllium
	Sensor window materials (9)	Dielectric layers (15)
	Titanium alloys (13)	Borides Nitrides
B.2. Ion assisted resistive heating Physical Vapour Deposition (PVD) (Ion Plating)	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15) Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal “matrix” “composites”	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
B.3. Physical Vapour Deposition (PVD): “Laser” Vaporization	Ceramics (19) and Low-expansion glasses (14)	Silicides Dielectric layers (15) Diamond-like carbon (17)

1. Coating Process (1) (*)	2. Substrate	3. Resultant Coating
B.4. Physical Vapour Deposition (PVD): Cathodic Arc Discharge	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon
	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5)
C. Pack cementation (see A above for out-of-pack cementation) (10)	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)
	Titanium alloys (13)	Silicides Aluminides Alloyed aluminides (2)
	Refractory metals and alloys (8)	Silicides Oxides
D. Plasma spraying	"Superalloys"	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester Alloyed aluminides (2)
	Aluminium alloys (6)	MCrAlX (5) Modified zirconia (12) Silicides Mixtures thereof (4)
	Refractory metals and alloys (8)	Aluminides Silicides Carbides

1. Coating Process (1) (*)	2. Substrate	3. Resultant Coating
	Corrosion resistant steel (7)  Titanium alloys (13)	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4)  Carbides Aluminides Silicides Alloyed aluminides (2) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester
E. Slurry Deposition	Refractory metals and alloys (8)  Carbon-carbon, Ceramic and Metal “matrix” “composites”	Fused silicides Fused aluminides except for resistance heating elements  Silicides Carbides Mixtures thereof (4)
F. Sputter Deposition	“Superalloys”  Ceramics and Low-expansion glasses (14)  Titanium alloys (13)	Alloyed silicides Alloyed aluminides (2) Noble metal modified aluminides (3) MCrAlX (5) Modified zirconia (12) Platinum Mixtures thereof (4)  Silicides Platinum Mixtures thereof (4) Dielectric layers (15) Diamond-like carbon (17)  Borides Nitrides Oxides Silicides Aluminides Alloyed aluminides (2) Carbides

1. Coating Process (1) (*)	2. Substrate	3. Resultant Coating
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Borides Dielectric layers (15) Beryllium
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
	Refractory metals and alloys (8)	Aluminides Silicides Oxides Carbides
G. Ion Implantation	High temperature bearing steels	Additions of Chromium Tantalum or Niobium (Columbium)
	Titanium alloys (13)	Borides Nitrides
	Beryllium and Beryllium alloys	Borides
	Cemented tungsten carbide (16)	Carbides Nitrides

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

TABLE — DEPOSITION TECHNIQUES — NOTES

1. The term 'coating process' includes coating repair and refurbishing as well as original coating.
2. The term 'alloyed aluminide coating' includes single or multiple-step coatings in which an element or elements are deposited prior to or during application of the aluminide coating, even if these elements are deposited by another coating process. It does not, however, include the multiple use of single-step pack cementation processes to achieve alloyed aluminides.

3. The term 'noble metal modified aluminide' coating includes multiple-step coatings in which the noble metal or noble metals are laid down by some other coating process prior to application of the aluminide coating.
4. The term 'mixtures thereof' includes infiltrated material, graded compositions, co-deposits and multilayer deposits and are obtained by one or more of the coating processes specified in the Table.
5. 'MCrAlX' refers to a coating alloy where M equals cobalt, iron, nickel or combinations thereof and X equals hafnium, yttrium, silicon, tantalum in any amount or other intentional additions over 0,01 % 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 % by weight 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 to 1,1 % 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. "Technology" for single-step pack cementation of solid airfoils is not controlled by Category 2.
11. 'Polymers', as follows: polyimide, polyester, polysulphide, polycarbonates and polyurethanes.
12. 'Modified zirconia' refers to additions of other metal oxides (e.g., calcia, magnesia, yttria, hafnia, rare earth oxides) to zirconia in order to stabilise certain crystallographic phases and phase compositions. Thermal barrier coatings made of zirconia, modified with calcia or magnesia by mixing or fusion, are not controlled.
13. 'Titanium alloys' refers only to aerospace alloys having an ultimate tensile strength of 900 MPa or more measured at 293 K (20 °C).
14. 'Low-expansion glasses' refers to glasses which have a coefficient of thermal expansion of  $1 \times 10^{-7} \text{ K}^{-1}$  or less measured at 293 K (20 °C).
15. 'Dielectric layers' are coatings constructed of multi-layers of insulator materials in which the interference properties of a design composed of materials of various refractive indices are used to reflect, transmit or absorb various wavelength bands. Dielectric layers refers to more than four dielectric layers or dielectric/metal "composite" layers.
16. 'Cemented tungsten carbide' does not include cutting and forming tool materials consisting of tungsten carbide/(cobalt, nickel), titanium carbide/(cobalt, nickel), chromium carbide/nickel-chromium and chromium carbide/nickel.
17. "Technology" specially designed to deposit diamond-like carbon on any of the following is not controlled: magnetic disk drives and heads, equipment for the manufacture of disposables, valves for faucets, acoustic diaphragms for speakers, engine parts for automobiles, cutting tools, punching-pressing dies, office automation equipment, micro-phones or 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.

### CATEGORY 3 — ELECTRONICS

#### 3A Systems, Equipment and Components

Note 1: The control status of equipment and components described in 3A001 or 3A002, other than those described in 3A001.a.3. to 3A001.a.10., 3A001.a.12. or 3A001.a.13, which are specially designed for or which have the same functional characteristics as other equipment is determined by the control status of the other equipment.

Note 2: The control status of integrated circuits described in 3A001.a.3. to 3A001.a.9., 3A001.a.12. or 3A001.a.13 which are unalterably programmed or designed for a specific function for another equipment is determined by the control status of the other equipment.

N.B.: When the manufacturer or applicant cannot determine the control status of the other equipment, the control status of the integrated circuits is determined in 3A001.a.3. to 3A001.a.9., 3A001.a.12 and 3A001.a.13.

**3A** (continued)

3A001 Electronic components and specially designed components therefor, as follows:

a. General purpose integrated circuits, as follows:

*Note 1:* The control status of wafers (finished or unfinished), in which the function has been determined, is to be evaluated against the parameters of 3A001.a.

*Note 2:* Integrated circuits include the following types:

- “Monolithic integrated circuits”;
- “Hybrid integrated circuits”;
- “Multichip integrated circuits”;
- “Film type integrated circuits”, including silicon-on-sapphire integrated circuits;
- “Optical integrated circuits”;
- “Three dimensional integrated circuits”.

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 (silicon) or higher;
- b. A dose rate upset of  $5 \times 10^6$  Gy (silicon)/s or higher; or
- c. A fluence (integrated flux) of neutrons (1 MeV equivalent) of  $5 \times 10^{13}$  n/cm<sup>2</sup> or higher on silicon, or its equivalent for other materials;

*Note:* 3A001.a.1.c. does not control Metal Insulator Semiconductors (MIS).

2. “Microprocessor microcircuits”, “microcomputer microcircuits”, microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, digital-to-analogue converters, electro-optical or “optical integrated circuits” designed for “signal processing”, field programmable logic devices, custom integrated circuits for which either the function is unknown or the control status of the equipment in which the integrated circuit will be used is unknown, Fast Fourier Transform (FFT) processors, electrical erasable programmable read-only memories (EEPROMs), flash memories or static random-access memories (SRAMs), having any of the following:

- a. Rated for operation at an ambient temperature above 398 K (125 °C);
- b. Rated for operation at an ambient temperature below 218 K (- 55 °C); or
- c. Rated for operation over the entire ambient temperature range from 218 K (- 55 °C) to 398 K (125 °C);

*Note:* 3A001.a.2. does not control integrated circuits for civil automobiles 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:* 3A001.a.3. includes digital signal processors, digital array processors and digital coprocessors.

4. Not used;



3A001 a. (continued)

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

a. ADCs having any of the following:

N.B.: SEE ALSO 3A101

1. A resolution of 8 bit or more, but less than 10 bit, with an output rate greater than 1 000 million words per second;
2. A resolution of 10 bit or more, but less than 12 bit, with an output rate greater than 300 million words per second;
3. A resolution of 12 bit with an output rate greater than 200 million words per second;
4. A resolution of more than 12 bit, but equal to or less than 14 bit, with an output rate greater than 125 million words per second; or
5. A resolution of more than 14 bit with an output rate greater than 20 million words per second;

Technical Notes:

1. A resolution of  $n$  bit corresponds to a quantisation of  $2^n$  levels.
  2. The number of bits in the output word is equal to the resolution of the ADC.
  3. The output rate is the maximum output rate of the converter, regardless of the architecture or oversampling.
  4. For 'multiple channel ADCs', the outputs are not aggregated and the output rate is the maximum output rate of any single channel.
  5. For 'interleaved ADCs' or for 'multiple channel ADCs' that are specified to have an interleaved mode of operation, the outputs are aggregated and the output rate is the maximum combined total output rate of all of the outputs.
  6. Vendors may also refer to the output rate as sampling rate, conversion rate or throughput rate. It is often specified in megahertz (MHz) or mega samples per second (MSPS).
  7. For the purpose of measuring output rate, one output word per second is equivalent to one Hertz or one sample per second.
  8. 'Multiple channel ADCs' are defined as devices which integrate more than one ADC, designed so that each ADC has a separate analogue input.
  9. 'Interleaved ADCs' are defined as devices which 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.
- b. Digital-to-Analogue Converters (DAC) having any of the following:
1. A resolution of 10 bit or more with an 'adjusted update rate' of 3 500 MSPS or greater; or
  2. A resolution of 12 bit or more with an 'adjusted update rate' of equal to or greater than 1 250 MSPS and having any of the following:
    - a. A settling time less than 9 ns to 0,024 % of full scale from a full scale step; or
    - b. 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.

## 3A001 a. 5. (continued)

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 500 or greater; or
  - b. An 'aggregate one-way peak serial transceiver data rate' of 200 Gb/s or greater;

Note: 3A001.a.7. includes:

- Simple Programmable Logic Devices (SPLDs)
- Complex Programmable Logic Devices (CPLDs)
- Field Programmable Gate Arrays (FPGAs)
- Field Programmable Logic Arrays (FPLAs)
- Field Programmable Interconnects (FPICs)

3A001 a. 7. (continued)

*Technical Notes:*

1. 'Field programmable logic devices' are also known as field programmable gate or field programmable logic arrays.
2. Maximum number of digital input/outputs in 3A001.a.7.a. is also referred to as the maximum user input/outputs or maximum available input/outputs, whether the integrated circuit is packaged or bare die.
3. '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;
9. Neural network integrated circuits;
10. Custom integrated circuits for which the function is unknown, or the control status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:
  - a. More than 1 500 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 3A001.a.3. to 3A001.a.10. and 3A001.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 3A001.a.12. gives an execution time of 500  $\mu$ s.

13. Direct Digital Synthesizer (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

- b. Microwave or millimetre wave components, as follows:

*Technical Note:*

For purposes of 3A001.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.

## 3A001 b. (continued)

## 1. Electronic vacuum tubes and cathodes, as follows:

Note 1: 3A001.b.1. does not control tubes designed or rated for operation in any frequency band 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: 3A001.b.1. does not control non-“space-qualified” tubes 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 tubes, pulsed or continuous wave, as follows:

1. Tubes operating at frequencies exceeding 31,8 GHz;
2. Tubes having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;
3. Coupled cavity tubes, or derivatives thereof, with a “fractional bandwidth” of more than 7 % or a peak power exceeding 2,5 kW;
4. Helix tubes, or derivatives thereof, 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; or
  - c. Being “space-qualified”;

## b. Crossed-field amplifier tubes with a gain of more than 17 dB;

c. Impregnated cathodes designed for electronic tubes producing a continuous emission current density at rated operating conditions exceeding 5 A/cm<sup>2</sup>;

## 2. Microwave “Monolithic Integrated Circuits” (MMIC) power 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 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;

3A001 b. 2. (continued)

- 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 0,1 nW (-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.

Note 2: The control status of the MMIC whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.2.a. to 3A001.b.2.h., is determined by the lowest peak saturated power output threshold.

Note 3: Notes 1 and 2 in 3A mean that 3A001.b.2. does not control 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;

## 3A001 b. 3. b. (continued)

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;

Note 1: The control status of a transistor whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.3.a. to 3A001.b.3.e., is determined by the lowest peak saturated power output threshold.

Note 2: 3A001.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 3A001.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 exceeding 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;

3A001 b. 4. (continued)

- 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. Rated for operation at frequencies above 2,7 GHz and having all of the following:
1. A peak saturation power (in watts),  $P_{\text{sat}}$ , greater than 400 divided by the maximum operating frequency (in GHz) squared [ $P_{\text{sat}} > 400 \text{ W} \cdot \text{GHz}^2 / f_{\text{GHz}}^2$ ];
  2. A “fractional bandwidth” of 5 % or greater; and
  3. Any two sides perpendicular to one another with either length  $d$  (in cm) equal to or less than 15 divided by the lowest operating frequency in GHz [ $d \leq 15 \text{ cm} \cdot \text{GHz} / f_{\text{GHz}}$ ];

Technical Note:

2,7 GHz should be used as the lowest operating frequency ( $f_{\text{GHz}}$ ) in the formula in 3A001.b.4.f.3., for amplifiers that have a rated operating range extending downward to 2,7 GHz and below [ $d \leq 15 \text{ cm} \cdot \text{GHz} / 2,7 \text{ GHz}$ ].

N.B.: MMIC power amplifiers should be evaluated against the criteria in 3A001.b.2.

Note 1: Not used.

Note 2: The control status of an item whose rated operating frequency includes frequencies listed in more than one frequency range, as defined by 3A001.b.4.a. to 3A001.b.4.e., is determined by the lowest peak saturation output threshold.

Note 3: 3A001.b.4. includes transmit/receive modules and transmit modules.

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 ( $f_{\text{max.}}/f_{\text{min.}}$ ) in less than 10  $\mu\text{s}$  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;
7. Converters and harmonic mixers, designed to extend the frequency range of equipment described in 3A002.c., 3A002.d., 3A002.e. or 3A002.f. beyond the limits stated therein;

## 3A001 b. (continued)

8. Microwave power amplifiers containing tubes specified in 3A001.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<sup>3</sup>;

*Note:* 3A001.b.8. does not control equipment designed or rated for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.

9. Microwave power modules (MPM) consisting of, at least, a travelling wave tube, a microwave "monolithic integrated circuit" and an integrated electronic power conditioner 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<sup>3</sup>/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 3A001.b.9.b., the following example is provided: for a maximum rated power of 20 W, the volume would be:  $20 \text{ W} \times 10 \text{ cm}^3/\text{W} = 200 \text{ cm}^3$ .
2. The 'turn-on time' in 3A001.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 all of the following:
  - a. A single sideband (SSB) phase noise, in dBc/Hz, better than  $-(126 + 20\log_{10}F - 20\log_{10}f)$  anywhere in the range of  $10 \text{ Hz} < F < 10 \text{ kHz}$ ; and
  - b. A single sideband (SSB) phase noise, in dBc/Hz, better than  $-(114 + 20\log_{10}F - 20\log_{10}f)$  anywhere in the range of  $10 \text{ kHz} \leq F < 500 \text{ kHz}$ ;

Technical Note:

In 3A001.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 156 ps;
  - b. Less than 100  $\mu\text{s}$  for any frequency change exceeding 1,6 GHz within the synthesised frequency range exceeding 4,8 GHz but not exceeding 10,6 GHz;
  - c. Less than 250  $\mu\text{s}$  for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 10,6 GHz but not exceeding 31,8 GHz;
  - d. Less than 500  $\mu\text{s}$  for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 31,8 GHz but not exceeding 43,5 GHz;



3A001 b. 11. (continued)

- e. Less than 1 ms for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 43,5 GHz but not exceeding 56 GHz;
- f. Less than 1 ms for any frequency change exceeding 2,2 GHz within the synthesized frequency range exceeding 56 GHz but not exceeding 75 GHz; or
- g. Less than 1 ms within the synthesized frequency range exceeding 75 GHz;

N.B.: For general purpose “signal analysers”, signal generators, network analysers and microwave test receivers, see 3A002.c., 3A002.d., 3A002.e. and 3A002.f., respectively.

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  $\mu\text{s}$  and bandwidth in MHz) of more than 100;
    - 3. A bandwidth greater than 250 MHz; or
    - 4. A dispersive delay of more than 10  $\mu\text{s}$ ; 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  $\mu\text{s}$  and bandwidth in MHz) of more than 100;
    - 2. A dispersive delay of more than 10  $\mu\text{s}$ ; 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: 3A001.c. does not control acoustic wave devices that are limited to a single band pass, low pass, high pass or notch filtering, or resonating function.

- 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;

3A001 (continued)

e. High energy devices as follows:

1. 'Cells' as follows:

- a. 'Primary cells' having an 'energy density' exceeding 550 Wh/kg at 20 °C;
- b. 'Secondary cells' having an 'energy density' exceeding 300 Wh/kg at 20 °C;

Technical Notes:

1. For the purpose of 3A001.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 3A001.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 3A001.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 3A001.e.1.b., a 'secondary cell' is a 'cell' that is designed to be charged by an external electrical source.

Note: 3A001.e.1. does not control batteries, including single-cell batteries.

2. High energy storage capacitors as follows:

N.B.: SEE ALSO 3A201.a. and the Military Goods Controls.

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

N.B.: SEE ALSO 3A201.b.

Note: 3A001.e.3. does not control "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance Imaging (MRI) medical equipment.

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

3A001 e. (continued)

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 ‘AMO’ illumination with an irradiance of 1 367 watts per square metre (W/m<sup>2</sup>);

*Technical Note:*

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

- f. Rotary input type absolute position encoders having an accuracy equal to or less (better) than ± 1,0 second of arc;
- 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: 3A001.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: 3A001.g. does not control thyristor devices and ‘thyristor modules’ incorporated into equipment designed for civil railway or “civil aircraft” applications.

*Technical Note:*

For the purposes of 3A001.g., a ‘thyristor module’ contains one or more thyristor devices.

- 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 3A001.h. includes drain to source voltage, collector to emitter voltage, repetitive peak reverse voltage and peak repetitive off-state blocking voltage.

3A001 h. (continued)

Note 2: 3A001.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: 3A001.h. does not control switches, diodes, or 'modules', incorporated into equipment designed for civil automobile, civil railway or "civil aircraft" applications.

Technical Note:

For the purposes of 3A001.h., 'modules' contain one or more solid-state power semiconductor switches or diodes.

3A002 General purpose electronic equipment as follows:

a. Recording equipment and oscilloscopes as follows:

1. Not used;
2. Not used;
3. Not used;
4. Not used;
5. Waveform digitisers and transient recorders, having all of the following:
  - a. Digitising rate equal to or more than 200 million samples per second and a resolution of 10 bit or more; and
  - b. A 'continuous throughput' of 2 Gbit/s or more;

Technical Notes:

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

3A002 a. (continued)

6. Digital instrumentation data recorder systems using magnetic disk storage technique and having all of the following, and specially designed digital recorders therefor:
  - a. Digitised instrumentation data rate equal to or more than 100 million samples per second at a resolution of 8 bit or more; and

- b. A 'continuous throughput' of 1 Gbit/s or more;

*Technical Note:*

*Digital instrumentation data recorder systems can be configured either with a digitiser integrated within or outside the digital recorder.*

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: 3A002.a.7. does not control equivalent-time sampling oscilloscopes.*

b. Not used;

c. Radio-frequency "signal analysers" as follows:

1. "Signal analysers" having a 3 dB resolution bandwidth (RBW) exceeding 10 MHz anywhere within the frequency range exceeding 31,8 GHz but not exceeding 37,5 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 75 GHz;
3. "Signal analysers" having a frequency exceeding 75 GHz;
4. "Signal analysers" having all of the following:
  - a. "Real-time bandwidth" exceeding 85 MHz; and

- b. 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  $\mu$ s or less;

*Technical Notes:*

1. Probability of discovery in 3A002.c.4.b. is also referred to as probability of intercept or probability of capture.

2. For the purposes of 3A002.c.4.b., the duration for 100 % probability of discovery is equivalent to the minimum signal duration necessary for the specified level measurement uncertainty.

*Note: 3A002.c.4. does not control those "signal analysers" using only constant percentage bandwidth filters (also known as octave or fractional octave filters).*

5. "Signal analysers" having a "frequency mask trigger" function with 100 % probability of trigger (capture) for signals having a duration of 15  $\mu$ s or less;

d. Frequency synthesised signal generators producing output frequencies, the accuracy and short term and long term stability of which are controlled, derived from or disciplined by the internal master reference oscillator, and having any of the following:

1. Specified to generate pulse-modulated signals having all of the following, anywhere within the synthesised frequency range exceeding 31,8 GHz but not exceeding 75 GHz:
  - a. 'Pulse duration' of less than 100 ns; and

- b. On/off ratio equal to or exceeding 65 dB;

## 3A002 d. (continued)

2. An output power exceeding 100 mW (20 dBm) anywhere within the synthesised frequency range exceeding 43,5 GHz but not exceeding 75 GHz;
3. A "frequency switching time" as specified by any of the following:
  - a. Not used;
  - b. Less than 100 µs for any frequency change exceeding 1,6 GHz within the synthesised frequency range exceeding 4,8 GHz but not exceeding 10,6 GHz;
  - c. Less than 250 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 10,6 GHz but not exceeding 31,8 GHz;
  - d. Less than 500 µs for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 31,8 GHz but not exceeding 43,5 GHz;
  - e. Less than 1 ms for any frequency change exceeding 550 MHz within the synthesised frequency range exceeding 43,5 GHz but not exceeding 56 GHz; or
  - f. Less than 1 ms for any frequency change exceeding 2,2 GHz within the synthesised frequency range exceeding 56 GHz but not exceeding 75 GHz;
4. Single sideband (SSB) phase noise, in dBc/Hz, specified as being all of the following:
  - a. Less (better) than  $-(126 + 20\log_{10}F - 20\log_{10}f)$  anywhere in the range of  $10 \text{ Hz} < F < 10 \text{ kHz}$  anywhere within the synthesized frequency range exceeding 3,2 GHz but not exceeding 75 GHz; and
  - b. Less (better) than  $-(114 + 20\log_{10}F - 20\log_{10}f)$  anywhere in the range of  $10 \text{ kHz} \leq F < 500 \text{ kHz}$  anywhere within the synthesized frequency range exceeding 3,2 GHz but not exceeding 75 GHz; or

Technical Note:

In 3A002.d.4.,  $F$  is the offset from the operating frequency in Hz and  $f$  is the operating frequency in MHz;

5. A maximum synthesised frequency exceeding 75 GHz;

Note 1: For the purpose of 3A002.d., frequency synthesised signal generators include arbitrary waveform and function generators.

Note 2: 3A002.d. does not control equipment in which the output frequency is either produced by the addition or subtraction of two or more crystal oscillator frequencies, or by an addition or subtraction followed by a multiplication of the result.

Technical Notes:

1. The maximum synthesized 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 3A002.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.
- 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 75 GHz;
  2. An output power exceeding 1 mW (0 dBm) anywhere within the operating frequency range exceeding 75 GHz but not exceeding 110 GHz;

- 3A002 e. (continued)
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;
- 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;
- 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 W.
- 3A003 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.
- 3A101 Electronic equipment, devices and components, other than those specified in 3A001, as follows:
- a. Analogue-to-digital converters, usable in "missiles", designed to meet military specifications for ruggedized equipment;
  - b. Accelerators capable of delivering electromagnetic radiation produced by bremsstrahlung from accelerated electrons of 2 MeV or greater, and systems containing those accelerators.
- Note:* 3A101.b. above does not specify equipment specially designed for medical purposes.
- 3A102 'Thermal batteries' designed or modified for 'missiles'.
- Technical Notes:*
1. In 3A102 '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.
  2. In 3A102 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

3A201 Electronic components, other than those specified in 3A001, as follows;

a. Capacitors having either of the following sets of characteristics:

1. a. Voltage rating greater than 1,4 kV;
- b. Energy storage greater than 10 J;
- c. Capacitance greater than 0,5 µF; and
- d. Series inductance less than 50 nH; or
2. a. Voltage rating greater than 750 V;
- b. Capacitance greater than 0,25 µF; and
- c. Series inductance less than 10 nH;

b. Superconducting solenoidal electromagnets having all of the following characteristics:

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

*Note:* 3A201.b. does not control magnets specially designed for and exported 'as parts of' medical nuclear magnetic resonance (NMR) imaging systems. The phrase '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 that the shipments are dispatched 'as part of' the imaging systems.

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

1. a. An accelerator peak electron energy of 500 keV or greater but less than 25 MeV; and
- b. With a 'figure of merit' (K) of 0,25 or greater; or
2. a. An accelerator peak electron energy of 25 MeV or greater; and
- b. A 'peak power' greater than 50 MW.

*Note:* 3A201.c. 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:

$$K = 1,7 \times 10^3 \times V^{2,65} \times Q$$

V is the peak electron energy in million electron volts.

If the accelerator beam pulse duration is less than or equal to 1 µs, then Q is the total accelerated charge in Coulombs. If the accelerator beam pulse duration is greater than 1 µs, then Q is the maximum accelerated charge in 1 µs.

Q equals the integral of i with respect to t, over the lesser of 1 µs or the time duration of the beam pulse ( $Q = \int i dt$ ), where i is beam current in amperes and t is time in seconds.

2. 'Peak power' = (peak potential in volts) × (peak beam current in amperes).



- 3A201 c. (continued)
3. In machines based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1  $\mu$ s 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.
- 3A225 Frequency changers or generators, other than those specified in 0B001.b.13., usable as a variable or fixed frequency motor drive, having all of the following characteristics:
- N.B. 1: "Software" specially designed to enhance or release the performance of a frequency changer or generator to meet the characteristics of 3A225 is specified in 3D225.
- N.B. 2: "Technology" in the form of codes or keys to enhance or release the performance of a frequency changer or generator to meet the characteristics of 3A225 is specified in 3E225.
- 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 %.
- Note: 3A225 does not control frequency changers or generators if they have hardware, "software" or "technology" constraints that limit the performance to less than that specified above, provided they meet any of the following:
1. They need to be returned to the original manufacturer to make the enhancements or release the constraints;
  2. They require "software" as specified in 3D225 to enhance or release the performance to meet the characteristics of 3A225; or
  3. They require "technology" in the form of keys or codes as specified in 3E225 to enhance or release the performance to meet the characteristics of 3A225.
- Technical Notes:
1. Frequency changers in 3A225 are also known as converters or inverters.
  2. Frequency changers in 3A225 may be marketed as Generators, Electronic Test Equipment, AC Power Supplies, Variable Speed Motors Drives, Variable Speed Drives (VSDs), Variable Frequency Drives (VFDs), Adjustable Frequency Drives (AFDs), or Adjustable Speed Drives (ASDs).
- 3A226 High-power direct current power supplies, other than those specified in 0B001.j.6., having both of the following characteristics:
- a. Capable of continuously producing, over a time period of 8 hours, 100 V or greater with current output of 500 A or greater; and
  - b. Current or voltage stability better than 0,1 % over a time period of 8 hours.
- 3A227 High-voltage direct current power supplies, other than those specified in 0B001.j.5., having both of the following characteristics:
- a. Capable of continuously producing, over a time period of 8 hours, 20 kV or greater with current output of 1 A or greater; and
  - b. Current or voltage stability better than 0,1 % over a time period of 8 hours.

3A228 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  $\mu$ s or less;

*Note: 3A228 includes gas krytron tubes and vacuum spraytron tubes.*

b. Triggered spark-gaps having both of the following characteristics:

1. An anode delay time of 15  $\mu$ s or less; and
2. Rated for a peak current of 500 A or more;

c. Modules or assemblies with a fast switching function, other than those specified in 3A001.g. or 3A001.h., 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  $\mu$ s or less.

3A229 High-current pulse generators as follows:

N.B.: SEE ALSO MILITARY GOODS CONTROLS.

a. Detonator firing sets (initiator systems, firesets), including electronically-charged, explosively-driven and optically-driven firing sets, other than those specified in 1A007.a., designed to drive multiple controlled detonators specified in 1A007.b.;

b. Modular electrical pulse generators (pulsers) having all of the following characteristics:

1. Designed for portable, mobile, or ruggedized-use;
2. Capable of delivering their energy in less than 15  $\mu$ s into loads of less than 40 ohms;
3. Having an output greater than 100 A;
4. No dimension greater than 30 cm;
5. Weight less than 30 kg; and
6. Specified for use over an extended temperature range 223 K ( $-50^{\circ}$ C) to 373 K ( $100^{\circ}$ C) or specified as suitable for aerospace applications.

*Note: 3A229.b. includes xenon flash-lamp drivers.*

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 1 kV; and
3. Capacitance of equal to or greater than 100 nF.

3A230 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 ohms, and
- b. 'Pulse transition time' less than 500 ps.

Technical Notes:

1. In 3A230, '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.

3A231 Neutron generator systems, including tubes, having both of the following characteristics:

- a. Designed for operation without an external vacuum system; and
- b. Utilizing any of the following:
  1. Electrostatic acceleration to induce a tritium-deuterium nuclear reaction; or
  2. Electrostatic acceleration to induce a deuterium-deuterium nuclear reaction and capable of an output of  $3 \times 10^9$  neutrons/s or greater.

3A232 Multipoint initiation systems, other than those specified in 1A007, as follows:

N.B.: SEE ALSO MILITARY GOODS CONTROLS.

N.B.: See 1A007.b. for detonators.

- a. Not used;
- b. Arrangements using single or multiple detonators designed to nearly simultaneously initiate an explosive surface over greater than 5 000 mm<sup>2</sup> from a single firing signal with an initiation timing spread over the surface of less than 2,5 µs.

Note: 3A232 does not control detonators using only primary explosives, such as lead azide.

3A233 Mass spectrometers, other than those specified in 0B002.g., capable of measuring ions of 230 atomic mass units or greater and having a resolution of better than 2 parts in 230, as follows, and ion sources therefor:

- a. Inductively coupled plasma mass spectrometers (ICP/MS);
- b. Glow discharge mass spectrometers (GDMS);
- c. Thermal ionization mass spectrometers (TIMS);
- d. Electron bombardment mass spectrometers 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 ionized by an electron beam; and
  2. One or more 'cold traps' that can be cooled to a temperature of 193 K (- 80 °C);
- e. Not used;
- f. Mass spectrometers equipped with a microfluorination ion source designed for actinides or actinide fluorides.

Technical Notes:

1. Electron bombardment mass spectrometers in 3A233.d. are also known as electron impact mass spectrometers or electron ionization mass spectrometers.
2. In 3A233.d.2., a 'cold trap' is a device that traps gas molecules by condensing or freezing them on cold surfaces. For the purposes of 3A233.d.2., a closed-loop gaseous helium cryogenic vacuum pump is not a 'cold trap'.

3A234 Striplines to provide low inductance path to detonators with the following characteristics:

- a. Voltage rating greater than 2 kV; and
- b. Inductance of less than 20 nH.

**3B Test, Inspection and Production Equipment**

3B001 Equipment for the manufacturing of semiconductor devices or materials, as follows and specially designed components and accessories therefor:

- a. Equipment designed for epitaxial growth as follows:
  1. Equipment capable of producing a layer of any material other than silicon with a thickness uniform to less than  $\pm 2,5\%$  across a distance of 75 mm or more;  
*Note: 3B001.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;
  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. Anisotropic plasma dry etching equipment having all of the following:
  1. Designed or optimised to produce critical dimensions of 65 nm or less; and
  2. Within-wafer non-uniformity equal to or less than 10 %  $3\sigma$  measured with an edge exclusion of 2 mm or less;
- d. Not used;
- 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 in 3B001.a., 3B001.b. or 3B001.c. are designed to be connected; and
  2. Designed to form an integrated system in a vacuum environment for 'sequential multiple wafer processing';  
*Note: 3B001.e. does not control automatic robotic wafer handling systems specially designed for parallel wafer processing.*

*Technical Notes:*

1. For the purpose of 3B001.e., 'semiconductor process tools' refers to modular tools that provide physical processes for semiconductor production that are functionally different, such as deposition, etch, implant or thermal processing.
2. For the purpose of 3B001.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.

3B001 (continued)

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 245 nm; or

b. Capable of producing a pattern with a 'Minimum Resolvable Feature size' (MRF) of 95 nm or less;

*Technical Note:*

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

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

*where the K factor = 0,35*

2. Imprint lithography equipment capable of producing features of 95 nm or less;

*Note: 3B001.f.2. includes:*

— *Micro contact printing tools*

— *Hot embossing tools*

— *Nano-imprint lithography tools*

— *Step and flash imprint lithography (S-FIL) tools*

3. Equipment specially designed for mask making or semiconductor device processing using direct writing methods, having all of the following:

a. Using deflected focussed electron beam, ion beam or "laser" beam; and

b. Having any of the following:

1. A spot size smaller than 0,2 µm;

2. Being capable of producing a pattern with a feature size of less than 1 µm; or

3. An overlay accuracy of better than ± 0,20 µm (3 sigma);

g. Masks and reticles, designed for integrated circuits specified in 3A001;

h. Multi-layer masks with a phase shift layer not specified by 3B001.g. and having any of the following:

1. Made on a mask "substrate blank" from glass specified as having less than 7 nm/cm birefringence; or

2. Designed to be used by lithography equipment having a light source wavelength less than 245 nm;

*Note: 3B001.h. does not control multi-layer masks with a phase shift layer designed for the fabrication of memory devices not controlled by 3A001.*

i. Imprint lithography templates designed for integrated circuits specified in 3A001.

3B002 Test equipment specially designed for testing finished or unfinished semiconductor devices as follows and specially designed components and accessories therefor:

- a. For testing S-parameters of transistor devices at frequencies exceeding 31,8 GHz;
- b. Not used;
- c. For testing microwave integrated circuits specified in 3A001.b.2.

### 3C Materials

3C001 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: 3C001.d. does not control a "substrate" having one or more P-type epitaxial layers of GaN, InGaN, AlGaN, InAlN, InAlGaN, GaP, InGaP, AlInP or InGaAlP, independent of the sequence of the elements, except if the P-type epitaxial layer is between N-type layers.*

3C002 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 245 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  $\mu\text{coulomb}/\text{mm}^2$  or better;
- c. Not used;
- d. All resists optimised for surface imaging technologies;
- e. All resists designed or optimised for use with imprint lithography equipment specified in 3B001.f.2. that use either a thermal or photo-curable process.

3C003 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: 3C003 only controls compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.*

3C004 Hydrides of phosphorus, arsenic or antimony, having a purity better than 99,999 %, even diluted in inert gases or hydrogen.

*Note: 3C004 does not control hydrides containing 20 % molar or more of inert gases or hydrogen.*

3C005 Silicon carbide (SiC), gallium nitride (GaN), aluminium nitride (AlN) or aluminium gallium nitride (AlGaIn) semiconductor “substrates”, or ingots, boules, or other preforms of those materials, having resistivities greater than 10 000 ohm-cm at 20 °C.

3C006 “Substrates” specified in 3C005 with at least one epitaxial layer of silicon carbide, gallium nitride, aluminium nitride or aluminium gallium nitride.

### 3D Software

3D001 “Software” specially designed for the “development” or “production” of equipment specified in 3A001.b. to 3A002.g. or 3B.

3D002 “Software” specially designed for the “use” of equipment specified in 3B001.a. to f., 3B002 or 3A225

3D003 ‘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 3D003 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”.*

3D004 “Software” specially designed for the “development” of the equipment specified in 3A003.

3D101 “Software” specially designed or modified for the “use” of equipment specified in 3A101.b.

3D225 “Software” specially designed to enhance or release the performance of frequency changers or generators to meet the characteristics of 3A225.

### 3E Technology

3E001 “Technology” according to the General Technology Note for the “development” or “production” of equipment or materials specified in 3A, 3B or 3C;

Note 1: 3E001 does not control “technology” for the “production” of equipment or components controlled by 3A003.

Note 2: 3E001 does not control “technology” for the “development” or “production” of integrated circuits specified in 3A001.a.3. to 3A001.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.

3E002 “Technology” according to the General Technology Note, other than that specified in 3E001, 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.*

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

3E002 (continued)

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

*Note:* 3E002.c. does not control “technology” for multimedia extensions.

*Note 1:* 3E002 does not control “technology” for the “development” or “production” of micro-processor cores, having all of the following:

- a. Using “technology” at or above 0,130  $\mu\text{m}$ ; and
- b. Incorporating multi-layer structures with five or fewer metal layers.

*Note 2:* 3E002 includes “technology” for digital signal processors and digital array processors.

3E003 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:* 3E003.b. does not control “technology” for high electron mobility transistors (HEMT) operating at frequencies lower than 31,8 GHz and hetero-junction bipolar transistors (HBT) operating at frequencies lower than 31,8 GHz.

- c. “Superconductive” electronic devices;
- d. Substrates of films of diamond for electronic components.
- e. Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide;
- f. Substrates of silicon carbide for electronic components;
- g. Electronic vacuum tubes operating at frequencies of 31,8 GHz or higher.

3E101 “Technology” according to the General Technology Note for the “use” of equipment or “software” specified in 3A001.a.1. or 2., 3A101, 3A102 or 3D101.

3E102 “Technology” according to the General Technology Note for the “development” of “software” specified in 3D101.

3E201 “Technology” according to the General Technology Note for the “use” of equipment specified in 3A001.e.2., 3A001.e.3., 3A001.g., 3A201, 3A225 to 3A234.

3E225 “Technology”, in the form of codes or keys, to enhance or release the performance of frequency changers or generators to meet the characteristics of 3A225.

#### CATEGORY 4 — COMPUTERS

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

*Note 2:* Control units which directly interconnect the buses or channels of central processing units, “main storage” or disk controllers are not regarded as telecommunications equipment described in Category 5, Part 1 (Telecommunications).

*N.B.:* For the control status of “software” specially designed for packet switching, see 5D001.

*Note 3:* Computers, related equipment and “software” performing cryptographic, cryptanalytic, certifiable multi-level security or certifiable user isolation functions, or which limit electromagnetic compatibility (EMC), must also be evaluated against the performance characteristics in Category 5, Part 2 (“Information Security”).



**4A Systems, Equipment and Components**

4A001 Electronic computers and related equipment, having any of the following and “electronic assemblies” and specially designed components therefor:

N.B.: SEE ALSO 4A101.

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: 4A001.a.1. does not control 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 (silicon);

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

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

Note: 4A001.a.2. does not control computers specially designed for “civil aircraft” applications.

b. Not used.

4A003 “Digital computers”, “electronic assemblies”, and related equipment therefor, as follows and specially designed components therefor:

Note 1: 4A003 includes the following:

- ‘Vector processors’;
- Array processors;
- Digital signal processors;
- Logic processors;
- Equipment designed for “image enhancement”;
- Equipment designed for “signal processing”.

Note 2: The control status of the “digital computers” and related equipment described in 4A003 is determined by the control status of other equipment or systems provided:

- a. The “digital computers” or related equipment are essential for the operation of the other equipment or systems;
- b. The “digital computers” or related equipment are not a “principal element” of the other equipment or systems; and

N.B. 1: The control status of “signal processing” or “image enhancement” equipment specially designed for other equipment with functions limited to those required for the other equipment is determined by the control status of the other equipment even if it exceeds the “principal element” criterion.

N.B. 2: For the control status of “digital computers” or related equipment for telecommunications equipment, see Category 5, Part 1 (Telecommunications).

c. The “technology” for the “digital computers” and related equipment is determined by 4E.

a. Not used;

b. “Digital computers” having an “Adjusted Peak Performance” (“APP”) exceeding 8,0 Weighted TeraFLOPS (WT);

## 4A003 (continued)

- 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 in 4A003.b.;

*Note 1:* 4A003.c. controls only “electronic assemblies” and programmable interconnections not exceeding the limit specified in 4A003.b. when shipped as unintegrated “electronic assemblies”. It does not control “electronic assemblies” inherently limited by nature of their design for use as related equipment specified in 4A003.e.

*Note 2:* 4A003.c. does not control “electronic assemblies” specially designed for a product or family of products whose maximum configuration does not exceed the limit specified in 4A003.b.

- d. Not used;

- e. Equipment performing analogue-to-digital conversions exceeding the limits specified in 3A001.a.5.;

- f. Not used;

- g. Equipment specially designed for aggregating the performance of “digital computers” by providing external interconnections which allows communications at unidirectional data rates exceeding 2,0 Gbyte/s per link.

*Note:* 4A003.g. does not control internal interconnection equipment (e.g. backplanes, buses), passive interconnection equipment, “network access controllers” or “communications channel controllers”.

## 4A004 Computers as follows and specially designed related equipment, “electronic assemblies” and components therefor:

- a. “Systolic array computers”;
- b. “Neural computers”;
- c. “Optical computers”.

## 4A005 Systems, equipment, and components therefor, specially designed or modified for the generation, operation or delivery of, or communication with, “intrusion software”.

## 4A101 Analogue computers, “digital computers” or digital differential analysers, other than those specified in 4A001.a.1., which are ruggedized and designed or modified for use in space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

## 4A102 “Hybrid computers” specially designed for modelling, simulation or design integration of space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

*Note:* This control only applies when the equipment is supplied with “software” specified in 7D103 or 9D103.

**4B Test, Inspection and Production Equipment**

None.

**4C Materials**

None.

**4D Software**

*Note:* The control status of “software” for equipment described in other Categories is dealt with in the appropriate Category.

**4D** (continued)

4D001 “Software” as follows:

- a. “Software” specially designed or modified for the “development” or “production” of equipment or “software” specified in 4A001 to 4A004, or 4D.
- b. “Software”, other than that specified in 4D001.a., specially designed or modified for the “development” or “production” of equipment as follows:
  1. “Digital computers” having an “Adjusted Peak Performance” (“APP”) exceeding 0,60 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 4D001.b.1.

4D002 “Software” specially designed or modified to support “technology” specified in 4E.

4D003 Not used.

4D004 “Software” specially designed or modified for the generation, operation or delivery of, or communication with, “intrusion software”.

**4E Technology**

- 4E001 a. “Technology” according to the General Technology Note, for the “development”, “production” or “use” of equipment or “software” specified in 4A or 4D.
- b. “Technology”, other than that specified in 4E001.a., specially designed or modified for the “development” or “production” of equipment as follows:
  1. “Digital computers” having an “Adjusted Peak Performance” (“APP”) exceeding 0,60 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 4E001.b.1.
- c. “Technology” for the “development” of “intrusion software”.

## 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.

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

**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

### 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 and/or multiplications. All floating point operations must be expressed in operations per processor cycle; operations requiring multiple cycles may be expressed in fractional results per cycle. For processors not capable of performing calculations on floating point operands of 64-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” =  $W_1 \times R_1 + W_2 \times R_2 + \dots + W_n \times R_n$ .
4. For ‘vector processors’,  $W_i = 0,9$ . For non-‘vector processors’,  $W_i = 0,3$ .

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

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

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

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

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

*Note 6:* “APP” values must be calculated for:

1. Processor combinations containing processors specially designed to enhance performance by aggregation, operating simultaneously and sharing memory; or
2. Multiple memory/processor combinations operating simultaneously utilizing specially designed hardware.

*Technical Note:*

Aggregate all processors and accelerators operating simultaneously and located on the same die.

*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 — TELECOMMUNICATIONS AND “INFORMATION SECURITY”

### PART 1 — TELECOMMUNICATIONS

*Note 1:* The control status of components, “lasers”, test and “production” equipment and “software” therefor which are specially designed for telecommunications equipment or systems is determined in Category 5, Part 1.

*N.B. 1:* For “lasers” specially designed for telecommunications equipment or systems, see 6A005.

*N.B. 2:* See also Category 5, Part 2 for equipment, components, and “software”, performing or incorporating “information security” functions.

*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.*

## **5A1 Systems, Equipment and Components**

5A001 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; or
3. Specially designed to operate outside the temperature range from 218 K (- 55 °C) to 397 K (124 °C);  
*Note: 5A001.a.3. applies only to electronic equipment.*

*Note: 5A001.a.2. and 5A001.a.3. do not control equipment designed or modified for use on board satellites.*

b. Telecommunication systems and equipment, and specially designed components and accessories therefor, having any of the following characteristics, functions or features:

1. Being underwater 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, other than those specified in 5A001.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: 5A001.b.3.b. does not control 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: 5A001.b.3 does not control equipment designed to operate at an output power of 1 W or less.*

5A001 b. (continued)

4. Being radio equipment employing ultra-wideband modulation techniques, having user programmable channelising 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: 5A001.b.5. does not control radio equipment specially designed for use with civil cellular radio-communications systems.

Technical Notes:

‘Channel switching time’ means the time (i.e., delay) to change from one receiving frequency to another, to arrive at or within  $\pm 0,05\%$  of the final specified receiving frequency. Items having a specified frequency range of less than  $\pm 0,05\%$  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 2 400 bit/s.

Technical Notes:

1. For variable rate ‘voice coding’, 5A001.b.6. applies to the ‘voice coding’ output of continuous speech.
2. For the purposes of 5A001.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  $2 \times 10^9$  N/m<sup>2</sup> or more;

N.B.: For underwater umbilical cables, see 8A002.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” operating above 31,8 GHz;

Note: 5A001.d. does not control “electronically steerable phased array antennae” for landing systems with instruments meeting ICAO standards covering Microwave Landing Systems (MLS).

5A001 (continued)

- 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 5A001.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 5A001.f.1., 5A001.f.2. or 5A001.f.3.;

Note: 5A001.f.1. and 5A001.f.2. do not control 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 MILITARY GOODS CONTROLS.

N.B. 2: For radio receivers see 5A001.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: 5A001.g. does not control any of the following:

- a. Radio-astronomical equipment; or
- b. Systems or equipment, that require any radio transmission from the target.

5A001 (continued)

h. Counter Improvised Explosive Device (IED) equipment and related equipment, as follows:

1. Radio Frequency (RF) transmitting equipment, not specified in 5A001.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 in 5A001.h.1. is transmitting.

N.B.: See also MILITARY GOODS CONTROLS.

i. Not used;

j. Internet Protocol (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 internet Protocol (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: 5A001.j. does not control 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' means data or set of data, related to an individual (e.g., family name, given name, e-mail, street address, phone number or group affiliations).

5A101 Telemetry and telecontrol equipment, including ground equipment, designed or modified for 'missiles'.

Technical Note:

In 5A101 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

Note: 5A101 does not control:

- a. Equipment designed or modified for manned aircraft or satellites;
- b. Ground based equipment designed or modified for terrestrial or marine applications;
- c. Equipment designed for commercial, civil or 'Safety of Life' (e.g. data integrity, flight safety) GNSS services;



**5B1 Test, Inspection and Production Equipment**

5B001 Telecommunications 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 in 5A001;

*Note: 5B001.a. does not control optical fibre characterization equipment.*

- b. Equipment and specially designed components or accessories therefor, specially designed for the “development” of any of the following telecommunication transmission or switching equipment:

1. Not used;

2. Equipment employing a “laser” and having any of the following:

a. A transmission wavelength exceeding 1 750 nm;

b. Performing “optical amplification” using praseodymium-doped fluoride fibre amplifiers (PDFFA);

c. Employing coherent optical transmission or coherent optical detection techniques; or

*Note: 5B001.b.2.c. controls equipment specially designed for the “development” of systems using an optical local oscillator in the receiving side to synchronise with a carrier “laser”.*

*Technical Note:*

*For the purpose of 5B001.b.2.c., these techniques include optical heterodyne, homodyne or intradyne techniques.*

d. Employing analogue techniques and having a bandwidth exceeding 2,5 GHz; or

*Note: 5B001.b.2.d. does not control equipment specially designed for the “development” of commercial TV systems.*

3. Not used;

4. Radio equipment employing Quadrature-Amplitude-Modulation (QAM) techniques above level 256;

5. Not used.

**5C1 Materials**

None

**5D1 Software**

5D001 “Software” as follows:

- a. “Software” specially designed or modified for the “development”, “production” or “use” of equipment, functions or features, specified in 5A001;

b. “Software” specially designed or modified to support “technology” specified in 5E001;

c. Specific “software” specially designed or modified to provide characteristics, functions or features of equipment, specified in 5A001 or 5B001;

d. “Software” specially designed or modified for the “development” of any of the following telecommunication transmission or switching equipment:

1. Not used;

5D001 d. (continued)

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: 5D001.d.2.b. does not control “software” specially designed or modified for the “development” of commercial TV systems.*

3. Not used;

4. Radio equipment employing Quadrature-Amplitude-Modulation (QAM) techniques above level 256.

5D101 “Software” specially designed or modified for the “use” of equipment specified in 5A101.

**5E1 Technology**

5E001 “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 in 5A001 or “software” specified in 5D001.a.;

b. Specific “technology” as follows:

1. “Required” “technology” for the “development” or “production” of telecommunications equipment specially designed to be used on board satellites;

2. “Technology” for the “development” or “use” of “laser” communication techniques with the capability of automatically acquiring and tracking signals and maintaining communications through exoatmosphere or sub-surface (water) media;

3. “Technology” for the “development” of digital cellular radio base station receiving equipment whose reception capabilities that allow multi-band, multi-channel, multi-mode, multi-coding algorithm or multi-protocol operation can be modified by changes in “software”;

4. “Technology” for the “development” of “spread spectrum” techniques, including “frequency hopping” techniques;

*Note: 5E001.b.4. does not control “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. Equipment employing digital techniques designed to operate at a “total digital transfer rate” exceeding 120 Gbit/s;

*Technical Note:*

*For telecommunication switching equipment the “total digital transfer rate” is the unidirectional speed of a single interface, measured at the highest speed port or line.*

2. Equipment employing a “laser” and having any of the following:

a. A transmission wavelength exceeding 1 750 nm;

b. Performing “optical amplification” using Praseodymium-Doped Fluoride Fibre Amplifiers (PDFFA);

5E001 c. 2. (continued)

c. Employing coherent optical transmission or coherent optical detection techniques;

*Note:* 5E001.c.2.c. controls “technology” for the “development” or “production” of systems using an optical local oscillator in the receiving side to synchronize with a carrier “laser”.

*Technical Note:*

For the purpose of 5E001.c.2.c., these techniques include optical heterodyne, homodyne or intradyne techniques.

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:* 5E001.c.2.e. does not control “technology” for the “development” or “production” of commercial TV systems.

*N.B.:* For “technology” for the “development” or “production” of non-telecommunications equipment employing a laser, see 6E.

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 256;

b. Operating at input or output frequencies exceeding 31,8 GHz; or

*Note:* 5E001.c.4.b. does not control “technology” for the “development” or “production” of equipment designed or modified for operation in any frequency band which is “allocated by the ITU” for radio-communications services, but not for radio-determination.

c. Operating in the 1,5 MHz to 87,5 MHz band and incorporating adaptive techniques providing more than 15 dB suppression of an interfering signal; or

5. Not used;

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 Microwave Monolithic Integrated Circuit (MMIC) power amplifiers specially designed for telecommunications and that are any of the following:

*Technical Note:*

For purposes of 5E001.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;

- 5E001 d. 1. (continued)
- 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.
- 5E101 “Technology” according to the General Technology Note for the “development”, “production” or “use” of equipment specified in 5A101.

## PART 2 — “INFORMATION SECURITY”

Note 1: The control status of “information security” equipment, “software”, systems, application specific “electronic assemblies”, modules, integrated circuits, components or functions is determined in Category 5, Part 2 even if they are components or “electronic assemblies” of other equipment.

Note 2: Category 5 – Part 2 does not control products when accompanying their user for the user's personal use.

Note 3: Cryptography Note

5A002 and 5D002 do not control items as follows:

- a. Items that meet 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 goods are accessible and will be provided, upon request, to the competent authorities of the Member State in which the exporter is established 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, 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 competent authorities of the Member State in which the exporter is established, details of the component or 'executable software' and details of relevant end-items are accessible and will be provided to the competent 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 5A002 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.

2. In determining eligibility of paragraph a. of Note 3, competent 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.

Note 4: Category 5 – Part 2 does not control items incorporating or using “cryptography” and meeting all of the following:

- a. The primary function or set of functions is not any of the following:
1. “Information security”;
  2. A computer, including operating systems, parts and components therefor;
  3. Sending, receiving or storing information (except in support of entertainment, mass commercial broadcasts, digital rights management or medical records management); or
  4. Networking (includes operation, administration, management and provisioning);
- b. The cryptographic functionality is limited to supporting their primary function or set of functions; and
- c. When necessary, details of the items are accessible and will be provided, upon request, to the appropriate authority in the exporter’s country in order to ascertain compliance with conditions described in paragraphs a. and b. above.

## 5A2 Systems, Equipment and Components

5A002 “Information security” systems, equipment and components therefor, as follows:

- a. Systems, equipment, application specific “electronic assemblies”, modules and integrated circuits for “information security”, as follows, and components therefor specially designed for “information security”:

N.B.: For the control of Global Navigation Satellite Systems (GNSS) receiving equipment containing or employing decryption, see 7A005 and for related decryption “software” and “technology” see 7D005 and 7E001.

1. Designed or modified to use “cryptography” employing digital techniques performing any cryptographic function other than authentication, digital signature or the execution of copy-protected “software”, and having any of the following:

Technical Notes:

1. Functions for authentication, digital signature and the execution of copy-protected “software” include their associated key management function.
2. Authentication includes all aspects of access control where there is no encryption of files or text except as directly related to the protection of passwords, Personal Identification Numbers (PINs) or similar data to prevent unauthorised access.
- a. A “symmetric algorithm” employing a key length in excess of 56 bits; or

Technical Note:

In Category 5 — Part 2, parity bits are not included in the key length.

- 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 5A002.a.1.b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve);

## 5A002 a. (continued)

2. Designed or modified to perform cryptanalytic functions;  
*Note:* 5A002.a.2. includes systems or equipment, designed or modified to perform cryptanalysis by means of reverse engineering.
3. Not used;
4. Specially designed or modified to reduce the compromising emanations of information-bearing signals beyond what is necessary for health, safety or electromagnetic interference standards;
5. Designed or modified to use cryptographic techniques to generate the spreading code for “spread spectrum” systems, other than those specified in 5A002.a.6., including the hopping code for “frequency hopping” systems;
6. 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:
  - a. A bandwidth exceeding 500 MHz; or
  - b. A “fractional bandwidth” of 20 % or more;
7. Non-cryptographic information and communications technology (ICT) security systems and devices that have been evaluated and certified by a national authority to exceed class EAL-6 (evaluation assurance level) of the Common Criteria (CC) or equivalent;
8. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion;  
*Note:* 5A002.a.8. only controls physical layer security.
9. Designed or modified to use or perform “quantum cryptography”.

*Technical Note:*

“Quantum cryptography” is also known as Quantum Key Distribution (QKD).

- b. Systems, equipment, application specific “electronic assemblies”, modules and integrated circuits, designed or modified to enable an item to achieve or exceed the controlled performance levels for functionality specified by 5A002.a. that would not otherwise be enabled.

*Note:* 5A002 does not control any of the following:

*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 is restricted for use in equipment or systems excluded from 5A002 by Note 4 in Category 5 – Part 2 or entries b. to i. of this Note, and 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.

5A002 Note: a. (continued)

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

Technical Note:

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

b. Not used;

c. Not used;

- d. Cryptographic equipment specially designed and limited for banking use or 'money transactions';

Technical Note:

'Money transactions' in 5A002 Note d. includes the collection and settlement of fares or credit functions.

- e. Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular 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));

- f. Cordless telephone equipment not capable of end-to-end encryption where the maximum effective range of unboosted cordless operation (i.e. a single, unrelayed hop between terminal and home base station) is less than 400 metres according to the manufacturer's specifications;

- g. 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;

h. Not used;

- i. Wireless "personal area network" equipment that implement only published or commercial cryptographic standards and where 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;

- j. Equipment, having no functionality specified by 5A002.a.2., 5A002.a.4., 5A002.a.7., or 5A002.a.8., where all cryptographic capability specified by 5A002.a. meets any of the following:

1. It cannot be used; or

2. It can only be made useable by means of "cryptographic activation"; or

N.B.: See 5A002.a. for equipment that has undergone "cryptographic activation".

- k. 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 0,1 W (20 dBm) or less, and supporting 16 or fewer concurrent users.



**5B2 Test, Inspection and Production Equipment**

5B002 "Information security" test, inspection and "production" equipment, as follows:

- a. Equipment specially designed for the "development" or "production" of equipment specified in 5A002 or 5B002.b.;
- b. Measuring equipment specially designed to evaluate and validate the "information security" functions of the equipment specified in 5A002 or "software" specified in 5D002.a. or 5D002.c.

**5C2 Materials**

None.

**5D2 Software**

5D002 "Software" as follows:

- a. "Software" specially designed or modified for the "development", "production" or "use" of equipment specified in 5A002 or "software" specified in 5D002.c.;
- b. "Software" specially designed or modified to support "technology" specified in 5E002;
- c. Specific "software", as follows:
  1. "Software" having the characteristics, or performing or simulating the functions of the equipment, specified in 5A002;
  2. "Software" to certify "software" specified in 5D002.c.1.
- d. "Software" designed or modified to enable an item to achieve or exceed the controlled performance levels for functionality specified by 5A002.a. that would not otherwise be enabled.

**5E2 Technology**

5E002 "Technology" as follows:

- a. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment specified in 5A002, 5B002 or "software" specified in 5D002.a. or 5D002.c.
- b. "Technology" to enable an item to achieve or exceed the controlled performance levels for functionality specified by 5A002.a. that would not otherwise be enabled.

*Note: 5E002 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****6A Systems, Equipment and Components**

6A001 Acoustic systems, equipment and components, as follows:

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

6A001 a. 1. (continued)

Note: 6A001.a.1. does not control equipment as follows:

- a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding  $\pm 20^\circ$ , and limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;
- b. Acoustic beacons, as follows:
  1. Acoustic emergency beacons;
  2. Pingers specially designed for relocating or returning to an underwater position.
- 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  $20^\circ$  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;
      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 in 6A001.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; 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.

- b. Survey equipment, not specified in 6A001.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  $20^\circ$  from the vertical;
  3. Having any of the following:
    - a. Operating frequency below 350 kHz; or

6A001 a. 1. a. 2. b. 3. (continued)

- 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:
  - a. Designed or modified to operate at depths exceeding 500 m;
  - b. An 'area coverage rate' of greater than 570 m<sup>2</sup>/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<sup>2</sup>/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;

6A001 a. 1. (continued)

- 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 control status of acoustic projectors, including transducers, specially designed for other equipment is determined by the control status of the other equipment.

*Note 2:* 6A001.a.1.c. does not control electronic sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosive) sources.

*Note 3:* Piezoelectric elements specified in 6A001.a.1.c. include those made from lead-magnesium-niobate/lead-titanate ( $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-PbTiO}_3$ , or PMN-PT) single crystals grown from solid solution or lead-indium-niobate/lead-magnesium niobate/lead-titanate ( $\text{Pb}(\text{In}_{1/2}\text{Nb}_{1/2})\text{O}_3\text{-Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-PbTiO}_3$ , or PIN-PMN-PT) single crystals grown from solid solution.

1. An instantaneous radiated 'acoustic power density' exceeding 0,01 mW/mm<sup>2</sup>/Hz for devices operating at frequencies below 10 kHz;
2. A continuously radiated 'acoustic power density' exceeding 0,001 mW/mm<sup>2</sup>/Hz for devices operating at frequencies below 10 kHz; or

*Technical Note:*

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

3. Side-lobe suppression exceeding 22 dB;

- d. Acoustic systems and equipment, designed to determine the position of surface vessels or underwater vehicles and having all the following, and specially designed components therefor:

1. Detection range exceeding 1 000 m; and
2. Positioning accuracy of less than 10 m rms (root mean square) when measured at a range of 1 000 m;

*Note:* 6A001.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. Positioning accuracy 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 Military Goods Controls.

*Note:* For 6A001.a.1.e., where multiple detection ranges are specified for various environments, the greatest detection range is used.

6A001 a. (continued)

2. Passive systems, equipment and specially designed components therefor, as follows:

a. Hydrophones having any of the following:

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

Technical Note:

*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.*

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.,  $\text{Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-PbTiO}_3$ , or PMN-PT) piezoelectric single crystals grown from solid solution; or
  - e. Lead-indium-niobate/lead-magnesium niobate/lead-titanate (i.e.,  $\text{Pb}(\text{In}_{1/2}\text{Nb}_{1/2})\text{O}_3\text{-Pb}(\text{Mg}_{1/3}\text{Nb}_{2/3})\text{O}_3\text{-PbTiO}_3$ , 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;

Technical Notes:

1. 'Piezoelectric polymer film' sensing elements consist of polarised 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  $\mu\text{Pa}$ . For example, a hydrophone of -160 dB (reference 1 V per  $\mu\text{Pa}$ ) would yield an output voltage of  $10^{-8}$  V in such a field, while one of -180 dB sensitivity would yield only  $10^{-9}$  V output. Thus, -160 dB is better than -180 dB.

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.*

## 6A001 a. 2. b. (continued)

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 6A001.a.2.b.1. and 2. 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 in 6A001.a.2.d.;

4. Longitudinally reinforced array hoses;

5. An assembled array of less than 40 mm in diameter;

6. Not used;

7. Hydrophone characteristics specified in 6A001.a.2.a.; or

8. Accelerometer-based hydro-acoustic sensors specified in 6A001.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  $\pm 0,5^\circ$ ; and

2. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m;

e. Bottom or bay-cable hydrophone arrays, having any of the following:

1. Incorporating hydrophones specified in 6A001.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 in 6A001.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);

6A001 a. 2. g. (continued)

3. Designed to operate at depths greater than 35 meters; and
4. Operating frequency below 20 kHz.

Note: 6A001.a.2.g. does not control 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<sup>2</sup>).

Note: 6A001.a.2. also controls receiving equipment, whether or not related in normal application to separate active equipment, and specially designed components therefor.

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: 6A001.b. does not control 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: 6A001.b. does not control equipment specially designed for installation on surface vessels.

c. Not used.

6A002 Optical sensors or equipment and components therefor, as follows:

N.B.: SEE ALSO 6A102.

a. Optical detectors as follows:

1. "Space-qualified" solid-state detectors as follows:

Note: For the purpose of 6A002.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;

- 6A002 a. 1. (continued)
- 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.
2. Image intensifier tubes and specially designed components therefor, as follows:
- Note: 6A002.a.2. does not control 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  $\mu\text{m}$ .

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  $\mu\text{m}$  or less; or
    - b. An electron sensing device with a non-binned pixel pitch of 500  $\mu\text{m}$  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  $\mu\text{A}/\text{lm}$ ;
    - 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  $\mu\text{m}$  or less; or
    - b. An electron sensing device with a non-binned pixel pitch of 500  $\mu\text{m}$  or less, specially designed or modified to achieve 'charge multiplication' other than by a microchannel plate; and



6A002 a. 2. b. (continued)

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  $\mu\text{m}$  or less;
2. An electron sensing device with a non-binned pixel pitch of 500  $\mu\text{m}$  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: 6A002.a.2.c.3. does not control 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.

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

N.B.: 'Microbolometer' non-"space-qualified" "focal plane arrays" are only specified in 6A002.a.3.f.

Technical Note:

Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays";

Note 1: 6A002.a.3. includes photoconductive arrays and photovoltaic arrays.

Note 2: 6A002.a.3. does not control:

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

6A002 a. 3. Note 2: c. 2. (continued)

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.

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. 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 in 6A002.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: 6A002.a.3.d. does not control “focal plane arrays” (not to exceed 32 elements) having detector elements limited solely to germanium material.

Technical Note:

For the purposes of 6A002.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.

6A002 a. 3. (continued)

- 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 6A002.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;
- 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  $\mu$ rad (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: 6A002.b.1. does not control “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”:*

- 1. Charge Coupled Devices (CCD) not designed or modified to achieve ‘charge multiplication’; or
  - 2. Complementary Metal Oxide Semiconductor (CMOS) devices not designed or modified to achieve ‘charge multiplication’.
- c. ‘Direct view’ imaging equipment incorporating any of the following:
    - 1. Image intensifier tubes specified in 6A002.a.2.a. or 6A002.a.2.b.;
    - 2. “Focal plane arrays” specified in 6A002.a.3.; or
    - 3. Solid state detectors specified in 6A002.a.1.;

6A002 c. (continued)

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: 6A002.c. does not control 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.
- 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: 6A002.d.3. does not control encapsulated optical sensing fibres specially designed for bore hole sensing applications.
- e. Not used.

6A003 Cameras, systems or equipment, and components therefor, as follows:

N.B.: SEE ALSO 6A203.

N.B.: For television and film-based photographic still cameras specially designed or modified for underwater use, see 8A002.d.1. and 8A002.e.

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

Note: Instrumentation cameras, specified in 6A003.a.3. to 6A003.a.5., with modular structures should be evaluated by their maximum capability, using plug-ins available according to the camera manufacturer's specifications.

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

Note: 6A003.a.1. does not control cinema recording cameras designed for civil purposes.

## 6A003 a. (continued)

2. Mechanical high speed cameras, in which the film does not move, capable of recording at rates exceeding 1 000 000 frames/s for the full framing height of 35 mm film, or at proportionately higher rates for lesser frame heights, or at proportionately lower rates for greater frame heights;
3. Mechanical or electronic streak cameras, having writing speeds exceeding 10 mm/ $\mu$ s;
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  $\mu$ s 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 in 6A003.a.; and
  - b. Enabling these cameras to meet the characteristics specified in 6A003.a.3., 6A003.a.4., or 6A003.a.5., according to the manufacturer's specifications;

## b. Imaging cameras as follows:

Note: 6A003.b. does not control television or video cameras, specially designed for television broadcasting.

1. Video cameras incorporating solid state sensors, having a peak response in the wavelength range exceeding 10 nm, but not exceeding 30 000 nm and having all of the following:
  - a. Having any of the following:
    1. More than  $4 \times 10^6$  "active pixels" per solid state array for monochrome (black and white) cameras;
    2. More than  $4 \times 10^6$  "active pixels" per solid state array for colour cameras incorporating three solid state arrays; or
    3. More than  $12 \times 10^6$  "active pixels" for solid state array colour cameras incorporating one solid state array; and
  - b. Having any of the following:
    1. Optical mirrors specified in 6A004.a.;
    2. Optical control equipment specified in 6A004.d.; or
    3. The capability for annotating internally generated 'camera tracking data';

Technical Note:

1. For the purpose of this entry, digital video cameras should be evaluated by the maximum number of "active pixels" used for capturing moving images.
  2. For the purpose of this entry, 'camera tracking data' is the information necessary to define camera line of sight orientation with respect to the earth. This includes: 1) the horizontal angle the camera line of sight makes with respect to the earth's magnetic field direction and; 2) the vertical angle between the camera line of sight and the earth's horizon.
2. Scanning cameras and scanning camera systems, having all of the following:
    - a. A peak response in the wavelength range exceeding 10 nm, but not exceeding 30 000 nm;

6A003 b. 2. (continued)

b. Linear detector arrays with more than 8 192 elements per array; and

c. Mechanical scanning in one direction;

Note: 6A003.b.2. does not control 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.

3. Imaging cameras incorporating image intensifier tubes specified in 6A002.a.2.a. or 6A002.a.2.b.;

4. Imaging cameras incorporating "focal plane arrays" having any of the following:

a. Incorporating "focal plane arrays" specified in 6A002.a.3.a. to 6A002.a.3.e.;

b. Incorporating "focal plane arrays" specified in 6A002.a.3.f.; or

c. Incorporating "focal plane arrays" specified in 6A002.a.3.g.;

Note 1: Imaging cameras specified in 6A003.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: 6A003.b.4.a. does not control 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: 6A003.b.4.b. does not control 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 10 mrad/pixel (milliradians/pixel);

2. Incorporating a fixed focal-length lens that is not designed to be removed;

3. Not incorporating a 'direct view' display, and

4. Having any of the following:

a. No facility to obtain a viewable image of the detected field-of-view, or

6A003 b. 4. Note 3: b. 4. (continued)

- b. The camera is designed for a single kind of application and designed not to be user modified; or
- c. The camera is specially designed for installation into a civilian passenger land vehicle of less than 3 tonnes (gross vehicle weight) and having all of the following:
  - 1. Is only operable when installed in any of the following:
    - a. The civilian passenger land vehicle for which it was intended; or
    - b. A specially designed, authorized maintenance test facility; and
  - 2. Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended.

Technical Notes:

- 1. 'Instantaneous Field of View (IFOV)' specified in 6A003.b.4. 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.

- 2. 'Direct view' in 6A003.b.4. Note 3.b. 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.

Note 4: 6A003.b.4.c. does not control imaging cameras having any of the following:

- 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 of less than 3 tonnes (gross vehicle weight), or passenger and vehicle ferries having a length overall (LOA) 65 m or greater, and having all of the following:
  - 1. Is only operable when installed in any of the following:
    - a. The civilian passenger land vehicle or passenger and vehicle ferry for which it was intended; or

6A003 b. 4. Note 4: b. 1. (continued)

- b. A specially designed, authorised maintenance test facility; and
2. Incorporates an active mechanism that forces the camera not to function when it is removed from the vehicle for which it was intended;
- 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.
5. Imaging cameras incorporating solid-state detectors specified in 6A002.a.1.

6A004 Optical equipment and components, as follows:

a. Optical mirrors (reflectors) as follows:

N.B.: For optical mirrors specially designed for lithography equipment, see 3B001.

1. “Deformable mirrors” having either continuous or multi-element surfaces, and specially designed components therefor, capable of dynamically repositioning portions of the surface of the mirror at rates exceeding 100 Hz;
  2. Lightweight monolithic mirrors having an average “equivalent density” of less than 30 kg/m<sup>2</sup> 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<sup>2</sup> and a total mass exceeding 2 kg;
  4. Beam steering mirrors more than 100 mm in diameter or length of major axis, which maintain a flatness of  $\lambda/2$  or better ( $\lambda$  is equal to 633 nm) having a control bandwidth exceeding 100 Hz;
- 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<sup>3</sup> in volume; or
  2. Exceeding 80 mm in diameter or length of major axis and 20 mm in thickness (depth);
- c. “Space-qualified” components for optical systems, as follows:
1. 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;



## 6A004 c. (continued)

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;
- d. Optical control equipment as follows:
1. Equipment specially designed to maintain the surface figure or orientation of the "space-qualified" components specified in 6A004.c.1. or 6A004.c.3.;
  2. Equipment having steering, tracking, stabilisation or resonator alignment bandwidths equal to or more than 100 Hz and an accuracy of 10  $\mu$ rad (microradians) or less;
  3. Gimbals having all of the following:
    - a. A maximum slew exceeding 5°;
    - b. A bandwidth of 100 Hz or more;
    - c. Angular pointing errors of 200  $\mu$ rad (microradians) or less; and
    - d. Having any of the following:
      1. Exceeding 0,15 m but not exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 2 rad (radians)/s<sup>2</sup>; or
      2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0,5 rad (radians)/s<sup>2</sup>;
  4. Specially designed to maintain the alignment of phased array or phased segment mirror systems consisting of mirrors with a segment diameter or major axis length of 1 m or more;
- e. 'Aspheric optical elements' having all of the following:
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 6A004.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the control parameter.

Note: 6A004.e. does not control '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  $2,5 \times 10^{-6}/K$  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 3B001.

6A005 “Lasers”, other than those specified in 0B001.g.5. or 0B001.h.6., components and optical equipment, as follows:

N.B.: SEE ALSO 6A205.

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

Note 2: Excimer, semiconductor, chemical, CO, CO<sub>2</sub>, and ‘non-repetitive pulsed’ Nd:glass “lasers” are only specified in 6A005.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: 6A005 includes fibre “lasers”.

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

Note 5: 6A005 does not control “lasers” as follows:

- a. Ruby with output energy below 20 J;
- b. Nitrogen;
- c. Krypton.

Technical Note:

In 6A005 ‘Wall-plug efficiency’ is defined as the ratio of “laser” output power (or “average output power”) to total electrical input power required to operate the “laser”, including the power supply/conditioning and thermal conditioning/heat exchanger.

a. Non-“tunable” continuous wave (CW) lasers” having any of the following:

1. 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: 6A005.a.2. does not control 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 and output power exceeding 200 W; or

6A005 a. 6. (continued)

b. Multiple transverse mode output and any of the following:

1. 'Wall-plug efficiency' exceeding 18 % and output power exceeding 500 W; or
2. Output power exceeding 2 kW;

Note 1: 6A005.a.6.b. does not control multiple transverse mode, industrial "lasers" with output power exceeding 2 kW and not exceeding 6 kW with a total mass greater than 1 200 kg. For the purpose of this note, total mass includes all components required to operate the "laser", e.g., "laser", power supply, heat exchanger, but excludes external optics for beam conditioning and/or delivery.

Note 2: 6A005.a.6.b. does not control multiple transverse mode, industrial "lasers" having any of the following:

- a. Output power exceeding 500 W but not exceeding 1 kW and having all of the following:
  1. Beam Parameter Product (BPP) exceeding 0,7 mm•mrad; and
  2. 'Brightness' not exceeding 1 024 W/(mm•mrad)<sup>2</sup>;
- 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 4 kW and having a BPP exceeding 3,5 mm•mrad;
- f. Output power exceeding 4 kW but not exceeding 5 kW and having a BPP exceeding 5 mm•mrad;
- g. Output power exceeding 5 kW but not exceeding 6 kW and having a BPP exceeding 7,2 mm•mrad;
- 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 6A005.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<sup>2</sup>.

7. Output wavelength exceeding 1 150 nm but not exceeding 1 555 nm and of the following:

- a. Single transverse mode and output power exceeding 50 W; or
- b. Multiple transverse mode and output power exceeding 80 W; or

8. Output wavelength exceeding 1 555 nm and output power exceeding 1 W;

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

6A005 b. 1. (continued)

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:* 6A005.b.2.b. does not control 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  $\mu$ s 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  $\mu$ s 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;

6A005 b. (continued)

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 10 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 10 W; or
    3. Output energy exceeding 0,1 J per pulse;
  - c. "Pulse duration" equal to or exceeding 1 ns but not exceeding 1  $\mu$ s, 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  $\mu$ s 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;

6A005 b. (continued)

7. Output wavelength exceeding 1 150 nm but not exceeding 1 555 nm, and any of the following:
  - a. "Pulse duration" not exceeding 1  $\mu$ s 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  $\mu$ s 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; or
8. Output wavelength exceeding 1 555 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;

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

Note: 6A005.c. includes titanium-sapphire (Ti:  $\text{Al}_2\text{O}_3$ ), thulium-YAG (Tm: YAG), thulium-YSGG (Tm: YSGG), alexandrite (Cr:  $\text{BeAl}_2\text{O}_4$ ), colour centre "lasers", dye "lasers", and liquid "lasers".

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: 6A005.c.1. does not control 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;

d. Other "lasers", not specified in 6A005.a., 6A005.b. or 6A005.c. as follows:

1. Semiconductor "lasers" as follows:

Note 1: 6A005.d.1. includes semiconductor "lasers" having optical output connectors (e.g., fibre optic pigtails).

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

- 6A005 d. 1. (continued)
- 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<sup>2</sup>;
      - 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 350 W/cm<sup>2</sup>;
      - c. Average or CW total output power exceeding 5 kW;
      - d. Peak pulsed ‘power density’ exceeding 2 500 W/cm<sup>2</sup>; or
      - 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<sup>2</sup>;
      - 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<sup>2</sup>;
      - c. Average or CW total output power exceeding 500 W;
      - d. Peak pulsed ‘power density’ exceeding 500 W/cm<sup>2</sup>; or
      - e. Spatially coherent average or CW total output power, exceeding 15 W;

6A005 d. 1. d. (continued)

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<sup>2</sup>;
  - 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 in 6A005.d.1.c.;

Technical Note:

*For the purposes of 6A005.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 in 6A005.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 6A005.d.1.e., that are not designed to be further combined or modified are specified by 6A005.d.1.d.

Note 2: 'Stacked arrays', formed by combining semiconductor "laser" 'stacked arrays' specified by 6A005.d.1.e., that are designed to be further combined or modified are specified by 6A005.d.1.e.

Note 3: 6A005.d.1.e. does not control 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<sub>2</sub>) "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



6A005 d. 3. c. (continued)

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 3B001.

5. "Chemical lasers" as follows:

a. Hydrogen Fluoride (HF) "lasers";

b. Deuterium Fluoride (DF) "lasers";

c. "Transfer lasers" as follows:

1. Oxygen Iodine (O<sub>2</sub>-I) "lasers";

2. Deuterium Fluoride-Carbon dioxide (DF-CO<sub>2</sub>) "lasers";

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;

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

e. Components as follows:

1. Mirrors cooled either by 'active cooling' or by heat pipe cooling;

Technical Note:

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

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

6A005 (continued)

f. Optical equipment as follows:

N.B.: For shared aperture optical elements, capable of operating in "Super-High Power Laser" ("SHPL") applications, see the Military Goods Controls.

1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront and any of the following:
  - a. Frame rates equal to or more than 100 Hz and phase discrimination of at least 5 % of the beam's wavelength; or
  - b. Frame rates equal to or more than 1 000 Hz and phase discrimination of at least 20 % of the beam's wavelength;
2. "Laser" diagnostic equipment capable of measuring "SHPL" system angular beam steering errors of equal to or less than 10  $\mu$ rad;
3. Optical equipment and components, specially designed for a phased-array "SHPL" system for coherent beam combination to an accuracy of  $\lambda/10$  at the designed wavelength, or 0,1  $\mu$ m, whichever is the smaller;
4. Projection telescopes specially designed for use with "SHPL" systems;

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.

6A006 "Magnetometers", "magnetic gradiometers", "intrinsic magnetic gradiometers", underwater electric field sensors, "compensation systems", and specially designed components therefor, as follows:

N.B.: SEE ALSO 7A103.d.

Note: 6A006 does not control instruments specially designed for fishery applications or biomagnetic measurements for medical diagnostics.

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;

- 6A006 a. (continued)
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) per square root Hz at frequencies of less than 1 Hz;
    - b.  $1 \times 10^{-3}$  nT (rms) per square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; or
    - c.  $1 \times 10^{-4}$  nT (rms) per 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;
- b. Underwater electric field sensors having a 'sensitivity' lower (better) than 8 nanovolt per metre per square root Hz when measured at 1 Hz;
- c. "Magnetic gradiometers" as follows:
1. "Magnetic gradiometers" using multiple "magnetometers" specified in 6A006.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;
- d. "Compensation systems" for magnetic or underwater electric field sensors resulting in a performance equal to or better than the specified parameters of 6A006.a., 6A006.b. or 6A006.c.;
- e. Underwater electromagnetic receivers incorporating magnetic field sensors specified by 6A006.a. or underwater electric field sensors specified by 6A006.b.

Technical Note:

For the purposes of 6A006., 'sensitivity' (noise level) is the root mean square of the device-limited noise floor which is the lowest signal that can be measured.

- 6A007 Gravity meters (gravimeters) and gravity gradiometers, as follows:

N.B.: SEE ALSO 6A107.

- a. Gravity meters designed or modified for ground use and having a static accuracy of less (better) than 10  $\mu$ Gal;

Note: 6A007.a. does not control 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 6A007.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.

6A008 Radar systems, equipment and assemblies, having any of the following, and specially designed components therefor:

N.B.: SEE ALSO 6A108.

Note: 6A008 does not control:

- 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  $\pm 6,25$  % of the 'centre operating frequency';

Technical Note:

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

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

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

e. Incorporating 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: 6A008.i. does not control:

- a. Fishing ground surveillance radar;
- b. Ground radar equipment specially designed for enroute air traffic control and having all 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.

6A008 (continued)

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  $\mu$ rad (microradians); or
3. Designed for carrying out airborne bathymetric littoral surveys to International Hydrographic Organization (IHO) Order 1a Standard (5th 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 in 6A008.j.3.

Note 2: 6A008.j. does not control 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)

$$= \pm \sqrt{(a^2 + (b \times d)^2)}, \text{ where:}$$

$a = 0,5 \text{ m} = \text{constant depth error, i.e. the sum of all constant depth errors}$

$b = 0,013 = \text{factor of depth dependent error}$

$b \times d = \text{depth dependent error, i.e. the sum of all depth dependent errors}$

$d = \text{depth}$

— 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: 6A008.k.2. does not control 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: 6A008.l.1. does not control conflict alert capability in ATC systems, or ‘marine radar’.

- 6A008
1. (continued)
  2. Not used;
  3. Not used;
  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 6A008.f. or 6A008.i.

*N.B.:* See also Military Goods Controls.

*Note:* 6A008.l.4. does not control systems, equipment and assemblies used for ‘vessel traffic service’.

Technical Notes:

1. For the purposes of 6A008, ‘marine radar’ is a radar that is used to navigate safely at sea, inland waterways or near-shore environments.
2. For the purposes of 6A008, ‘vessel traffic service’ is a vessel traffic monitoring and control service similar to air traffic control for aircraft.

- 6A102 Radiation hardened ‘detectors’, other than those specified in 6A002, specially designed or modified for protecting against nuclear effects (e.g. electromagnetic pulse (EMP), X-rays, combined blast and thermal effects) and usable for “missiles”, designed or rated to withstand radiation levels which meet or exceed a total irradiation dose of  $5 \times 10^5$  rads (silicon).

Technical Note:

In 6A102, 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.

- 6A107 Gravity meters (gravimeters) and components for gravity meters and gravity gradiometers, as follows:
- a. Gravity meters, other than those specified in 6A007.b, designed or modified for airborne or marine use, and having a static or operational accuracy equal to or less (better) than 0,7 milligal (mgal), and having a time-to-steady-state registration of two minutes or less;
  - b. Specially designed components for gravity meters specified in 6A007.b or 6A107.a. and gravity gradiometers specified in 6A007.c.

- 6A108 Radar systems and tracking systems, other than those specified in entry 6A008, as follows:
- a. Radar and laser radar systems designed or modified for use in space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;

*Note:* 6A108.a. includes the following:

- a. Terrain contour mapping equipment;
- b. Imaging sensor equipment;
- c. Scene mapping and correlation (both digital and analogue) equipment;
- d. Doppler navigation radar equipment.

- b. Precision tracking systems, usable for ‘missiles’, as follows:
  1. Tracking systems which use a code translator in conjunction with either surface or airborne references or navigation satellite systems to provide real-time measurements of in-flight position and velocity;
  2. Range instrumentation radars including associated optical/infrared trackers with all of the following capabilities:
    - a. Angular resolution better than 1,5 milliradians;

6A108 b. 2. (continued)

b. Range of 30 km or greater with a range resolution better than 10 m rms;

c. Velocity resolution better than 3 m/s.

Technical Note:

In 6A108.b. 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

6A202 Photomultiplier tubes having both of the following characteristics:

a. Photocathode area of greater than 20 cm<sup>2</sup>; and

b. Anode pulse rise time of less than 1 ns.

6A203 Cameras and components, other than those specified in 6A003, as follows:

N.B. 1: "Software" specially designed to enhance or release the performance of a camera or imaging device to meet the characteristics of 6A203.a., 6A203.b. or 6A203.c. is specified in 6D203.

N.B. 2: "Technology" in the form of codes or keys to enhance or release the performance of a camera or imaging device to meet the characteristics of 6A203.a., 6A203.b. or 6A203.c. is specified in 6E203.

Note: 6A203.a. to 6A203.c. does not control cameras or imaging devices if they have hardware, "software" or "technology" constraints that limit the performance to less than that specified above, provided they meet any of the following:

1. They need to be returned to the original manufacturer to make the enhancements or release the constraints;
2. They require "software" as specified in 6D203 to enhance or release the performance to meet the characteristics of 6A203; or
3. They require "technology" in the form of keys or codes as specified in 6E203 to enhance or release the performance to meet the characteristics of 6A203.

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 6A203.a.2.;
4. Plug-ins specially designed for use with streak cameras which have modular structures and that enable the performance specifications in 6A203.a.1. or 6A203.a.2.;
5. Synchronizing electronics units, rotor assemblies consisting of turbines, mirrors and bearings specially designed for cameras specified in 6A203.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 6A203.b.1 or 6A203.b.2.;

## 6A203 b. (continued)

4. Plug-ins specially designed for use with framing cameras which have modular structures and that enable the performance specifications in 6A203.b.1 or 6A203.b.2.;
5. Synchronizing electronics units, rotor assemblies consisting of turbines, mirrors and bearings specially designed for cameras specified in 6A203.b.1 or 6A203.b.2.;

*Technical Note:*

*In 6A203.b., 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.*

## c. Solid state or electron tube cameras, and specially designed components therefor, as follows:

1. Solid-state cameras 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 6A203.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 6A203.c.1.
- d. Radiation-hardened TV cameras, or lenses therefor, specially designed or rated as radiation hardened to withstand a total radiation dose greater than  $50 \times 10^3$  Gy(silicon) ( $5 \times 10^6$  rad (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.*

## 6A205 "Lasers", "laser" amplifiers and oscillators, other than those specified in 0B001.g.5., 0B001.h.6. and 6A005; as follows:

N.B.: For copper vapour lasers, see 6A005.b.

- a. Argon ion "lasers" having both of the following characteristics:
  1. Operating at wavelengths between 400 nm and 515 nm; and
  2. An average output power greater than 40 W;
- b. Tunable pulsed single-mode dye laser oscillators having all of the following characteristics:
  1. Operating at wavelengths between 300 nm 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;
- c. Tunable pulsed dye laser amplifiers and oscillators, having all of the following characteristics:
  1. Operating at wavelengths between 300 nm and 800 nm;
  2. An average output power greater than 30 W;
  3. A repetition rate greater than 1 kHz; and



- 6A205 c. (*continued*)
4. Pulse width less than 100 ns;
- Note:* 6A205.c. does not control single mode oscillators;
- d. Pulsed carbon dioxide “lasers” having all of the following characteristics:
1. Operating at wavelengths between 9 000 nm 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;
- e. Para-hydrogen Raman shifters designed to operate at 16  $\mu\text{m}$  output wavelength and at a repetition rate greater than 250 Hz;
- f. 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 more 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 having an average 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 more than 40 W;
- g. Pulsed carbon monoxide lasers, other than those specified in 6A005.d.2., having all of the following:
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.

6A225 Velocity interferometers for measuring velocities exceeding 1 km/s during time intervals of less than 10 microseconds.

*Note:* 6A225 includes velocity interferometers such as VISARs (*Velocity Interferometer Systems for Any Reflector*), DLIs (*Doppler Laser Interferometers*) and PDV (*Photonic Doppler Velocimeters*) also known as Het-V (*Heterodyne Velocimeters*).

6A226 Pressure sensors, as follows:

- a. Shock pressure gauges capable of measuring pressures greater than 10 GPa, including gauges made with manganin, ytterbium, and polyvinylidene bifluoride (PVBF, PVF<sub>2</sub>);
- b. Quartz pressure transducers for pressures greater than 10 GPa.

## **6B Test, Inspection and Production Equipment**

6B004 Optical equipment as follows:

- a. Equipment for measuring absolute reflectance to an accuracy of  $\pm 0,1$  % of the reflectance value;
- b. Equipment other than optical surface scattering measurement equipment, having an unobscured aperture of more than 10 cm, specially designed for the non-contact optical measurement of a non-planar optical surface figure (profile) to an “accuracy” of 2 nm or less (better) against the required profile.

*Note:* 6B004 does not control microscopes.

6B007 Equipment to produce, align and calibrate land-based gravity meters with a static accuracy of better than 0,1 mGal.

6B008 Pulse radar cross-section measurement systems having transmit pulse widths of 100 ns or less, and specially designed components therefor.

*N.B.: SEE ALSO 6B108.*

6B108 Systems, other than those specified in 6B008, specially designed for radar cross section measurement usable for 'missiles' and their subsystems.

*Technical Note:*

*In 6B108 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.*

## 6C Materials

6C002 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 moles of CdTe and ZnTe present in the crystal.*

6C004 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<sup>3</sup>; 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<sub>2</sub>, also known as AGSE) (CAS 12002-67-4);
  3. Thallium arsenic selenide (Tl<sub>3</sub>AsSe<sub>3</sub>, also known as TAS) (CAS 16142-89-5);
  4. Zinc germanium phosphide (ZnGeP<sub>2</sub>, 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 in 6C004.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<sup>-6</sup> m<sup>2</sup>/V<sup>2</sup> 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 × 10<sup>-11</sup> m/V or more;

6C004 (continued)

- 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  $10^{-5} \text{ cm}^{-1}$  for wavelengths exceeding 200 nm but not exceeding 14 000 nm.

6C005 Synthetic crystalline "laser" host material in unfinished form as follows:

- a. Titanium doped sapphire;
- b. Not used.

## 6D Software

6D001 "Software" specially designed for the "development" or "production" of equipment specified in 6A004, 6A005, 6A008 or 6B008.

6D002 "Software" specially designed for the "use" of equipment specified in 6A002.b., 6A008 or 6B008.

6D003 Other "software" as follows:

- a. "Software" as follows:
  1. "Software" specially designed for acoustic beam forming for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;
  2. "Source code" for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;
  3. "Software" specially designed for acoustic beam forming for "real time processing" of acoustic data for passive reception using bottom or bay cable systems;
  4. "Source code" for "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 6A001.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 Military Goods Controls.*
- b. Not used;
- c. "Software" designed or modified for cameras incorporating "focal plane arrays" specified in 6A002.a.3.f. and designed or modified to remove a frame rate restriction and allow the camera to exceed the frame rate specified in 6A003.b.4. Note 3.a.
- d. Not used;
- e. Not used;

6D003 (continued)

f. “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 6A006.e.;
4. “Source code” for “real time processing” of electromagnetic data using underwater electromagnetic receivers specified by 6A006.e.;

g. “Software” specially designed to correct motional influences of gravity meters or gravity gradiometers;

h. “Software” as follows:

1. Air Traffic Control (ATC) “software” application “programmes” 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 and having all of the following:
  - a. Specially designed to protect the “electronically steerable phased array antennae” specified in 6A008.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 6D003.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.

6D102 “Software” specially designed or modified for the “use” of goods specified in 6A108.

6D103 “Software” which processes post-flight, recorded data, enabling determination of vehicle position throughout its flight path, specially designed or modified for ‘missiles’.

Technical Note:

In 6D103 ‘missile’ means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

6D203 “Software” specially designed to enhance or release the performance of cameras or imaging devices to meet the characteristics of 6A203.a. to 6A203.c.

**6E Technology**

6E001 “Technology” according to the General Technology Note for the “development” of equipment, materials or “software” specified in 6A, 6B, 6C or 6D.

6E002 “Technology” according to the General Technology Note for the “production” of equipment or materials specified in 6A, 6B or 6C.

6E003 Other “technology” as follows:

a. “Technology” as follows:

1. Optical surface coating and treatment “technology”, “required” 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 2E003.f.

*Technical Note:*

‘Optical thickness’ is the mathematical product of the index of refraction and the physical thickness of the coating.

2. Optical fabrication “technology” using single point diamond turning techniques to produce surface finish accuracies of better than 10 nm rms on non-planar surfaces exceeding 0,5 m<sup>2</sup>;

b. “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;

6E101 “Technology” according to the General Technology Note for the “use” of equipment or “software” specified in 6A002, 6A007.b. and c., 6A008, 6A102, 6A107, 6A108, 6B108, 6D102 or 6D103.

*Note:* 6E101 only specifies “technology” for equipment specified in 6A008 when it is designed for airborne applications and is usable in “missiles”.

6E201 “Technology” according to the General Technology Note for the “use” of equipment specified in 6A003, 6A005.a.2., 6A005.b.2., 6A005.b.3., 6A005.b.4., 6A005.b.6., 6A005.c.2., 6A005.d.3.c., 6A005.d.4.c., 6A202, 6A203, 6A205, 6A225 or 6A226.

6E203 “Technology”, in the form of codes or keys, to enhance or release the performance of cameras or imaging devices to meet the characteristics of 6A203a. to 6A203.c.

## CATEGORY 7 — NAVIGATION AND AVIONICS

### 7A Systems, Equipment and Components

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

7A001 Accelerometers as follows and specially designed components therefor:

*N.B.:* SEE ALSO 7A101.

*N.B.:* For angular or rotational accelerometers, see 7A001.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

7A001 a. (continued)

3. Designed for use in inertial navigation or guidance systems and specified to function at linear acceleration levels exceeding 100 g;

Note: 7A001.a.1. and 7A001.a.2. do not control accelerometers limited to measurement of only vibration or shock.

b. Angular or rotational accelerometers, specified to function at linear acceleration levels exceeding 100 g.

7A002 Gyros or angular rate sensors, having any of the following and specially designed components therefor:

N.B.: SEE ALSO 7A102.

N.B.: For angular or rotational accelerometers, see 7A001.b.

a. Specified to function at linear acceleration levels less than or equal to 100 g and having any of the following:

1. A 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: 7A002.a.1.b. does not control “spinning mass gyros”.

2. A 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: 7A002.a.2.b. does not control “spinning mass gyros”.

b. Specified to function at linear acceleration levels exceeding 100 g.

7A003 ‘Inertial measurement equipment or systems’, having any of the following:

N.B.: SEE ALSO 7A103.

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 (INSSs);
- Inertial Reference Systems (IRSs);
- Inertial Reference Units (IRUs).

Note 2: 7A003 does not control ‘inertial measurement equipment or systems’ which are certified for use on “civil aircraft” by civil authorities of “participating states”.

Technical Notes:

1. ‘Positional aiding references’ independently provide position, and include:

- a. Global Navigation Satellite Systems (GNSS);

## 7A003 1. (continued)

- b. "Data-Based Referenced Navigation" ("DBRN").
2. 'Circular Error Probable' ('CEP') - 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.
- 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 7A003.a.1., 7A003.a.2. and 7A003.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 7A003.a.1., 7A003.a.2., or 7A003.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:

7A003.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); or
- d. Providing acceleration measurements or angular rate measurements, in more than one dimension, and having any of the following:
1. Performance specified by 7A001 or 7A002 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: 7A003.d.2. does not control 'inertial measurement equipment or systems' that contain "spinning mass gyros" as the only type of gyro.

## 7A004 'Star trackers' and components therefor, as follows:

N.B.: SEE ALSO 7A104.

- 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;

7A004 (continued)

b. Components specially designed for equipment specified in 7A004.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.

7A005 Global Navigation Satellite Systems (GNSS) receiving equipment having any of the following and specially designed components therefor:

N.B.: SEE ALSO 7A105.

N.B.: For equipment specially designed for military use, see Military Goods Controls.

- 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: 7A005.b. does not control GNSS 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 7A005.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.

7A006 Airborne altimeters operating at frequencies other than 4,2 to 4,4 GHz inclusive and having any of the following:

N.B.: SEE ALSO 7A106.

- a. "Power management"; or
- b. Using phase shift key modulation.

7A008 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 traveled 'Circular Error Probable' ('CEP') and specially designed components therefor.

Note: 7A008 does not control systems specially designed for installation on surface vessels or systems requiring acoustic beacons or buoys to provide positioning data.

N.B.: See 6A001.a. for acoustic systems, and 6A001.b. for correlation-velocity and Doppler-velocity sonar log equipment.

See 8A002 for other marine systems.

7A101 Linear accelerometers, other than those specified in 7A001, designed for use in inertial navigation systems or in guidance systems of all types, usable in 'missiles', having all the following characteristics, and specially designed components therefor:

- a. A "bias" "repeatability" of less (better) than 1 250 micro g; and
- b. A "scale factor" "repeatability" of less (better) than 1 250 ppm;



## 7A101 (continued)

Note: 7A101 does not control accelerometers specially designed and developed as Measurement While Drilling (MWD) Sensors for use in downhole well service operations.

Technical Notes:

1. In 7A101 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km;
2. In 7A101 the measurement of "bias" and "scale factor" refers to a one sigma standard deviation with respect to a fixed calibration over a period of one year;

## 7A102 All types of gyros, other than those specified in 7A002, usable in 'missiles', with a rated "drift rate" 'stability' of less than 0,5° (1 sigma or rms) per hour in a 1 g environment and specially designed components therefor.

Technical Notes:

1. In 7A102 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.
2. In 7A102 '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 (IEEE STD 528-2001 paragraph 2.247).

## 7A103 Instrumentation, navigation equipment and systems, other than those specified in 7A003, as follows; and specially designed components therefor:

- a. Inertial or other equipment, using accelerometers or gyros as follows, and systems incorporating such equipment:
  1. Accelerometers specified in 7A001.a.3., 7A001.b. or 7A101 or gyros specified in 7A002 or 7A102;  
or
  2. Accelerometers specified in 7A001.a.1. or 7A001.a.2. designed for use in inertial navigation systems or in guidance systems of all types, and usable in 'missiles';

Note: 7A103.a. does not specify equipment containing accelerometers specified in 7A001 where such accelerometers are specially designed and developed as MWD (Measurement While Drilling) sensors for use in down-hole well services operations.

- b. Integrated flight instrument systems which include gyrostabilisers or automatic pilots, designed or modified for use in 'missiles';
- c. 'Integrated navigation systems', designed or modified for 'missiles' and capable of providing a navigational accuracy of 200 m Circle of Equal Probability (CEP) or less;

Technical Note:

An 'integrated navigation system' typically incorporates the following components:

1. An inertial measurement device (e.g., an attitude and heading reference system, inertial reference unit, or inertial navigation system);
2. 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
3. Integration hardware and software;

7A103 (continued)

d. Three axis magnetic heading sensors, designed or modified to be integrated with flight control and navigation systems, other than those specified in 6A006, having all the following characteristics, and specially designed components therefor;

1. Internal tilt compensation in pitch ( $\pm 90$  degrees) and roll ( $\pm 180$  degrees) axes;
2. Capable of providing azimuthal accuracy better (less) than 0,5 degrees rms at latitude of  $\pm 80$  degrees, reference to local magnetic field.

*Note: Flight control and navigation systems in 7A103.d. include gyrostabilizers, automatic pilots and inertial navigation systems.*

Technical Note:

*In 7A103 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.*

7A104 Gyro-astro compasses and other devices, other than those specified in 7A004, which derive position or orientation by means of automatically tracking celestial bodies or satellites and specially designed components therefor.

7A105 Receiving equipment for Global Navigation Satellite Systems (GNSS; e.g. GPS, GLONASS, or Galileo), other than those specified in 7A005, having any of the following characteristics, and specially designed components therefor:

- a. Designed or modified for use in space launch vehicles specified in 9A004, unmanned aerial vehicles specified in 9A012 or sounding rockets specified in 9A104; or
- b. Designed or modified for airborne applications and having any of the following:
  1. Capable of providing navigation information at speeds in excess of 600 m/s;
  2. Employing decryption, designed or modified for military or governmental services, to gain access to GNSS secured 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: 7A105.b.2. and 7A105.b.3. do not control equipment designed for commercial, civil or 'Safety of Life' (e.g., data integrity, flight safety) GNSS services.*

7A106 Altimeters, other than those specified in 7A006, of radar or laser radar type, designed or modified for use in space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

7A115 Passive sensors for determining bearing to specific electromagnetic source (direction finding equipment) or terrain characteristics, designed or modified for use in space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

Note: 7A115 includes sensors for the following equipment:

- a. Terrain contour mapping equipment;
- b. Imaging sensor equipment (both active and passive);
- c. Passive interferometer equipment.

7A116 Flight control systems and servo valves, as follows; designed or modified for use in space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

- a. Hydraulic, mechanical, electro-optical, or electro-mechanical flight control systems (including fly-by-wire types);

7A116 (continued)

- b. Attitude control equipment;
- c. Flight control servo valves designed or modified for the systems specified in 7A116.a. or 7A116.b., and designed or modified to operate in a vibration environment greater than 10 g rms between 20 Hz and 2 kHz.

7A117 "Guidance sets", usable in "missiles" 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).

## 7B Test, Inspection and Production Equipment

7B001 Test, calibration or alignment equipment, specially designed for equipment specified in 7A.

*Note:* 7B001 does not control test, calibration or alignment equipment for 'Maintenance Level I' or 'Maintenance Level II'.

### Technical Notes:

#### 1. Maintenance Level I

The failure of an inertial navigation unit is detected on the aircraft by indications from the Control and Display Unit (CDU) or by the status message from the corresponding sub-system. By following the manufacturer's manual, the cause of the failure may be localised at the level of the malfunctioning Line Replaceable Unit (LRU). The operator then removes the LRU and replaces it with a spare.

#### 2. Maintenance Level II

The defective LRU is sent to the maintenance workshop (the manufacturer's or that of the operator responsible for level II maintenance). At the maintenance workshop, the malfunctioning LRU is tested by various appropriate means to verify and localise the defective Shop Replaceable Assembly (SRA) module responsible for the failure. This SRA is removed and replaced by an operative spare. The defective SRA (or possibly the complete LRU) is then shipped to the manufacturer. 'Maintenance Level II' does not include the disassembly or repair of controlled accelerometers or gyro sensors.

7B002 Equipment specially designed to characterize mirrors for ring "laser" gyros, as follows:

N.B.: SEE ALSO 7B102.

- 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).

7B003 Equipment specially designed for the "production" of equipment specified in 7A.

Note: 7B003 includes:

- Gyro tuning test stations;
- Gyro dynamic balance stations;
- Gyro run-in/motor test stations;
- Gyro evacuation and fill stations;
- Centrifuge fixtures for gyro bearings;
- Accelerometer axis align stations;
- Fibre optic gyro coil winding machines.

7B102 Reflectometers specially designed to characterise mirrors, for "laser" gyros, having a measurement accuracy of 50 ppm or less (better).

- 7B103 “Production facilities” and “production equipment” as follows:
- a. “Production facilities” specially designed for equipment specified in 7A117;
  - b. “Production equipment”, and other test, calibration and alignment equipment, other than that specified in 7B001 to 7B003, designed or modified to be used with equipment specified in 7A.

**7C Materials**

None.

**7D Software**

7D001 “Software” specially designed or modified for the “development” or “production” of equipment specified in 7A. or 7B.

7D002 “Source code” for the operation or maintenance of any inertial navigation equipment, including inertial equipment not specified in 7A003 or 7A004, or Attitude and Heading Reference Systems (‘AHRS’).

*Note: 7D002 does not control “source code” for the “use” of gimballed ‘AHRS’.*

*Technical Note:*

*‘AHRS’ generally differ from Inertial Navigation Systems (INS) in that an ‘AHRS’ provides attitude and heading information and normally does not provide the acceleration, velocity and position information associated with an INS.*

7D003 Other “software” as follows:

- a. “Software” specially designed or modified to improve the operational performance or reduce the navigational error of systems to the levels specified in 7A003, 7A004 or 7A008;
- b. “Source code” for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified in 7A003 or 7A008 by continuously combining heading data with any of the following:
  1. Doppler radar or sonar velocity data;
  2. Global Navigation Satellite Systems (GNSS) reference data; or
  3. Data from “Data-Based Referenced Navigation” (“DBRN”) systems;
- c. Not used;
- d. Not used;
- 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 in 7E004.b., 7E004.c.1. or 7E004.c.2.

7D004 “Source code” incorporating “development” “technology” specified in 7E004.a.1. to 7E004.a.6. or 7E004.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 or fly-by-light control systems;
- d. Fault-tolerant or self-reconfiguring “active flight control systems”;
- e. Not used;
- f. Air data systems based on surface static data; or

7D004 (continued)

g. Three dimensional displays.

*Note: 7D004. does not control “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.*

7D005 “Software” specially designed to decrypt Global Navigation Satellite Systems (GNSS) ranging code designed for government use.

7D101 “Software” specially designed or modified for the “use” of equipment specified in 7A001 to 7A006, 7A101 to 7A106, 7A115, 7A116.a., 7A116.b., 7B001, 7B002, 7B003, 7B102 or 7B103.

7D102 Integration “software” as follows:

- a. Integration “software” for the equipment specified in 7A103.b.;
- b. Integration “software” specially designed for the equipment specified in 7A003 or 7A103.a.
- c. Integration “software” designed or modified for the equipment specified in 7A103.c.

*Note: A common form of integration “software” employs Kalman filtering.*

7D103 “Software” specially designed for modelling or simulation of the “guidance sets” specified in 7A117 or for their design integration with the space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

*Note: “Software” specified in 7D103 remains controlled when combined with specially designed hardware specified in 4A102.*

## 7E Technology

7E001 “Technology” according to the General Technology Note for the “development” of equipment or “software”, specified in 7A, 7B, 7D001, 7D002, 7D003, 7D005 and 7D101 to 7D103.

*Note: 7E001 includes key management “technology” exclusively for equipment specified in 7A005.a.*

7E002 “Technology” according to the General Technology Note for the “production” of equipment specified in 7A or 7B.

7E003 “Technology” according to the General Technology Note for the repair, refurbishing or overhaul of equipment specified in 7A001 to 7A004.

*Note: 7E003 does not control maintenance “technology” directly associated with calibration, removal or replacement of damaged or unserviceable LRUs and SRAs of a “civil aircraft” as described in ‘Maintenance Level I’ or ‘Maintenance Level II’.*

*N.B.: See Technical Notes to 7B001.*

7E004 Other “technology” as follows:

- a. “Technology” for the “development” or “production” of any of the following:
  1. Not used;
  2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;

- 7E004 a. (continued)
3. Three dimensional displays for “aircraft”;
  4. Not used;
  5. Electric actuators (i.e., electromechanical, electrohydrostatic and integrated actuator package) specially designed for “primary flight control”;
  6. “Flight control optical sensor array” specially designed for implementing “active flight control systems”; or
  7. “DBRN” systems designed to navigate underwater, using sonar or gravity databases, that provide a positioning accuracy equal to or less (better) than 0,4 nautical miles;
- b. “Development” “technology”, as follows, for “active flight control systems” (including fly-by-wire or fly-by-light):
1. Photonic-based “technology” for sensing aircraft or flight control component state, transferring flight control data, or commanding actuator movement, “required” for fly-by-light “active flight control systems”;
  2. Not used;
  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: 7E004.b.3. does not control algorithms for 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: 7E004.b.4. does not control 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: 7E004.b.5. does not control:*
    - a. “Development” “technology” for integration of digital flight control, navigation and propulsion control data, into a digital flight management system for “flight path optimisation”;
    - b. “Development” “technology” for “aircraft” flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches.
  6. Not used;
- Note: 7E004.b. does not control 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;

- 7E004 c. (*continued*)
2. "Circulation-controlled anti-torque or circulation-controlled directional control systems";
  3. Rotor blades incorporating "variable geometry airfoils", for use in systems using individual blade control.
- 7E101 "Technology" according to the General Technology Note for the "use" of equipment specified in 7A001 to 7A006, 7A101 to 7A106, 7A115 to 7A117, 7B001, 7B002, 7B003, 7B102, 7B103, 7D101 to 7D103.
- 7E102 "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 the determination of hardening criteria of 7E102.a. and 7E102.b.
- 7E104 "Technology" for the integration of the flight control, guidance, and propulsion data into a flight management system for optimization of rocket system trajectory.

#### CATEGORY 8 — MARINE

##### 8A Systems, Equipment and Components

- 8A001 Submersible vehicles and surface vessels, as follows:

*Note: For the control status of equipment for submersible vehicles, see:*

- Category 5, Part 2 "Information Security" for encrypted communication equipment;
- Category 6 for sensors;
- Categories 7 and 8 for navigation equipment;
- Category 8A 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 8A001.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 8A001.b., 'range' means half the maximum distance a submersible vehicle can 'operate autonomously'.

8A001 (continued)

- c. Unmanned, tethered submersible vehicles designed to operate at depths exceeding 1 000 m and having any of the following:
1. Designed for self-propelled manoeuvre using propulsion motors or thrusters specified in 8A002.a.2.;  
or
  2. Fibre optic data link;
- d. Unmanned, untethered submersible vehicles having any of the following:
1. Designed for deciding a course relative to any geographical reference without real-time human assistance;
  2. Acoustic data or command link; or
  3. Optical data or command link exceeding 1 000 m;
- e. Ocean salvage systems with a lifting capacity exceeding 5 MN for salvaging objects from depths exceeding 250 m and having any of the following:
1. Dynamic positioning systems capable of position keeping within 20 m of a given point provided by the navigation system; or
  2. Seafloor navigation and navigation integration systems, for depths exceeding 1 000 m and with positioning accuracies to within 10 m of a predetermined point;
- f. Surface-effect vehicles (fully skirted variety) having all of the following:
1. Maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1,25 m (Sea State 3) or more;
  2. Cushion pressure exceeding 3 830 Pa; and
  3. Light-ship-to-full-load displacement ratio of less than 0,70;
- g. Surface-effect vehicles (rigid sidewalls) with a maximum design speed, fully loaded, exceeding 40 knots in a significant wave height of 3,25 m (Sea State 5) or more;
- h. Hydrofoil vessels with active systems for automatically controlling foil systems, with a maximum design speed, fully loaded, of 40 knots or more in a significant wave height of 3,25 m (Sea State 5) or more;
- i. 'Small waterplane area vessels' having any of the following:
1. Full load displacement exceeding 500 tonnes with a maximum design speed, fully loaded, exceeding 35 knots in a significant wave height of 3,25 m (Sea State 5) or more; or
  2. Full load displacement exceeding 1 500 tonnes with a maximum design speed, fully loaded, exceeding 25 knots in a significant wave height of 4 m (Sea State 6) or more.

Technical Note:

A 'small waterplane area vessel' is defined by the following formula: waterplane area at an operational design draught less than  $2 \times (\text{displaced volume at the operational design draught})^{2/3}$ .



8A002 Marine systems, equipment and components, as follows:

*Note:* 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 in 8C001;

*Technical Note:*

*The objective of 8A002.a.4. should not be defeated by the export of 'syntactic foam' specified in 8C001 when an intermediate stage of manufacture has been performed and it is not yet in the final component form.*

b. Systems specially designed or modified for the automated control of the motion of submersible vehicles specified in 8A001, 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 as follows:

1. Television systems and television cameras, as follows:

- a. Television systems (comprising camera, monitoring and signal transmission equipment) having a 'limiting resolution' when measured in air of more than 800 lines and specially designed or modified for remote operation with a submersible vehicle;
- b. Underwater television cameras having a 'limiting resolution' when measured in air of more than 1 100 lines;
- c. Low light level television cameras specially designed or modified for underwater use and having all of the following:
  1. Image intensifier tubes specified in 6A002.a.2.a.; and
  2. More than 150 000 "active pixels" per solid state area array;

*Technical Note:*

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

2. Systems specially designed or modified for remote operation with an underwater vehicle, employing techniques to minimise the effects of back scatter and including range-gated illuminators or "laser" systems;

8A002 (continued)

- e. Photographic still cameras specially designed or modified for underwater use below 150 m, with a film format of 35 mm or larger and having any of the following:
1. Annotation of the film with data provided by a source external to the camera;
  2. Automatic back focal distance correction; or
  3. Automatic compensation control specially designed to permit an underwater camera housing to be usable at depths exceeding 1 000 m;
- f. Not used;
- 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:

8A002 j. 1. d. (continued)

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. Skirts, seals and fingers, having any of the following:
1. Designed for cushion pressures of 3 830 Pa or more, operating in a significant wave height of 1,25 m (Sea State 3) or more and specially designed for surface effect vehicles (fully skirted variety) specified in 8A001.f.; or
  2. Designed for cushion pressures of 6 224 Pa or more, operating in a significant wave height of 3,25 m (Sea State 5) or more and specially designed for surface effect vehicles (rigid sidewalls) specified in 8A001.g.;
- l. Lift fans rated at more than 400 kW and specially designed for surface effect vehicles specified in 8A001.f. or 8A001.g.;
- m. Fully submerged subcavitating or supercavitating hydrofoils, specially designed for vessels specified in 8A001.h.;
- n. Active systems specially designed or modified to control automatically the sea-induced motion of vehicles or vessels, specified in 8A001.f., 8A001.g., 8A001.h. or 8A001.i.;

8A002 (continued)

o. Propellers, power transmission systems, power generation systems and noise reduction systems, as follows:

1. Water-screw propeller or power transmission systems, as follows, specially designed for surface effect vehicles (fully skirted or rigid sidewall variety), hydrofoils or 'small waterplane area vessels' specified in 8A001.f., 8A001.g., 8A001.h. or 8A001.i., as follows:

a. Supercavitating, super-ventilated, partially-submerged or surface piercing propellers, rated at more than 7,5 MW;

b. Contrarotating propeller systems rated at more than 15 MW;

c. Systems employing pre-swirl or post-swirl techniques, for smoothing the flow into a propeller;

d. Light-weight, high capacity (K factor exceeding 300) reduction gearing;

e. Power transmission shaft systems incorporating "composite" material components and capable of transmitting more than 1 MW;

2. Water-screw propeller, power generation systems or transmission systems, designed for use on vessels, as follows:

a. Controllable-pitch propellers and hub assemblies, rated at more than 30 MW;

b. Internally liquid-cooled electric propulsion engines with a power output exceeding 2,5 MW;

c. "Superconductive" propulsion engines or permanent magnet electric propulsion engines, with a power output exceeding 0,1 MW;

d. Power transmission shaft systems incorporating "composite" material components 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;

8A002 q. (continued)

2. Semi-closed circuit rebreathers;

*Note:* 8A002.q. does not control individual rebreathers for personal use when accompanying their users.

*N.B.:* For equipment and devices specially designed for military use, see the Military Goods Controls.

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  $\mu$ Pa at 1 m) at frequencies of 200 Hz and below.

*Note 1:* 8A002.r. does not control diver deterrent systems based on underwater explosive devices, air guns or combustible sources.

*Note 2:* 8A002.r. includes diver deterrent acoustic systems that use spark gap sources, also known as plasma sound sources.

## **8B Test, Inspection and Production Equipment**

8B001 Water tunnels having a background noise of less than 100 dB (reference 1  $\mu$ Pa, 1 Hz), in the frequency range from 0 to 500 Hz and designed for measuring acoustic fields generated by a hydro-flow around propulsion system models.

## **8C Materials**

8C001 'Syntactic foam' designed for underwater use and having all of the following:

*N.B.:* See also 8A002.a.4.

- a. Designed for marine depths exceeding 1 000 m; and
- b. A density less than 561 kg/m<sup>3</sup>.

*Technical Note:*

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

## **8D Software**

8D001 "Software" specially designed or modified for the "development", "production" or "use" of equipment or materials, specified in 8A, 8B or 8C.

8D002 Specific "software" specially designed or modified for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction.

## **8E Technology**

8E001 "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials, specified in 8A, 8B or 8C.

8E002 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 in 8A001, 8A002.b., 8A002.j., 8A002.o. or 8A002.p.

## **CATEGORY 9 – AEROSPACE AND PROPULSION**

### **9A Systems, Equipment and Components**

*N.B.:* For propulsion systems designed or rated against neutron or transient ionizing radiation, see the Military Goods Controls.

9A001 Aero gas turbine engines having any of the following:

N.B.: SEE ALSO 9A101.

a. Incorporating any of the “technologies” specified in 9E003.a., 9E003.h. or 9E003.i.; or

Note 1: 9A001.a. does not control aero gas turbine engines which meet all of the following:

a. Certified by the civil aviation authority in a “participating state”; and

b. Intended to power non-military manned aircraft for which any of the following has been issued by a “participating state” for the aircraft with this specific engine type:

1. A civil type certificate; or

2. An equivalent document recognized by the International Civil Aviation Organisation (ICAO).

Note 2: 9A001.a. does not control aero gas turbine engines designed for Auxiliary Power Units (APUs) approved by the civil aviation authority in a “participating state”.

b. Designed to power an aircraft to cruise at Mach 1 or higher, for more than thirty minutes.

9A002 ‘Marine gas turbine engines’ with an ISO standard continuous power rating of 24 245 kW or more and a specific fuel consumption not exceeding 0,219 kg/kWh in the power range from 35 to 100 %, and specially designed assemblies and components therefor.

Note: The term ‘marine gas turbine engines’ includes those industrial, or aero-derivative, gas turbine engines adapted for a ship’s electric power generation or propulsion.

9A003 Specially designed assemblies and components, incorporating any of the “technologies” specified in 9E003.a., 9E003.h. or 9E003i., for any of the following gas turbine engine propulsion systems:

a. Specified in 9A001; or

b. Whose design or production origins are either non-“participating states” or unknown to the manufacturer.

9A004 Space launch vehicles and “spacecraft”.

N.B.: SEE ALSO 9A104.

Note: 9A004 does not control payloads.

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

9A005 Liquid rocket propulsion systems containing any of the systems or components, specified in 9A006.

N.B.: SEE ALSO 9A105 AND 9A119.

9A006 Systems and components, specially designed for liquid rocket propulsion systems, as follows:

N.B.: SEE ALSO 9A106, 9A108 AND 9A120.

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”;

9A006 (continued)

- c. Slush hydrogen storage or transfer systems;
- d. High pressure (exceeding 17,5 MPa) turbo pumps, pump components or their associated gas generator or expander cycle turbine drive systems;
- e. High-pressure (exceeding 10,6 MPa) thrust chambers and nozzles therefor;
- f. Propellant storage systems using the principle of capillary containment or positive expulsion (i.e., with flexible bladders);
- g. Liquid propellant injectors with individual orifices of 0,381 mm or smaller in diameter (an area of  $1,14 \times 10^{-3} \text{ cm}^2$  or smaller for non-circular orifices) and specially designed for liquid rocket engines;
- h. One-piece carbon-carbon thrust chambers or one-piece carbon-carbon exit cones, with densities exceeding  $1,4 \text{ g/cm}^3$  and tensile strengths exceeding 48 MPa.

9A007 Solid rocket propulsion systems having any of the following:

N.B.: SEE ALSO 9A107 AND 9A119.

- 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 in 9A008; 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:

'Strong mechanical bond' means bond strength equal to or more than propellant strength.

9A008 Components specially designed for solid rocket propulsion systems, as follows:

N.B.: SEE ALSO 9A108.

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

Technical Note:

'Strong mechanical bond' means bond strength equal to or more than propellant strength.

- b. Filament-wound "composite" motor cases exceeding 0,61 m in diameter or having 'structural efficiency ratios (PV/W)' exceeding 25 km;

Technical Note:

'Structural efficiency ratio (PV/W)' is the burst pressure (P) multiplied by the vessel volume (V) divided by the total pressure vessel weight (W).

- c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0,075 mm/s;
- d. Movable nozzle or secondary fluid injection thrust vector control systems, capable of any of the following:
  - 1. Omni-axial movement exceeding  $\pm 5^\circ$ ;
  - 2. Angular vector rotations of  $20^\circ/\text{s}$  or more; or
  - 3. Angular vector accelerations of  $40^\circ/\text{s}^2$  or more.

9A009 Hybrid rocket propulsion systems having any of the following:

N.B.: SEE ALSO 9A109 AND 9A119.

- a. Total impulse capacity exceeding 1,1 MNs; or
- b. Thrust levels exceeding 220 kN in vacuum exit conditions.

9A010 Specially designed components, systems and structures, for launch vehicles, launch vehicle propulsion systems or "spacecraft", as follows:

N.B.: SEE ALSO 1A002 AND 9A110.

- a. Components and structures, each exceeding 10 kg and specially designed for launch vehicles manufactured using metal "matrix", "composite", organic "composite", ceramic "matrix" or intermetallic reinforced materials, specified in 1C007 or 1C010;

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

- b. Components and structures, specially designed for launch vehicle propulsion systems specified in 9A005 to 9A009 manufactured using metal "matrix", "composite", organic "composite", ceramic "matrix" or intermetallic reinforced materials, specified in 1C007 or 1C010;
- c. Structural components and isolation systems, specially designed to control actively the dynamic response or distortion of "spacecraft" structures;
- d. Pulsed liquid rocket engines with thrust-to-weight ratios equal to or more than 1 kN/kg and a response time (the time required to achieve 90 % of total rated thrust from start-up) of less than 30 ms.

9A011 Ramjet, scramjet or combined cycle engines, and specially designed components therefor.

N.B.: SEE ALSO 9A111 AND 9A118.

9A012 "Unmanned aerial vehicles" ("UAVs"), unmanned "airships", related systems, equipment and components, as follows:

- a. "UAVs" or unmanned "airships", having any of the following:
  1. An autonomous flight control and navigation capability (e.g., an autopilot with an Inertial Navigation System); or
  2. Capability of controlled-flight out of the direct vision range involving a human operator (e.g., television remote control);
- b. Related systems, equipment and components, as follows:
  1. Equipment specially designed for remotely controlling the "UAVs" or unmanned "airships", specified in 9A012.a.;
  2. Systems for navigation, attitude, guidance or control, other than those specified in 7A, specially designed to be integrated into "UAVs" or unmanned "airships", specified in 9A012.a.;
  3. Equipment or components, specially designed to convert a manned "aircraft" or manned "airship", to a "UAV" or unmanned "airship", specified in 9A012.a.;
  4. Air breathing reciprocating or rotary internal combustion type engines, specially designed or modified to propel "UAVs" or unmanned "airships", at altitudes above 50 000 feet (15 240 metres).



- 9A101 Turbojet and turbofan engines, other than those specified in 9A001, as follows:
- a. Engines having both of the following characteristics:
    1. 'Maximum thrust value' greater than 400 N (achieved un-installed) excluding civil certified engines with a 'maximum thrust value' greater than 8 890 N (achieved un-installed), and
    2. Specific fuel consumption of 0,15 kg/N/hr or less (at maximum continuous power at sea level static conditions using the ICAO standard atmosphere);

*Technical Note:*

*For the purpose of 9A101.a.1. 'maximum thrust value' is the manufacturer's demonstrated maximum thrust for the engine type un-installed. The civil type certified thrust value will be equal or less than the manufacturer's demonstrated maximum thrust for the engine type.*

- b. Engines designed or modified for use in "missiles" or unmanned aerial vehicles specified in 9A012,

- 9A102 'Turboprop engine systems' specially designed for unmanned aerial vehicles specified in 9A012, and specially designed components therefor, having a 'maximum power' greater than 10 kW.

*Note: 9A102 does not control civil certified engines.*

*Technical Notes:*

1. For the purposes of 9A102 a 'turboprop engine system' incorporates all of the following:
  - a. Turboshaft engine; and
  - b. Power transmission system to transfer the power to a propeller.
2. For the purposes of 9A102 the 'maximum power' is achieved uninstalled at sea level static conditions using ICAO standard atmosphere.

- 9A104 Sounding rockets, capable of a range of at least 300 km.

N.B.: SEE ALSO 9A004.

- 9A105 Liquid propellant rocket engines, as follows:

N.B.: SEE ALSO 9A119.

- a. Liquid propellant rocket engines usable in "missiles", other than those specified in 9A005, integrated, or designed or modified to be integrated, into a liquid propellant propulsion system which has a total impulse capacity equal to or greater than 1,1 MNs;
- b. Liquid propellant rocket engines, usable in complete rocket systems or unmanned aerial vehicles, capable of a range of 300 km, other than those specified in 9A005 or 9A105.a., integrated, or designed or modified to be integrated, into a liquid propellant propulsion system which has a total impulse capacity equal to or greater than 0,841 MNs.

- 9A106 Systems or components, other than those specified in 9A006 as follows, specially designed for liquid rocket propulsion systems:

- a. Ablative liners for thrust or combustion chambers, usable in "missiles", space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;
- b. Rocket nozzles, usable in "missiles", space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;
- c. Thrust vector control sub-systems, usable in "missiles";

*Technical Note:*

*Examples of methods of achieving thrust vector control specified in 9A106.c. are:*

1. Flexible nozzle;

9A106 c. (continued)

2. Fluid or secondary gas injection;
3. Movable engine or nozzle;
4. Deflection of exhaust gas stream (jet vanes or probes); or
5. Thrust tabs.

d. Liquid, slurry and gel propellant (including oxidisers) control systems, and specially designed components therefor, usable in "missiles", designed or modified to operate in vibration environments greater than 10 g rms between 20 Hz and 2 kHz.

Note: The only servo valves and pumps specified in 9A106.d., 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 r.p.m. or with discharge pressures equal to or greater than 7 MPa.

9A107 Solid propellant rocket engines, usable in complete rocket systems or unmanned aerial vehicles, capable of a range of 300 km, other than those specified in 9A007, having total impulse capacity equal to or greater than 0,841 MNs.

N.B.: SEE ALSO 9A119.

9A108 Components, other than those specified in 9A008, as follows, specially designed for solid rocket propulsion systems:

- a. Rocket motor cases and "insulation" components therefor, usable in "missiles", space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;
- b. Rocket nozzles, usable in "missiles", space launch vehicles specified in 9A004 or sounding rockets specified in 9A104;
- c. Thrust vector control sub-systems, usable in "missiles".

Technical Note:

Examples of methods of achieving thrust vector control specified in 9A108.c. are:

1. Flexible nozzle;
2. Fluid or secondary gas injection;
3. Movable engine or nozzle;
4. Deflection of exhaust gas stream (jet vanes or probes); or
5. Thrust tabs.

9A109 Hybrid rocket motors and specially designed components as follows:

- a. Hybrid rocket motors usable in complete rocket systems or unmanned aerial vehicles, capable of 300 km, other than those specified in 9A009, having a total impulse capacity equal to or greater than 0,841 MNs, and specially designed components therefor;
- b. Specially designed components for hybrid rocket motors specified in 9A009 that are usable in "missiles".

N.B.: SEE ALSO 9A009 and 9A119.

9A110 Composite structures, laminates and manufactures thereof, other than those specified in 9A010, specially designed for use in 'missiles' or the subsystems specified in 9A005, 9A007, 9A105, 9A106.c., 9A107, 9A108.c., 9A116 or 9A119.

*N.B.:* SEE ALSO 1A002.

*Technical Note:*

In 9A110 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

9A111 Pulse jet engines, usable in "missiles" or unmanned aerial vehicles specified in 9A012, and specially designed components therefor.

*N.B.:* SEE ALSO 9A011 AND 9A118.

9A115 Launch support equipment as follows:

- a. Apparatus and devices for handling, control, activation or launching, designed or modified for space launch vehicles specified in 9A004, unmanned aerial vehicles specified in 9A012 or sounding rockets specified in 9A104;
- b. Vehicles for transport, handling, control, activation or launching, designed or modified for space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

9A116 Reentry vehicles, usable in "missiles", and equipment designed or modified therefor, as follows:

- a. Reentry vehicles;
- b. Heat shields and components therefor, fabricated of ceramic or ablative materials;
- c. Heat sinks and components therefor, fabricated of light-weight, high heat capacity materials;
- d. Electronic equipment specially designed for reentry vehicles.

9A117 Staging mechanisms, separation mechanisms, and interstages, usable in "missiles".

*N.B.:* See also 9A121.

9A118 Devices to regulate combustion usable in engines, which are usable in "missiles" or unmanned aerial vehicles specified in 9A012, specified in 9A011 or 9A111.

9A119 Individual rocket stages, usable in complete rocket systems or unmanned aerial vehicles, capable of a range of 300 km, other than those specified in 9A005, 9A007, 9A009, 9A105, 9A107 and 9A109.

9A120 Liquid propellant tanks, other than those specified in 9A006, specially designed for propellants specified in 1C111 or 'other liquid propellants', used in rocket systems capable of delivering at least a 500 kg payload to a range of at least 300 km.

*Note:* In 9A120 'other liquid propellants' includes, but is not limited to, propellants specified in the Military Goods Controls.

9A121 Umbilical and interstage electrical connectors specially designed for "missiles", space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

*Technical Note:*

Interstage connectors referred to in 9A121 also include electrical connectors installed between the "missile", space launch vehicle or sounding rocket and their payload.

- 9A350 Spraying or fogging systems, specially designed or modified for fitting to aircraft, "lighter-than-air vehicles" or unmanned aerial vehicles, and specially designed components therefor, as follows:
- a. Complete spraying or fogging systems capable of delivering, from a liquid suspension, an initial droplet 'VMD' of less than 50 µm at a flow rate of greater than two litres per minute;
  - b. Spray booms or arrays of aerosol generating units capable of delivering, from a liquid suspension, an initial droplet 'VMD' of less than 50 µm at a flow rate of greater than two litres per minute;
  - c. Aerosol generating units specially designed for fitting to systems specified in 9A350.a. and b.

*Note: Aerosol generating units are devices specially designed or modified for fitting to aircraft such as nozzles, rotary drum atomizers and similar devices.*

*Note: 9A350 does not control spraying or fogging systems and components that are demonstrated not to be capable of delivering biological agents in the form of infectious aerosols.*

Technical Notes:

1. Droplet size for spray equipment or nozzles specially designed for use on aircraft, "lighter-than-air vehicles" or unmanned aerial vehicles should be measured using either of the following:
  - a. Doppler laser method;
  - b. Forward laser diffraction method.
2. In 9A350 'VMD' means Volume Median Diameter and for water-based systems this equates to Mass Median Diameter (MMD).

**9B Test, Inspection and Production Equipment**

- 9B001 Equipment, tooling and fixtures, specially designed for manufacturing gas turbine blades, vanes or "tip shroud" castings, as follows:
- a. Directional solidification or single crystal casting equipment;
  - b. Ceramic cores or shells;
- 9B002 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 "technology" specified in 9E003.h. or 9E003.i.
- 9B003 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.
- 9B004 Tools, dies or fixtures, for the solid state joining of "superalloy", titanium or intermetallic airfoil-to-disk combinations described in 9E003.a.3. or 9E003.a.6. for gas turbines.
- 9B005 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:

N.B.: SEE ALSO 9B105.

9B005 (continued)

- a. Wind tunnels designed for speeds of Mach 1,2 or more;

*Note: 9B005.a. does not control 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  $25 \times 10^6$ .

9B006 Acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20  $\mu$ Pa) with a rated output of 4 kW or more at a test cell temperature exceeding 1 273 K (1 000 °C), and specially designed quartz heaters therefor.

N.B.: SEE ALSO 9B106.

9B007 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.

9B008 Direct measurement wall skin friction transducers specially designed to operate at a test flow total (stagnation) temperature exceeding 833 K (560 °C).

9B009 Tooling specially designed for producing turbine engine powder metallurgy rotor components capable of operating at stress levels of 60 % of Ultimate Tensile Strength (UTS) or more and metal temperatures of 873 K (600 °C) or more.

9B010 Equipment specially designed for the production of "UAVs" and associated systems, equipment and components, specified in 9A012.

9B105 'Aerodynamic test facilities' for speeds of Mach 0,9 or more, usable for 'missiles' and their subsystems.

N.B.: SEE ALSO 9B005.

*Note: 9B105 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. In 9B105 'aerodynamic test facilities' includes wind tunnels and shock tunnels for the study of airflow over objects.
2. In Note to 9B105, '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. In 9B105 'missile' means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

9B106 Environmental chambers and anechoic chambers, as follows:

a. Environmental chambers capable of simulating all the following flight conditions:

1. Having any of the following:

a. Altitude equal to or greater than 15 km; or

b. Temperature range from below 223 K (– 50 °C) to above 398 K (+ 125 °C);

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. 9B106.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 9B106.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 2B116.

3. In 9B106.a.2. ‘bare table’ means a flat table, or surface, with no fixture or fittings.

b. Environmental chambers capable of simulating the following flight conditions:

1. Acoustic environments at an overall sound pressure level of 140 dB or greater (referenced to 20 µPa) or with a total rated acoustic power output of 4 kW or greater; and

2. Altitude equal to or greater than 15 km; or

3. Temperature range from below 223 K (– 50 °C) to above 398 K (+ 125 °C).

9B115 Specially designed “production equipment” for the systems, sub-systems and components specified in 9A005 to 9A009, 9A011, 9A101, 9A102, 9A105 to 9A109, 9A111, 9A116 to 9A120.

9B116 Specially designed “production facilities” for the space launch vehicles specified in 9A004, or systems, sub-systems, and components specified in 9A005 to 9A009, 9A011, 9A101, 9A102, 9A104 to 9A109, 9A111, 9A116 to 9A120 or ‘missiles’.

Technical Note:

In 9B116 ‘missile’ means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

9B117 Test benches and test stands for solid or liquid propellant rockets or rocket motors, having either of the following characteristics:

a. The capacity to handle more than 68 kN of thrust; or

b. Capable of simultaneously measuring the three axial thrust components.

## 9C Materials

9C108 “Insulation” material in bulk form and “interior lining”, other than those specified in 9A008, for rocket motor cases usable in “missiles” or specially designed for ‘missiles’.

Technical Note:

In 9C108 ‘missile’ means complete rocket systems and unmanned aerial vehicle systems capable of a range exceeding 300 km.

9C110 Resin impregnated fibre prepregs and metal coated fibre preforms therefor, for composite structures, laminates and manufactures specified in 9A110, 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.

*N.B.: SEE ALSO 1C010 AND 1C210.*

*Note: The only resin impregnated fibre prepregs specified in entry 9C110 are those using resins with a glass transition temperature ( $T_g$ ), after cure, exceeding 418 K (145 °C) as determined by ASTM D4065 or equivalent.*

## 9D Software

9D001 “Software” specially designed or modified for the “development” of equipment or “technology”, specified in 9A001 to 9A119, 9B or 9E003.

9D002 “Software” specially designed or modified for the “production” of equipment specified in 9A001 to 9A119 or 9B.

9D003 “Software” incorporating “technology” specified in 9E003.h. and used in “FADEC Systems” for propulsion systems specified in 9A or equipment specified in 9B.

9D004 Other “software” as follows:

- a. 2D or 3D viscous “software”, validated with wind tunnel or flight test data required for detailed engine flow modelling;
- b. “Software” for testing aero gas turbine engines, assemblies or components, specially designed to collect, reduce and analyse data in real time and capable of feedback control, including the dynamic adjustment of test articles or test conditions, as the test is in progress;
- c. “Software” specially designed to control directional solidification or single crystal casting;
- d. Not used;
- e. “Software” specially designed or modified for the operation of “UAVs” and associated systems, equipment and components, specified in 9A012;
- f. “Software” specially designed to design the internal cooling passages of aero gas turbine blades, vans 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.

9D101 “Software” specially designed or modified for the “use” of goods specified in 9B105, 9B106, 9B116 or 9B117.

9D103 “Software” specially designed for modelling, simulation or design integration of the space launch vehicles specified in 9A004 or sounding rockets specified in 9A104, or the subsystems specified in 9A005, 9A007, 9A105, 9A106.c., 9A107, 9A108.c., 9A116 or 9A119.

*Note: “Software” specified in 9D103 remains controlled when combined with specially designed hardware specified in 4A102.*

9D104 “Software” specially designed or modified for the “use” of goods specified in 9A001, 9A005, 9A006.d., 9A006.g., 9A007.a., 9A008.d., 9A009.a., 9A010.d., 9A011, 9A101, 9A102, 9A105, 9A106.c., 9A106.d., 9A107, 9A108.c., 9A109, 9A111, 9A115.a., 9A116.d., 9A117 or 9A118.

9D105 “Software” which coordinates the function of more than one subsystem, specially designed or modified for “use” in space launch vehicles specified in 9A004 or sounding rockets specified in 9A104.

## 9E Technology

*Note: “Development” or “production” “technology” specified in 9E001 to 9E003 for gas turbine engines remains controlled when used for repair or overhaul. Excluded from control are: technical data, drawings or documentation for maintenance activities directly associated with calibration, removal or replacement of damaged or unserviceable line replaceable units, including replacement of whole engines or engine modules.*

9E001 “Technology” according to the General Technology Note for the “development” of equipment or “software”, specified in 9A001.b., 9A004 to 9A012, 9A350, 9B or 9D.

9E002 “Technology” according to the General Technology Note for the “production” of equipment specified in 9A001.b., 9A004 to 9A011, 9A350 or 9B.

*N.B.: For “technology” for the repair of controlled structures, laminates or materials, see 1E002.f.*

9E003 Other “technology” as follows:

a. “Technology” “required” for the “development” or “production” of any of the following gas turbine engine components or systems:

1. Gas turbine blades, vanes or “tip shrouds”, made from directionally solidified (DS) or single crystal (SC) alloys 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;

2. Combustors having any of the following:

a. Thermally decoupled liners designed to operate at ‘combustor exit temperature’ exceeding 1 883K (1 610 °C);

b. Non-metallic liners;

c. Non-metallic shells; or

d. Liners designed to operate at ‘combustor exit temperature’ exceeding 1 883K (1 610 °C) and having holes that meet the parameters specified by 9E003.c.;

*Note: The “required” “technology” for holes in 9E003.a.2. is limited to the derivation of the geometry and location of the holes.*

### Technical Note:

‘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 9E003.c. for “technology” “required” for manufacturing cooling holes.*

3. Components manufactured from any of the following:

a. Organic “composite” materials designed to operate above 588 K (315 °C);



9E003 a. 3. (continued)

b. Metal “matrix” “composite”, ceramic “matrix”, intermetallic or intermetallic reinforced materials, specified in 1C007; or

c. “Composite” material specified in 1C010 and manufactured with resins specified in 1C008;

4. Uncooled turbine blades, vanes, “tip-shrouds” or other components, designed to operate at gas path total (stagnation) temperatures of 1 323 K (1 050 °C) or more at sea-level static take-off (ISA) in a ‘steady state mode’ of engine operation;

5. Cooled turbine blades, vanes, “tip-shrouds” other than those described in 9E003.a.1., designed to operate at a ‘gas path temperature’ of 1 693 K (1 420 °C) or more;

*Technical Notes:*

1. ‘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 certified or specified maximum continuous operating temperature.

2. 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.

6. Airfoil-to-disk blade combinations using solid state joining;

7. Gas turbine engine components using “diffusion bonding” “technology” specified in 2E003.b.;

8. ‘Damage tolerant’ gas turbine engine rotor components using powder metallurgy materials specified in 1C002.b.; or

*Technical Note:*

‘Damage tolerant’ components are designed using methodology and substantiation to predict and limit crack growth.

9. Not used;

10. Not used;

11. Hollow fan blades;

b. “Technology” “required” for the “development” or “production” of any of the following:

1. Wind tunnel aero-models equipped with non-intrusive sensors capable of transmitting data from the sensors to the data acquisition system; or

2. “Composite” propeller blades or propfans, capable of absorbing more than 2 000 kW at flight speeds exceeding Mach 0,55;

c. “Technology” “required” for manufacturing cooling holes, in gas turbine engine components incorporating any of the “technologies” specified by 9E003.a.1., 9E003.a.2. or 9E003.a.5., and having any of the following:

1. Having all of the following:

a. Minimum ‘cross-sectional area’ less than 0,45 mm<sup>2</sup>;

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<sup>2</sup>;

b. ‘Hole shape ratio’ greater than 5,65; and

c. ‘Incidence angle’ more than 25°;

9E003 c. (continued)

*Note:* 9E003.c. does not control “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 9E003.c., the ‘cross-sectional area’ is the area of the hole in the plane perpendicular to the hole axis.
  2. For the purposes of 9E003.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 9E003.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. Techniques for manufacturing holes in 9E003.c include “laser”, water jet, Electro-Chemical Machining (ECM) or Electrical Discharge Machining (EDM) methods.
- d. “Technology” “required” for the “development” or “production” of helicopter power transfer systems or tilt rotor or tilt wing “aircraft” power transfer systems;
- e. “Technology” for the “development” or “production” of reciprocating diesel engine ground vehicle propulsion systems having all of the following:
1. ‘Box volume’ of 1,2 m<sup>3</sup> 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<sup>3</sup> of ‘box volume’;

*Technical Note:*

‘Box volume’ in 9E003.e. 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.

- 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 in 1C007:
    - 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);

9E003 f. (continued)

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 multi-fuel (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<sup>3</sup> 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;
- 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.

- 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: 9E003.h. does not control technical data related to engine-aircraft integration required by the civil aviation certification authorities 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).*

- 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.

9E003 i. (continued)

Note: 9E003.i. does not control “development” or “production” “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.

- 9E101
- a. “Technology” according to the General Technology Note for the “development” of goods specified in 9A006.b., 9A006.f., 9A101, 9A102, 9A104 to 9A111 or 9A115 to 9A121.
  - b. “Technology” according to the General Technology Note for the “production” of ‘UAV’s specified in 9A012 or goods specified in 9A006.b., 9A006.f., 9A101, 9A102, 9A104 to 9A111 or 9A115 to 9A121.

Technical Note:

In 9E101.b. ‘UAV’ means unmanned aerial vehicle systems capable of a range exceeding 300 km.

- 9E102
- “Technology” according to the General Technology Note for the “use” of space launch vehicles specified in 9A004, goods specified in 9A005 to 9A011, ‘UAV’s specified in 9A012 or goods specified in 9A101, 9A102, 9A104 to 9A111, 9A115 to 9A121, 9B105, 9B106, 9B115, 9B116, 9B117, 9D101 or 9D103.

Technical Note:

In 9E102 ‘UAV’ means unmanned aerial vehicle systems capable of a range exceeding 300 km.’

---