## SCHEDULE 1

Regulation 3(1)(a)

## PROHIBITED GOODS

**NOTES:**

**1.** All Schedules of this Regulation need to be consulted to determine whether any control therein is applicable.

**2.** For controls on chemical mixtures see also entry 1C950 of Schedule 3.

**3.** For additional controls for equipment for the production, handling and acceptance testing of goods described in entry 1C115 of this Schedule see entry 1B915 of Schedule 3.

**4.** For additional controls for missiles with no payload or for a payload of less than 500 kg see category 9 of Schedule 3.

**5.** Entries 1C351 and 1C352 of this Schedule do not specify goods in the form of a vaccine.

**6.** References to “SEE ALSO MILITARY GOODS CONTROLS” in this Schedule refer to goods in Group 1 of Part III of Schedule 1 of the Export of Goods (Control) Order 1994 as amended(**1**).

**7.** See Schedule 2 for those goods which also require a licence in accordance with regulation 3(1)(b).

**8.** For convenience only, defined terms are printed in quotation marks.

**9.** The description for CTP can be found in category 4.

# LIST OF DUAL-USE GOODS AS SET OUT IN ANNEX I TO THE DECISION

*NOTES TO ANNEX 1*

### TECHNOLOGY

The control of technology transfer in this Annex is limited to tangible forms.

### NUCLEAR TECHNOLOGY NOTE (NTN)

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

The transfer of “technology” directly associated with any goods in Category 0, will be subject to as great a degree of scrutiny and control as will the goods.

“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 transfer 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.

(**1**) S.I. 1994/1191, as amended by S.I. 1994/1632, 2518 and 2711.

"Technology" "required" 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.

N.B.: This does not release the repair "technology" specified in 8E002.a.

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

**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 either:

(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) Telephone order transactions; and

(2) Designed for installation by the user without further substantial support by the supplier; or

(b) "In the public domain".

**DEFINITIONS OF TERMS IN THIS ANNEX**

Category references are given in brackets after the defined term.

**1.** "2–D Vector Rate" (4) means the number of vectors generated per second which have 10 pixel poly line vectors, clip tested, randomly oriented, with either integer or floating point X-Y coordinate values (whichever produces the maximum rate).

**2.** "3–D Vector Rate" (4) means the number of vectors generated per second which have 10 pixel poly line vectors, clip tested, randomly oriented, with either integer or floating point X-Y-Z coordinate values (whichever produces the maximum rate).

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

**4.** "Active flight control systems" (7) are systems whose 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.

**5.** "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.

**6.** "Adaptive control" (2) means a control system that adjusts the response from conditions detected during the operation (ref. ISO 2806-1980).

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

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

**8.** "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 (ref. VDI/VDE 2617, Draft: 'Rotary tables on coordinate measuring machines').

**9.** "Asynchronous transfer mode" (ATM) (5) means a transfer mode in which the information is organised into cells; it is asynchronous in the sense that the recurrence of cells depends on the required or instantaneous bit rate (CCITT recommendation L.113).

**10.** "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.

**11.** "Bandwidth of one voice channel" (5), in the case of data communication equipment, means designed to operate in one voice channel of 3,100 Hz, as defined in CCITT recommendation G.151.

**12.** "Basic gate propagation delay time" (3) means the propagation delay time value corresponding to the basic gate used within a "family" of "monolithic integrated circuits". This may be specified, for a given "family", either as the propagation delay time per typical gate or as the typical propagation delay time per gate.

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

**13.** "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.

**14.** "Beat length" (6) means the distance over which two orthogonally polarised signals, initially in phase, must pass in order to achieve a 2 Piradian(s) phase difference.

**15.** "Bias" (accelerometer) (7) means an accelerometer output when no acceleration is applied.

**186.** "Boron equivalent" (BE) is defined as:

BE=CF×Concentration of element Z in ppm

where

CFistheconversionfactor=gammaZ×ABgammaB×AZ

and $gamma_B$ and $gamma_Z$ are the thermal neutron capture cross sections (in barns) for boron and element Z respectively;

and $A_B$ and $A_Z$ are the atomic weights of boron and element Z respectively;

**16.** "Camming" (axial displacement) (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 (ref. ISO 230/1 1986, paragraph 5.63).

**17.** "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.

**18.** "Chemical Laser" (6) means a "laser" in which the excited species is produced by the output energy from a chemical reaction.

**19.** "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.

**20.** "Civil aircraft" (7 9) 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".

**189.** “Civil aviation authorities” (7 9) means the competent authority in Austria, Australia, Belgium, Canada, Denmark, Ireland, Finland, France, Germany, Greece, Italy, Japan, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Turkey, United Kingdom or United States of America.

**21.** “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.

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

**23.** “Common channel signalling” (5) is a signalling method in which a single channel between exchanges conveys, by means of labelled messages, signalling information relating to a multiplicity of circuits or calls and other information such as that used for network management.

**24.** “Communications channel controller” (5) 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.

**25.** “Composite” (1 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.

**26.** “Composite theoretical performance” (CTP) (4) is a measure of computational performance given in millions of theoretical operations per second (Mtops), calculated using the aggregation of “computing elements” (CE).

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

**27.** “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”.

**28.** “Computing element” (CE) (4) means the smallest computational unit that produces an arithmetic or logic result.

**29.** “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).

**30.** “Critical temperature” (1 3 6) (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.

**31.** “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.

N.B.: “Secret parameter”: a constant or key kept from the knowledge of others or shared only within a group.

**32.** “Datagram” (4 5) means a self-contained, independent entity of data carrying sufficient information to be routed from the source to the destination data terminal equipment without reliance on earlier exchanges between this source or destination data terminal equipment and the transporting network.

**33.** “Data signalling rate” (5) means the rate, as defined in ITU Recommendation 53-36, taking into account that, for non-binary modulation, baud and bit per second are not equal. Bits for coding, checking and synchronisation functions are to be included.

N.B.: 1. When determining the "data signalling rate", servicing and administrative channels shall be excluded.

N.B.: 2. It is the maximum one-way rate, i.e., the maximum rate in either transmission or reception.

**34.** "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.

**35.** "Depleted uranium" (0) means uranium depleted in the isotope 235 below that occurring in nature.

**36.** "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.

**37.** "Diffusion bonding" (1 2 9) means a solid state molecular joining of at least two separate metals into a single piece with a joint strength equivalent to that of the weakest material.

**38.** "Digital computer" (4 5) means equipment which can, in the form of one or more discrete variables:

(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.

**39.** "Digital transfer rate" (5) 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".

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

**41.** "Drift rate" (gyro) (7) means the time rate of output deviation from the desired output. It consists of random and systematic components and is expressed as an equivalent input angular displacement per unit time with respect to inertial space.

**42.** "Dynamic adaptive routing" (5) means automatic rerouting of traffic based on sensing and analysis of current actual network conditions.

N.B.: This does not include cases of routing decisions taken on predefined information.

**43.** "Dynamic signal analysers" (3) means "signal analysers" which use digital sampling and transformation techniques to form a Fourier spectrum display of the given waveform including amplitude and phase information.

N.B.: See also "signal analysers".

**44.** "Effective gramme" (0) of "special fissile material" or "other 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 U-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 U-235, the element weight in grammes multiplied by 0.0001;

(d) For americium-242m, curium-245 and -247, californium-249 and -251, the isotope weight in grammes multiplied by 10;

**45.** "Electronic assembly" (3 4) 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.

**46.** "Electronically steerable phased array antenna" (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.

**47.** "End-effectors" (2) include 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": a device for applying motive power, process energy or sensing to the workpiece.

**48.** "Equivalent Density" (6) means the mass of an optic per unit optical area projected onto the optical surface.

**49.** "Expert systems" (4) mean systems providing results by application of rules to data which are stored independently of the "programme" and capable of any of the following:

(a) Modifying automatically the "source code" introduced by the user;

(b) Providing knowledge linked to a class of problems in quasi-natural language; or

(c) Acquiring the knowledge required for their development (symbolic training).

**50.** "Family" (3) means a group of microprocessor or microcomputer microcircuits with:

(a) The same architecture;

(b) The same basic instruction set; and

(c) The same basic technology (e.g., only NMOS or only CMOS).

**51.** "Fast select" (4 5) means a facility applicable to virtual calls which allows a data terminal equipment to expand the possibility to transmit data in call set-up and clearing packets beyond the basic capabilities of a virtual call.

N.B.: "Packet": a group of binary digits including data and call control signals which is switched as a composite whole. The data, call control signals and possibly error control information are arranged in a specified format.

**52.** "Fault tolerance" (4) is the capability of a computer system, after any malfunction of any of its hardware or "software" components, to continue to operate without human intervention, at a given level of service that provides: continuity of operation, data integrity and recovery of service within a given time.

**53.** "Fibrous or filamentary materials" (0 2 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.

**54.** "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": a single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.

**55.** "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.

**56.** "Flexible manufacturing unit" (FMU) (2) (sometimes also referred to as "flexible manufacturing system" (FMS) or "flexible manufacturing cell" (FMC)) means an entity which includes a combination of at least:

(a) A "digital computer" including its own "main storage" and its own related equipment; and

(b) Two or more of the following:

(1) A machine tool specified in 2B001.c.;

(2) A dimensional inspection machine specified in Category 2., or another digitally controlled measuring machine specified in Category 2.;

(3) A "robot" specified in Categories 2. or 8.;

(4) .Digitally controlled equipment specified in 1B003, 2B003 or 9B001;

(5) "Stored programme controlled" equipment specified in 3B001.a.;

(6) Digitally controlled equipment specified in 1B001;

(7) Digitally controlled electronic equipment specified in 3A002.c.

**57.** "Fluoride fibres" (6) means fibres manufactured from bulk fluoride compounds.

**190.** "Focal plane array" (6) 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.

**58.** "Frequency agility" (frequency hopping) (5) means a form of "spread spectrum" in which the transmission frequency of a single communication channel is made to change by discrete steps.

**59.** "Frequency switching time" (3 5) means the maximum time (i.e., delay), taken by a signal, when switched from one selected output frequency to another selected output frequency, to reach:

(a) A frequency within 100 Hz of the final frequency; or

(b) An output level within 1 dB of the final output level.

**60.** "Frequency synthesiser" (3) means any kind of frequency source or signal generator, regardless of the actual technique used, providing a multiplicity of simultaneous or alternative output frequencies, from one or more outputs, controlled by, derived from or disciplined by a lesser number of standard (or master) frequencies.

**61.** "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.

**62.** "Gateway" (5) means the function, realised by any combination of equipment and "software", to carry out the conversion of conventions for representing, processing or communicating information used in one system into the corresponding but different conventions used in another system.

**63.** "Generic software" (5) means a set of instructions for a "stored programme controlled" switching system that is the same for all switches using that type of switching system.

N.B.: The data base portion is not considered to be part of the "generic software".

**64.** "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".

**65.** "Global interrupt latency time" (4) means the time taken by the computer system to recognize an interrupt due to the event, service the interrupt and perform a context switch to an alternate memory-resident task waiting on the interrupt.

**66.** "Guidance set" (7) means systems that integrate the process of measuring and computing a vehicles position and velocity (ie. navigation) with that of computing and sending commands to the vehicles flight control systems to correct the trajectory.

**67.** "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.

**68.** "Hybrid computer" (4) means equipment which can:

(a) Accept data;

(b) Process data, in both analogue and digital representations; and

(c) Provide output of data.

**69.** "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:

Containing at least one unencapsulated device;

Connected together using typical IC production methods;

Replaceable as an entity; and

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.

2. "Discrete component": a separately packaged "circuit element" with its own external connections.

**70.** "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.

**71.** "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").

**72.** "Information security" (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", "cryptanalysis", protection against compromising emanations and computer security.

N.B.: "Crypanalysis": the analysis of a cryptographic system or its inputs and outputs to derive confidential variables or sensitive data, including clear text.

**73.** "Instantaneous bandwidth" (3 5) means the bandwidth over which output power remains constant within 3dB without adjustment of other operating parameters.

**74.** "Instrumented range" (6) means the specified unambiguous display range of a radar.

**75.** "Insulation" (9) is applied to the components of a rocket motor, ie. 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.

**76.** "Integrated Services Digital Network" (ISDN) (5) means a unified end-to-end digital network, in which data originating from all types of communication (e.g., voice, text, data, still and moving pictures) are transmitted from one port (terminal) in the exchange (switch) over one access line to and from the subscriber.

**77.** "Interconnected radar sensors" (6) means two or more radar sensors are interconnected when they mutually exchange data in real time.

**78.** "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, eg carbon filled HTPB or other polymer with added curing agents sprayed or screeded over a case interior.

**79.** "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".

**191.** "Isolated live cultures" includes live cultures in dormant form and in dried preparations.

**80.** "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.

**81.** "Laser" (0 2 3 5 6 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";

"Q-switched laser";

"Super High Power";

"Transfer laser".

**82.** "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.

**83.** "Local area network" (4) is a data communication system which:

(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”: equipment capable of transmitting or receiving sequences of digital information.

**84.** “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”.

**85.** “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.

**86.** “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.

**87.** “Matrix” (1 6 8 9) means a substantially continuous phase that fills the space between particles, whiskers or fibres.

**88.** “Maximum bit transfer rate” (“MBTR”) of:

(a) solid state storage equipment means the number of data bits per second transferred between the equipment and its controller;

(b) a disk drive means the internal data transfer rate calculated as

B×R×T (bits per second)

where:

| | | |
|---|---|---|
| B | = | maximum number of data bits per track available to read or write in a single revolution; |
| R | = | revolutions per second; |
| T | = | number of tracks which can be read or written simultaneously. |

**192.** “MBTR”—see Maximum Bit transfer Rate.

**89.** “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. VDI/VDE 2617).

**90.** “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.

**91.** “Media access unit” (5) means equipment which contains one or more communication interfaces (“network access controller”, “communications channel controller”, modem or computer bus) to connect terminal equipment to a network.

**92.** “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/sec.

**93.** “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/sec.

**94.** "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.

**95.** "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.

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

**187.** "Microorganisms" (1 2) means bacteria, viruses, mycoplasms, 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.

**96.** "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.

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

**98.** "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 semiconducting 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": a single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.

**99.** "Motion control board" (2) means an "electronic assembly" specially designed to provide a computer system with the capability to coordinate simultaneously the motion of axes of machine tools for "contouring control".

**100.** "Multichip integrated circuit" (3) means two or more "monolithic integrated circuits" bonded to a common "substrate".

**101.** "Multi-data-stream processing" (4) means the "microprogramme" or equipment architecture technique which permits simultaneous processing of two or more data sequences under the control of one or more instruction sequences by means such as:

(a) Single Instruction Multiple Data (SIMD) architectures such as vector or array processors;

(b) Multiple Single Instruction Multiple Data (MSIMD) architectures;

(c) Multiple Instruction Multiple Data (MIMD) architectures, including those which are tightly coupled, closely coupled or loosely coupled; or

(d) Structured arrays of processing elements, including systolic arrays.

**102.** "Multilevel security" (5) means a class of system containing information with different sensitivities that simultaneously permits access by users with different security clearances and needs-to-know, but prevents users from obtaining access to information for which they lack authorization.

N.B.: "Multilevel security" is computer security and not computer reliability which deals with equipment fault prevention or human error prevention in general.

**103.** "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.

**104.** "Natural uranium" (0) means uranium containing the mixtures of isotopes occurring in nature.

**105.** "Network access controller" (4 5) 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.

**106.** "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.

**107.** "Noise level" (6) means an electrical signal given in terms of power spectral density. The relation between "noise level" expressed in peak-to-peak is given by $S^{2}_{pp} = 8N_o(f_2 - f_1)$, where $S_{pp}$ is the peak-to-peak value of the signal (e.g., nanoteslas), $N_o$ is the power spectral density (e.g., $(\text{nanotesla})^2/\text{Hz}$) and $(f_2 - f_1)$ defines the bandwidth of interest.

**108.** "Nuclear reactor" (0) means 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.

**109.** "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).

**110.** "Operate autonomously" (8) means operating 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.

**111.** "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.

**112.** "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.

**113.** "Optical fibre preforms" (5 6) means bars, ingots, or rods of glass, plastic or other materials which have been specially processed for use in fabricating optical fibres. The characteristics of the preform determine the basic parameters of the resultant drawn optical fibres.

**114.** "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).

**115.** "Optical switching" (5) means the routing of or switching of signals in optical form without conversion to electrical signals.

**116.** "Other fissile materials" (0) mean "previously separated" americium-242m, curium-245 and -247, californium-249 and -251, isotopes of plutonium other than plutonium-238 and -239, and any material containing the foregoing.

**117.** "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.).

**118.** "Part programme" (2) means an ordered set of instructions in a language and in a format required to cause operations to be effected under automatic control, which is either written in the form of a machine program on an input medium or prepared as input data for processing in a computer to obtain a machine program (ref. ISO 2806-1980).

**119.** "Peak power" (6), means energy per pulse in joules divided by the pulse duration in seconds.

**120.** "Personalized smart card" (5) means a smart card containing a microcircuit, in accordance with ISO/IEC 781, which has been programmed by the issuer and cannot be changed by the user.

**121.** "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.

**122.** "Previously separated" (0) means the application of any process intended to increase the concentration of the controlled isotope.

**123.** "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.

**124.** "Private automatic branch exchange" (PABX) (5) means an automatic telephone exchange, typically incorporating a position for an attendant, designed to provide access to the public network and serving extensions in an institution such as a business, government, public service or similar organisation.

**125.** "Production" (GTN NTN All) means all production phases, such as: construction, production engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

**126.** "Production equipment" (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".

**127.** "Production facilities" (9) means equipment and specially designed software therefor integrated into installations for "development" or for one or more phases of "production".

**128.** "Programme" (2 4 5) means a sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

**129.** "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.

**130.** "Pulse duration" (6) is the duration of a "laser" pulse measured at Full Width Half Intensity (FWHI) levels.

**131.** "Q-switched laser" (6) means a "laser" in which the energy is stored in the population inversion or in the optical resonator and subsequently emitted in a pulse.

**132.** "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.

**133.** "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.

**134.** "Range" (8) means half the maximum distance a submersible vehicle can cover.

**135.** "Real time bandwidth" (3) for "dynamic signal analysers" is the widest frequency range which the analyser can output to display or mass storage without causing any discontinuity in the analysis of the input data. For analysers with more than one channel, the channel configuration yielding the widest "real-time bandwidth" shall be used to make the calculation.

**136.** "Real time processing" (2 4) means processing of data by an electronic computer in response to an external event according to time requirements imposed by the external event.

**137.** "Required" (GTN 1-9), as applied to "technology" or "software", refers to only that portion of "technology" or "software" which is peculiarly responsible for achieving or extending the controlled performance levels, characteristics or functions. Such "required" "technology" or "software" may be shared by different goods.

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

**139.** "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.

**140.** "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.

**141.** "Run out" (out-of-true running) (2) 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 (ref. ISO 230/1-1986, paragraph 5.61).

**142.** "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.

**143.** "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.

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

**145.** "Signal processing" (4 5) 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).

**146.** "Simple educational devices" (3) means devices designed for use in teaching basic scientific principles and demonstrating the operation of those principles in educational institutions.

**147.** "Software" (GSN All) means a collection of one or more "programmes" or "microprogrammes" fixed in any tangible medium of expression.

**148.** "Source code" (or source language) (4 5) 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)).

**149.** "Spacecraft" (7 9) means active and passive satellites and space probes.

**150.** "Space qualified" (3 6) refers to products designed, manufactured and tested to meet the special electrical, mechanical or environmental requirements for use in the launch and deployment of satellites or high altitude flight systems operating at altitudes of 100 km or higher.

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

**152.** "Specific modulus" (0 1) 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 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

**153.** "Specific tensile strength" (0 1) 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 ± 2) K ((23 ± °C) and a relative humidity of (50 ± 5)%.

**154.** "Spectral efficiency" (5) is a figure of merit parametrized to characterize the efficiency of transmission system which uses complex modulation schemes such as QAM (quadrature amplitude modulation), Trellis coding, QPSK (Q-phased shift key), etc. It is defined as follows:

Spectralefficiency=Digital transfer rate(bits/second)6dB spectrum bandwidth (Hz)

**155.** "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/sec.

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

**157.** "Sputtering" (4) means an overlay coating process wherein positively charged 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 the substrate.

N.B.: Triode, magnetron or radio frequency sputtering to increase adhesion of coating and rate of deposition are ordinary modifications of the process.

**158.** "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.

**159.** "Stored programme controlled" (2 3 5) means controlled by using instructions stored in an electronic storage which a processor can execute in order to direct the performance of predetermined functions.

N.B.: Equipment may be "stored programme controlled" whether the electronic storage is internal or external to the equipment.

**160.** "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.: "Discrete component": a separately packaged "circuit element" with its own external connections.

**161.** "Substrate blanks" (6) means monolithic compounds with dimensions suitable for the production of optical elements such as mirrors or optical windows.

**162.** "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.

**163.** "Superconductive" (1 3 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.

**164.** "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.

**165.** "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.

**166.** "Swept frequency network analysers" (3) means analysers which involve the automatic measurement of equivalent circuit parameters over a range of frequencies, involving swept frequency measurement techniques but not continuous wave point-to-point measurements.

**167.** "Switch fabric" (5) is that hardware and associated "software" which provides the physical or virtual connection path for in-transit message traffic being switched.

**168.** "Synchronous digital hierarchy" (SDH) (5) means a digital hierarchy providing a means to manage, multiplex and access various forms of digital traffic using a synchronous transmission format on different types of media. The format is based on the Synchronous Transport Module (STM) which is defined by CCITT Recommendation G.703, G.707, G.708, G.709 and others yet to be published. The first level rate of "SDH" is 155.52 Mbit/s.

**169.** "Synchronous optical network" (SONET) (5) means a network providing a means to manage, multiplex and access various forms of digital traffic using a synchronous transmission format on fibre optics. The format is the North America version of "SDH" and also uses the Synchronous Transport Module (STM). However, it uses the Synchronous Transport Signal (STS) as the basic transport module with a first level rate of 51.81 Mbit/s. The SONET standards are being integrated into those of "SDH".

**170.** "Systems 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.

**171.** "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.

**172.** "Technical assistance" (GTN NTN) may take forms such as instructions, skills, training, working knowledge and consulting services and may involve the transfer of "technical data".

**173.** "Technical data" (GTN NTN) 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.

**174.** "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".

**175.** "Terminal interface equipment" (4) means equipment at which information enters or leaves the telecommunication system, e.g., telephone, data device, computer, facsimile device.

**176.** "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.

**177.** "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).

**188.** "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".

**178.** "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".

**179.** "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.

**180.** "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".

**181.** "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 0.72 per cent);

**182.** "Use" (GTN NTN All) means Operation, installation (including on-site installation), maintenance (checking), repair, overhaul and refurbishing.

**183.** "User-accessible programmability" (5 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.

**184.** "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.

**185.** "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.

| CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT | |
|---|---|
| **0A** | **Equipment, Assemblies and Components** |
| **0A001** | "Nuclear reactors", i.e. reactors capable of operation so as to maintain a controlled, self-sustaining fission chain reaction, and equipment and components specially designed or prepared for use in connection with a "nuclear reactor", including:<br>a. Pressure vessels, i.e. metal vessels as complete units or parts therefor, which are specially designed or prepared to contain the core of a "nuclear reactor" and are capable of withstanding the operating pressure of the primary coolant, including the top plate for a reactor pressure vessel;<br>b. Fuel element handling equipment, including reactor fuel charging and discharging machines;<br>c. Control rods specially designed or prepared for the control of the reaction rate in a "nuclear reactor", including the neutron absorbing part and the support or suspension structures therefore, and control rod guide tubes;<br>d. Electronic controls for controlling the power levels in "nuclear reactors", including reactor control rod drive mechanisms and radiation detection and measuring instruments to determine neutron flux levels; |

**CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT**

| | |
|---|---|
| | e. Pressure tubes specially designed or prepared to contain fuel elements and the primary coolant in a "nuclear reactor" at an operating pressure in excess of 5.1 MPa;<br>f. Tubes or assemblies of tubes, made from zirconium metal or alloy in which the ratio of hafnium to zirconium is less than 1:500 parts by weight, specially designed or prepared for use in a "nuclear reactor";<br>g. Coolant pumps specially designed or prepared for circulating the primary coolant of "nuclear reactors";<br>h. Internal components specially designed or prepared for the operation of a "nuclear reactor", including core support structures, thermal shields, baffles, core grid plates and diffuser plates;<br>i. Heat exchangers. |
| **0A002** | Power generating or propulsion equipment specially designed for use with space, marine or mobile "nuclear reactors".<br><br>N.B.: SEE ALSO MILITARY GOODS CONTROLS.<br><br>NOTE: This entry does not apply to conventional power generating equipment which, although designed for use in a particular nuclear station, could in principle be used in conjunction with conventional systems. |
| **0B** | **Test, Inspection and Production Equipment** |
| **0B001** | Plant for the separation of isotopes of "natural uranium" and "depleted uranium", "special fissile materials" and "other fissile materials", and specially designed or prepared equipment and components therefor, as follows:<br>a. Plant specially designed for separating isotopes of "natural uranium" and "depleted uranium", "special fissile materials" and "other fissile materials", as follows:<br>1. Gaseous diffusion separation plant;<br>2. Gas centrifuge separation plant;<br>3. Aerodynamic separation plant;<br>4. Chemical exchange separation plant;<br>5. Ion-exchange separation plant;<br>6. Atomic vapour "laser" isotopic separation plant; |

7. Molecular “laser” isotopic separation plant;
8. Plasma separation plant;
9. Electro magnetic separation plant;

b. Equipment and components, specially designed or prepared for gaseous diffusion separation process, as follows:

1. Bellow valves made of or protected by materials resistant to $UF_6$ (e.g. aluminium, aluminium alloys, nickel or alloy containing 60 weight percent or more nickel), with a diameter of 40 mm to 1500 mm;
2. a. Compressors (positive displacement, centrifugal and axial flowtypes) or gas blowers with a suction volume capacity of 1 $m^3$/min or more of $UF_6$, and discharge pressure up to 666.7 kPa, made of or protected by materials resistant to $UF_6$ (e.g. aluminium, aluminium alloys, nickel or alloy containing 60 weight percent or more nickel);

   b. Rotary shaft seals for compressors or blowers specified in 0B001.b.2.a. and designed for a buffer gas in-leakage rate of less than 1,000 $cm^3$/min.;
3. Gaseous diffusion barriers made of porous metallic, polymer or ceramic materials resistant to corrosion by $UF_6$ 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;
4. Gaseous diffuser housings made of or protected by materials resistant to corrosion by $UF_6$;
5. Heat exchangers made of aluminium, copper, nickel, or alloys containing more than 60 weight percent nickel, or combinations of these metals as clad tubes, designed to operate at sub-atmospheric pressure with a leak rate that limits the pressure rise to less than

10 Pa per hour under a pressure differential of 100 kPa;

c. Equipment and components, specially designed or prepared for gas centrifuge separation process, as follows:
  1. Gas centrifuges;
  2. Complete rotor assemblies consisting of one or more rotor tube cylinders;
  3. Rotor tube cylinders with a thickness of 12 mm or less, a diameter of between 75 mm and 400 mm, made from any of the following high strength-to-density ratio materials:
     a. Maraging steel capable of an ultimate tensile strength of 2050 MPa or more;
     b. Aluminium alloys capable of an ultimate tensile strength of 460 MPa or more; or
     c. "Fibrous or filamentary materials" with a "specific modulus" of more than $3.18 \times 10^6$ m and a "specific tensile strength" greater than $76.2 \times 10^3$ m;
  4. Magnetic suspension bearings consisting of an annular magnet suspended within a housing made of $UF_6$ resistant materials (e.g. aluminium, aluminium alloys, nickel or alloy containing 60 weight percent or more nickel) containing a damping medium and having the magnet coupling with a pole piece or second magnet fitted to the top cap of the rotor;
  5. Specially prepared bearings comprising a pivot-cup assembly mounted on a damper;
  6. Rings or bellows with a wall thickness of 3 mm or less and a diameter of between 75 mm and 400 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 described in the Note below;
  7. Baffles of between 75 mm and 400 mm diameter for mounting inside a

rotor tube, made from high strength-to-density ratio materials described in the Note below;

8. Top and bottom caps of between 75 mm and 400 mm diameter to fit the ends of a rotor tube, made from any of the following high strength-to-density ratio materials:
   a. Maraging steel capable of an ultimate tensile strength of 2050 MPa or more; or
   b. Aluminium alloys capable of an ultimate tensile strength of 460 MPa or more;
   c. “Fibrous or filamentary materials” with a “specific modulus” of more than 3.18 × $10^6$ m and a “specific tensile strength” greater than 7.62 × $10^4$ m.
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 in the frequency range of 600 to 2,000 Hz and a power range of 50 to 1,000 Volt-Amps;
11. 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. Multiphase output of 600 to 2000 Hz;
    b. Frequency control better than 0.1%;
    c. Harmonic distortion of less than 2%; and
    d. An efficiency greater than 80%;
12. 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 and made of or protected by $UF_6$ resistant materials;

13. Scoops consisting of tubes of up to 12 mm internal diameter for the extraction of $UF_6$ gas from within a centrifuge rotor tube by a Pitot tube action, made of or protected by $UF_6$ resistant materials;

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 and having a knife-edge contained within the nozzle which separates the gas flowing through the nozzle into two streams;
2. Tangential inlet flow-driven cylindrical or conical tubes, (vortex tubes), made of or protected by $UF_6$ resistant materials with a diameter of between 0.5 cm and 4 cm and a length to diameter ratio of 20:1 or less and with one or more tangential inlets;
3. Compressors (positive displacement, centrifugal and axial flow types) or gas blowers with a suction volume capacity of 2 $m^3$/min, made of or protected by materials resistant to $UF_6$ (e.g., aluminium, aluminium alloys, nickel or alloy containing 60 weight percent or more nickel), and rotary shaft seals therefor;
4. Aerodynamic separation element housings, made of or protected by materials resistant to $UF_6$ to contain vortex tubes or separation nozzles;
5. Heat exchangers made of aluminium, copper, nickel, or alloy containing more than 60 weight percent nickel, or combinations of these metals as clad tubes, designed to operate at pressures of 600 kPa or less;
6. Bellows valves made of or protected by $UF_6$ resistant materials with a diameter of 40 to 1500 mm;

7. Process systems for separating $UF_6$ from carrier gas (hydrogen or helium) to 1 ppm $UF_6$ content or less, including:
   a. Cryogenic heat exchangers and cryoseparators capable of temperatures of−120°C or less;
   b. Cryogenic refrigeration units capable of temperatures of −120°C or less;
   c. Separation nozzle or vortex tube units for the separation of $UF_6$ from carrier gas;
   d. $UF_6$ cold traps capable of temperatures of−20°C or less;

e. Equipment and components, specially designed or prepared for chemical exchange separation process, as follows:
1. 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 lined with suitable plastic materials such as fluorocarbon polymers or lined with glass);
2. 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 lined with suitable plastic materials such as fluorocarbon polymers or lined with glass);
3. Electrochemical reduction cells designed to reduce uranium from one valence state to another;
4. Electrochemical reduction cells feed equipment to take $U+^{4}$ 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 $U+^6$ or $U+^4$ to $U+^3$;

6. Uranium oxidation systems for oxidation of $U+^3$ to $U+^4$;

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 100°C to 200°C;
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 100°C to 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 "laser" isotopic separation process, as follows:

1. High power electron beam guns with total power of more than 50 kW and strip or scanning electron beam guns with a delivered power of more than 2.5 kW/cm for use in uranium vaporization systems;

**CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT**

2. Trough shaped crucibles and cooling equipment made of or protected by materials resistant to heat and corrosion of molten uranium or uranium alloy,s (e.g., tantalum, yttria-coated graphite, graphite coated with other rare earth oxides or mixtures thereof);

   N.B: SEE ALSO ENTRY 2A225.
3. Product and tails collector systems made of or lined with materials resistant to the heat and corrosion of uranium vapour, 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 for the separation of uranium isotopes with a spectrum frequency stabiliser for operation over extended periods of time;

h. Equipment and components, specially designed or prepared for molecular "laser" isotopic separation process, as follows:
   1. Supersonic expansion nozzles for cooling mixtures of $UF_6$ and carrier gas to 150 K or less and made from $UF_6$ resistant materials;
   2. Uranium fluoride ($UF_5$) product collectors consisting of filter, impact, or cyclone-type collectors or combinations thereof, and made of $UF_5/UF_6$ resistant materials (e.g. aluminium, aluminium alloys, nickel or alloys containing 60 weight percent of nickel and $UF_6$ resistant fully fluorinated hydrocarbon polymers);
   3. Equipment for fluorinating $UF_5$ to $UF_6$;
   4. Compressors made of or protected by materials resistant to $UF_6$ (e.g., aluminium, aluminium alloys, nickel or alloy containing 60 weight

percent or more nickel), and rotary shaft seals therefor;

5. Process systems for separating $UF_6$ from carrier gas (e.g., nitrogen or argon) including:
   a. Cryogenic heat exchangers and cryoseparators capable of temperatures of−120°C or less;
   b. Cryogenic refrigeration units capable of temperatures of −120°C or less;
   c. $UF_6$ cold traps capable of temperatures of−20°C or less;
6. Lasers or laser systems for the separation of uranium isotopes with a spectrum frequency stabiliser for operation over extended periods of time;

i. Equipment and components, specially designed or prepared for plasma separation process, as follows:
   1. Product and tails collectors made of or protected by materials resistant to the heat and corrosion of uranium vapour such as yttria-coated graphite or tantalum;
   2. Radio frequency ion excitation coils for frequencies of more than 100 kHz and capable of handling more than 40 kW mean power.
   3. 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;
   4. Uranium plasma generation systems;
   5. Liquid uranium metal handling systems consisting of crucibles, made of or protected by suitable corrosion and heat resistant materials (e.g., tantalum, yttria-coated graphite, graphite coated with other rare earth oxides or mixtures thereof), and cooling equipment for the crucibles;

      N.B.: SEE ALSO ENTRY 2A225.
   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, ionizer, and beam accelerator made of suitable 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 materials (e.g. graphite or stainless steel);
   3. Vacuum housings for uranium electromagnetic separators made of non-magnetic materials (e.g. graphite or 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;
      d. Voltage regulation of better than 0.01% over a period of 8 hours;
   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;
      b. Current or voltage regulation better than 0.01% over a period of 8 hours.

| CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT | |
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| **0B002** | Specially designed or prepared auxiliary systems, equipment and components, as follows, for isotope separation plant specified in 0B001, made of or protected by $UF_6$ resistant materials:<br>a. Feed autoclaves, ovens or systems used for passing $UF_6$ to the enrichment process;<br>b. Desublimers or cold traps, used to remove $UF_6$ from the enrichment process for subsequent transfer upon heating;<br>c. Product and tails stations for transferring $UF_6$ into containers;<br>d. Liquefaction or solidification stations used to remove $UF_6$ from the enrichment process by compressing and converting $UF_6$ to a liquid or solid form;<br>e. Piping systems and header systems specially designed for handling $UF_6$ within gaseous diffusion, centrifuge or aerodynamic cascades made of or protected by $UF_6$ resistant materials;<br>f. 1. Vacuum manifolds or vacuum headers having a suction capacity of 5 $m^3$/minute or more; or<br>2. vacuum pumps specially designed for use in $UF_6$ bearing atmospheres;<br>g. $UF_6$ mass spectrometers/ion sources specially designed or prepared for taking on-line samples of feed, product or tails from $UF_6$ gas streams and having all of the following characteristics:<br>1. Unit resolution for mass of more than 320 amu;<br>2. Ion sources constructed of or lined with nichrome or monel, or nickel plated;<br>3. Electron bombardment ionization sources; and<br>4. Collector system suitable for isotopic analysis. |
| **0B003** | Plant for the production of uranium hexafluoride ($UF_6$) and specially designed or prepared equipment and components therefor, as follows:<br>a. Plant for the production of $UF_6$;<br>b. Equipment and components, as follows, specially designed or prepared for $UF_6$ production: |

1. Fluorination and hydrofluorination screw and fluid bed reactors and flame towers;
2. Distillation equipment for the purification of $UF_6$.

**0B004** Plant for the production of heavy water, deuterium or 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. Hydrogen sulphide-water exchange plants;
   2. Ammonia-hydrogen exchange plants;
   3. Hydrogen distillation plants;
b. Equipment and components, as follows, designed for:
   1. Hydrogen sulphide-water exchange process:
      a. Tray exchange towers;
      b. Hydrogen sulphide gas compressors;
   2. Ammonia-hydrogen exchange process:
      a. High-pressure ammonia-hydrogen exchange towers;
      b. High-efficiency stage contactors;
      c. Submersible stage recirculation pumps;
      d. Ammonia crackers designed for pressures of more than 3 MPa;
   3. Hydrogen distillation process:
      a. Hydrogen cryogenic distillation towers and cold boxes designed for operation below 35 K (−238°c);
      b. Turboexpanders or turboexpander-compressor sets designed for operation below 35 K (−238°c);
   4. Heavy water concentration process to reactor grade level (99.75 weight percent deuterium oxide):
      a. Water distillation towers containing specially designed packings;

| CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT | |
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| | b. Ammonia distillation towers containing specially designed packings;<br>c. Catalytic burners for conversion of fully enriched deuterium to heavy water;<br>d. Infrared absorption analysers capable of on-line hydrogen-deuterium ratio analysis where deuterium concentrations are equal to or more than 90 weight percent. |
| **0B005** | Plant specially designed for the fabrication of “nuclear reactor” fuel elements and specially designed equipment therefor.<br><br>NOTE: A plant for the fabrication of “nuclear reactor” fuel elements includes equipment which:<br>a. Normally comes into direct contact with or directly processes or controls the production flow of nuclear materials;<br>b. Seals the nuclear materials within the cladding;<br>c. Checks the integrity of the cladding or the seal; and<br>d. Checks the finish treatment of the solid fuel. |
| **0B006** | Plant for the reprocessing of irradiated “nuclear reactor” fuel elements, and specially designed or prepared equipment and components therefore, including:<br>a. Fuel element chopping or shredding machines, i.e. remotely operated equipment to cut, chop, shred or shear irradiated “nuclear reactor” fuel assemblies, bundles or rods;<br>b. 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;<br>c. Counter-current solvent extractors and ion-exchange processing equipment specially designed or prepared for use in a plant for the reprocessing of irradiated “natural uranium”, “depleted uranium” or “special fissile materials” and “other fissile materials”; |

d. Process control instrumentation specially designed or prepared for monitoring or controlling the reprocessing of irradiated "natural uranium", "depleted uranium" or "special fissile materials" and "other fissile materials";

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

NOTE: Critically safe tanks may have the following features:

1. Walls or internal structures with a boron equivalent of at least two percent;
2. A maximum diameter or 175 mm for cylindrical vessels; or
3. A maximum width of 75 mm for either a slab or annular vessel.

f. Complete systems specially designed or prepared for the conversion of plutonium nitrate to plutonium oxide;

g. Complete systems specially designed or prepared for the production of plutonium metal.

NOTE: Plant for the reprocessing of irradiated "nuclear reactor" fuel elements includes 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.

**0B007**

Equipment, as follows, specially designed or prepared for the separation of isotopes of lithium:

a. Packed liquid-liquid exchange columns specially designed for lithium amalgams;
b. Amalgam pumps;
c. Amalgam electrolysis cells;
d. Evaporators for concentrated lithium hydroxide solution.

**0B008**

Equipment for "nuclear reactors":

a. Simulators specially designed for "nuclear reactors";
b. Ultrasonic or eddy current test equipment specially designed for "nuclear reactors".

**0B009**

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 $UO_3$;
b. Systems for the conversion of $UO_3$ to $UF_6$;
c. Systems for the conversion of $UO_3$ to $UO_2$;
d. Systems for the conversion of $UO_2$ to $UF_4$;
e. Systems for the conversion of $UF_4$ to $UF_6$;
f. Systems for the conversion of $UF_4$ to uranium metal;
g. Systems for the conversion of $UF_6$ to $UO_2$;
h. Systems for the conversion of $UF_6$ to $UF_4$.

**0C** **Materials**

**0C001** "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;

except:

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;
    4. Counter-weights.

**0C002** "Special fissile materials" and "other fissile materials";

except:

Four "effective grammes" or less when contained in a sensing component in instruments.

**0C003** Materials, which may be used in nuclear heat sources, as follows:

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

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| | Three grammes or less when contained in a sensing component in instruments;<br>b. "Previously separated" neptunium-237 in any form;<br>except:<br>Shipments with a neptunium-237 content of one gramme or less. |
| **0C004** | Deuterium, heavy water, deuterated paraffins and other compounds of deuterium, and mixtures and solutions containing deuterium, in which the isotopic ratio of deuterium to hydrogen exceeds 1:5000. |
| **0C005** | Graphite, nuclear-grade, having a purity level of less than 5 parts per million "boron equivalent" and with a density greater than 1.5 g/cm$^3$. |
| **0C006** | Nickel powder and porous nickel metal, as follows:<br>a. Powder with a nickel purity content of 99.9 weight percent or more and a mean particle size of less than 10 micrometres measured by American Society for Testing and Materials (ASTM) B330 standard and a high degree of particle size uniformity;<br>b. Porous nickel metal produced from materials specified in 0C006.a.;<br>except:<br>Single porous nickel sheets not exceeding 930 cm$^2$ intended for use in batteries for civil applications. |
| **0C201** | Specially prepared compounds or powders, other than nickel, resistant to corrosion by $UF_6$ (e.g. aluminium oxide and fully fluorinated hydrocarbon polymers), for the manufacture of gaseous diffusion barriers, having a purity of 99.9 weight percent or more and a mean particle size of less than 10 micrometres 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** |

| CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT | |
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| **0E001** | "Technology" according to the Nuclear Technology Note for the "development", "production" or "use" of goods specified in this Category. |

**CATEGORY 1—MATERIALS, CHEMICALS, "MICROORGANISMS" & "TOXINS"**

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| **1A** | **Equipment, Assemblies and Components** |
| **1A001** | Components made from fluorinated compounds, as follows:<br>a. Seals, gaskets, sealants or fuel bladders specially designed for aircraft or aerospace use made from more than 50% of any of the materials specified in 1C009.b. or c.;<br>b. Piezoelectric polymers and copolymers made from vinylidene fluoride:<br>1. In sheet or film form; and<br>2. With a thickness exceeding 200 micrometre;<br>c. Seals, gaskets, valve seats, bladders or diaphragms made from fluoroelastomers containing at least one vinylether monomer, specially designed for aircraft, aerospace or missile use.<br><br>"Missile" in 1A001.c. means complete rocket systems and unmanned air vehicle systems. |
| **1A002** | "Composite" structures or laminates, as follows:<br><br>N.B.: SEE ALSO 1A202, 9A010 and 9A110.<br>a. Having an organic "matrix" and made from materials specified in 1C010.c., d. or e.; or<br>b. Having a metal or carbon "matrix" and made from:<br>1. Carbon "fibrous or filamentary materials" with:<br>a. A "specific modulus" exceeding $10.15 \times 10^6$ m; and<br>b. A "specific tensile strength" exceeding $17.7 \times 10^4$ m; or<br>2. Materials specified in 1C010.c.<br><br>NOTE: 1A002 does not control composite structures or laminates made from epoxy resin impregnated carbon "fibrous or filamentary materials" for the repair of aircraft structures or laminates, |

provided the size does not exceed 1 m&2sup;.

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| **1A003** | Manufactures of non-fluorinated polymeric substances specified in 1C008.a., in film, sheet, tape or ribbon form:<br>a. With a thickness exceeding 0.254 mm; or<br>b. Coated or laminated with carbon, graphite, metals or magnetic substances. |
| **1A102** | Resaturated pyrolized carbon-carbon materials designed for systems specified in 9A004 or 9A104. |
| **1A202** | Composite structures, other than those specified in 1A002, in the form of tubes with an inside diameter of between 75 mm and 400 mm made with “fibrous or filamentary materials” specified in 1C010.a. or b. or 1C210.<br><br>N.B.: SEE ALSO 9A110. |
| **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 for use in separating heavy water from ordinary water and made of phosphor bronze mesh or copper (both chemically treated to improve wettability) and designed for use in vacuum distillation towers. |
| **1A227** | High-density (lead glass or other) radiation shielding windows greater than 0.3 m on a side and with a density greater than 3 g/cm$^3$ and a thickness of 100 mm or greater; and specially designed frames therefor. |
| **1B** | **Test, Inspection and Production Equipment** |
| **1B001** | Equipment for the production of fibres, prepregs, preforms or “composites” specified in 1A002 or 1C010, as follows, and specially designed components and accessories therefor:<br><br>N.B.: SEE ALSO 1B101 AND 1B201.<br>a. Filament winding machines of which the motions for positioning, wrapping and winding fibres are coordinated and programmed in three or more axes, specially designed for the manufacture of “composite” structures or laminates from “fibrous or filamentary materials”; |

b. Tape-laying or tow-placement machines of which the motions for positioning and laying tape, tows or sheets are coordinated and programmed in two or more axes, specially designed for the manufacture of "composite" airframe or missile structures;

In 1B001.b., 'missile' means complete rocket systems and unmanned air vehicle systems.

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

except:

Textile machinery not modified for the above end-uses;

d. Equipment specially designed or adapted for the production of reinforcement fibres, as follows:
   1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon, pitch or polycarbosilane) into carbon fibres or silicon carbide fibres, including special equipment to strain the fibre during heating;
   2. Equipment for the chemical vapour deposition of elements or compounds on heated filamentary substrates to manufacture silicon carbide fibres;
   3. Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide);
   4. Equipment for converting aluminium containing precursor fibres into alumina fibres by heat treatment;
e. Equipment for producing prepregs specified in 1C010.e. by the hot melt method;
f. Non-destructive inspection equipment capable of inspecting defects three dimensionally, using ultrasonic or X-ray tomography and specially designed for "composite" materials.

| CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT | |
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| **1B002** | Systems and components therefor specially designed for producing metal alloys, metal alloy powder or alloyed materials specified in 1C002.a.2., 1C002.b. or 1C002.c. |
| **1B003** | Tools, dies, moulds or fixtures, for "superplastic forming" or "diffusion bonding" titanium or aluminium or their alloys, specially designed for the manufacture of:<br>a. Airframe or aerospace structures;<br>b. Aircraft or aerospace engines; or<br>c. Specially designed components for those structures or engines. |
| **1B101** | Equipment, other than that specified in entry 1B001, for the production of structural composites as follows; and specially designed components and accessories therefor:<br><br>N.B.: SEE ALSO 1B201.<br><br>NOTE: Components and accessories specified in this entry include moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.<br>a. Filament winding 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;<br>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;<br>c. Equipment designed or modified for the production of fibrous or filamentary materials as follows:<br>1. Equipment for converting polymeric fibres (such as polyacrylonitrile, rayon or polycarbosilane) including special provision to strain the fibre during heating;<br>2. Equipment for the vapour deposition of elements or |

compounds on heated filament substrates; and

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 9A110.

NOTE: Equipment covered by this sub-head includes rollers, tension stretchers, coating equipment, cutting equipment and clicker dies.

**1B115** Equipment for the production, handling and acceptance testing of propellants or propellant constituents specified in 1C115 or in the Military Goods Controls, and specially designed components therefor.

NOTES:

1. The only mixers specified in this item are those, which have provision for mixing under vacuum in the range of zero to 13.326 kPa and with temperature control capability of the mixing chamber:
   a. Batch mixers having a total volumetric capacity of 110 litres or more and at least one mixing/kneading shaft mounted off centre;
   b. Continuous mixers having two or more mixing/kneading shafts and capability to open the mixing chamber.
2. For equipment specially designed for the production of military goods, see the Military Goods Controls.

**1B116** Specially designed nozzles for producing pyrolitically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1573 K (1300°C) to 3173 K (2900°C) temperature range at pressures of 130 Pa to 20 kPa.

**1B201** Filament winding machines, other than those specified in 1B001 or 1B101, in which the motions for positioning, wrapping, and winding fibres are coordinated and programmed in two or more axes, specially designed to fabricate composite structures or laminates from "fibrous or filamentary materials" and capable of winding cylindrical rotors of diameter between

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| | 75 mm and 400 mm and lengths of 600 mm or greater and coordinating and programming controls and precision mandrels therefor. |
| **1B225** | Electrolytic cells for fluorine production with a production capacity greater than 250g 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.<br><br>NOTE: 1B226 includes separators:<br>a. Capable of enriching stable isotopes;<br>b. With the ion sources and collectors both in the magnetic field and those configurations in which they are external to the field. |
| **1B227** | Ammonia synthesis converters or ammonia synthesis units in which the synthesis gas (nitrogen and hydrogen) is withdrawn from an ammonia/hydrogen high-pressure exchange column and the synthesized ammonia is returned to said column. |
| **1B228** | Hydrogen-cryogenic distillation columns having all of the following characteristics:<br>a. Designed to operate with internal temperatures of 35 K (−238°C) or less;<br>b. Designed to operate at an internal pressure of 0.5 to 5 MPa (5 to 50 atmospheres);<br>c. Constructed of fine-grain stainless steels of the 300 series with low sulphur content or equivalent cryogenic and $H_2$-compatible materials; and<br>d. With internal diameters of 1 m or greater and effective lengths of 5 m or greater. |
| **1B229** | Water-hydrogen sulphide exchange tray columns constructed from fine carbon steel with a diameter of 1.8m or greater to operate at a nominal pressure of 2 MPa or greater.<br>1. NOTES: For columns which are specially designed or prepared for the production of heavy water see 0B004.<br>2. 1B229 includes internal contactors of the columns, which are segmented trays with an effective assembled diameter of 1.8m or greater, such as sieve trays, valve trays, bubble cap trays, and turbogrid trays designed to facilitate countercurrent |

contacting and constructed of materials resistant to corrosion by hydrogen sulphide/water mixtures, such as 304L or 316 stainless steel.

3. Fine Carbon steels include steels such as specified by ASTM A516.

**1B230**

Pumps circulating solutions of diluted or concentrated potassium amide catalyst in liquid ammonia ($KNH_2/NH_3$), with all of the following characteristics:

a. Airtight (i.e., hermetically sealed);

b. For concentrated potassium amide solutions (1% or greater), operating pressure of 1.5-60 MPa (15-600 atmospheres); for dilute potassium amide solutions (less than 1%), operating pressure of 20-60 MPa (200-600 atmospheres); and

c. A capacity greater than 8.5 $m^3$/hr.

**1B231**

Facilities or plants for the production, recovery, extraction, concentration, or handling of tritium, and equipment as follows:

a. Hydrogen or helium refrigeration units capable of cooling to 23K (−250°C) or less, with heat removal capacity greater than 150 watts; or

b. Hydrogen isotope storage and purification systems using metal hydrides as the storage, or purification medium.

**1C** **Materials**

**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;

except:

Materials as follows:

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

1. Hair type absorbers, constructed of natural or synthetic fibres, with non-magnetic loading to provide absorption;

2. Absorbers having no magnetic loss and whose incident surface is non-planar in shape, including pyramids,

cones, wedges and convoluted surfaces;

3. Planar absorbers:
   a. Made from:
      1. Plastic foam materials (flexible or non-flexible) with carbon-loading, or organic materials, including binders, providing more than 5% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 450 K (177°C); or
      2. Ceramic materials providing more than 20% echo compared with metal over a bandwidth exceeding ±15% of the centre frequency of the incident energy, and not capable of withstanding temperatures exceeding 800 K (527°C);

      Technical Note: Absorption test samples for 1C001.a.3.a. 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.
   b. Tensile strength less than $7 \times 10^6$ N/m$^2$; and
   c. Compressive strength less than $14 \times 10^6$ N/m$^2$;
4. Planar absorbers made of sintered ferrite, with:
   a. A specific gravity exceeding 4.4; and
   b. A maximum operating temperature of 548 K (275°C);

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;

**CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT**

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

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

**1C002** Metal alloys, metal alloy powder or alloyed materials, as follows:

N.B.: SEE ALSO 1C202.

NOTE: 1C002 does not control metal alloys, metal alloy powder or alloyed materials for coating substrates.

a. Metal alloys, as follows:
   1. Nickel or titanium-based alloys in the form of aluminides, as follows, in crude or semi-fabricated forms:
      a. Nickel aluminides containing 10 weight percent or more aluminium;
      b. Titanium aluminides containing 12 weight percent or more aluminium;
   2. Metal alloys, as follows, made from metal alloy powder or particulate material specified in 1C002.b.:
      a. Nickel alloys with:
         1. A stress-rupture life of 10,000 hours or longer at 923 K (650°C) at a stress of 550 MPa; or
         2. A low cycle fatigue life of 10,000 cycles or more at 823 K (550°C) at a maximum stress of 700 MPa;
      b. Niobium alloys with:
         1. A stress-rupture life of 10,000 hours or longer

at 1,073 K (800°C) at a stress of 400 MPa; or
2. A low cycle fatigue life of 10,000 cycles or more at 973 K (700°C) at a maximum stress of 700 MPa;

c. Titanium alloys with:
1. A stress-rupture life of 10,000 hours or longer at 723 K (450°C) at a stress of 200 MPa; or
2. A low cycle fatigue life of 10,000 cycles or more at 723 K (450°C) at a maximum stress of 400 MPa;

d. Aluminium alloys with a tensile strength of:
1. 240 MPa or more at 473 K (200°C); or
2. 415 MPa or more at 298 K (25°C);

e. Magnesium alloys with a tensile strength of 345 MPa or more and a corrosion rate of less than 1 mm/year in 3% sodium chloride aqueous solution measured in accordance with ASTM standard G-31 or equivalents;

Technical Notes:
1. The metal alloys specified in 1C002.a. 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 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 equivalents. Testing should be axial with an average stress ratio equal to 1 and a stress-concentration factor ($K_t$) equal to 1. The average stress

is defined as maximum stress minus minimum stress divided by maximum stress.

b. Metal alloy powder or particulate material for materials specified in 1C002.a., as follows:

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 micrometre in $10^9$ alloy particles;

b. Niobium alloys (Nb-Al-X or Nb-X-Al, Nb-Si-X or Nb-X-Si, Nb-Ti-X or Nb-X-Ti);

c. Titanium alloys (Ti-Al-X or Ti-X-Al);

d. Aluminium alloys (Al-Mg-X or Al-X-Mg, Al-Zn-X or Al-X-Zn, Al-Fe-X or Al-X-Fe); or

e. Magnesium alloys (Mg-Al-X or Mg-X-Al); and

2. Made in a controlled environment by any of the following processes:

a. “Vacuum atomisation”;

b. “Gas atomisation”;

c. “Rotary atomisation”;

d. “Splat quenching”;

e. “Melt spinning” and “comminution”;

f. “Melt extraction” and “comminution”; or

g. “Mechanical alloying”;

c. Alloyed materials, in the form of uncomminuted flakes, ribbons or thin rods produced in a controlled environment by “splat quenching”, “melt spinning” or “melt extraction”, used in the manufacture of metal alloy powder or particulate material specified in 1C002.b.

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**1C003**

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

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

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

b. Magnetostrictive alloys with:
  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 alloy strips with:
  1. A composition having a minimum of 75 weight percent of iron, cobalt or nickel; and
  2. A saturation magnetic induction ($B_s$) of 1.6 T or more, and:
    a. A strip thickness of 0.02 mm or less; or
    b. An electrical resistivity of $2 \times 10^{-4}$ ohm cm or more.

**1C004**

Uranium titanium alloys or tungsten alloys with a “matrix” based on iron, nickel or copper, with:

a. A density exceeding 17.5 $g/cm^3$;
b. An elastic limit exceeding 1,250 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. Multifilamentary “superconductive” “composite” conductors containing one or more niobium-titanium filaments:
  1. Embedded in a “matrix” other than a copper or copper-based mixed “matrix”; or
  2. With a cross-section area less than $0.28 \times 10^{-4}$ $mm^2$ (6 micrometre in diameter for circular filaments);

b. “Superconductive” “composite” conductors consisting of one or more “superconductive” filaments other than niobium-titanium:
  1. With a “critical temperature” at zero magnetic induction exceeding 9.85

K (−263.31°C) but less than 24 K (−249.16°C);
2. With a cross-section area less than $0.28 \times 10^{-4}$ $mm^2$; and
3. Which remain in the "superconductive" state at a temperature of 4.2 K (−268.96°C) when exposed to a magnetic field corresponding to a magnetic induction of 12 T.

**1C006**

Fluids and lubricating materials, as follows:

a. Hydraulic fluids containing, as their principal ingredients, any of the following compounds or materials:
   1. Synthetic hydrocarbon oils or silahydrocarbon oils with:
      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

      NOTE: For the purpose of 1C006.a.1., silahydrocarbon oils contain exclusively silicon, hydrogen and carbon.
   2. Chlorofluorocarbons with:
      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;

      NOTE: For the purpose of 1C006.a.2, chlorofluorocarbons contain exclusively carbon, fluorine and chlorine.
b. Lubricating materials containing, as their principal ingredients, any of the following compounds or materials:
   1. Phenylene or alkylphenylene ethers or thio-ethers, or their mixtures, containing more than two ether or

thio-ether functions or mixtures thereof; or

2. Fluorinated silicone fluids with a kinematic viscosity of less than 5,000 $mm^2/s$ (5,000 centistokes) measured at 298 K (25°C);

c. Damping or flotation fluids with a purity exceeding 99.8%, containing less than 25 particles of 200 micrometre or larger in size per 100 ml and made from at least 85% of any of the following compounds or materials:

1. Dibromotetrafluoroethane;
2. Polychlorotrifluoroethylene (oily and waxy modifications only); or
3. Polybromotrifluoroethylene;

Technical Note:

For the purpose of 1C006:

a. Flash point is determined using the Cleveland Open Cup Method described in ASTM D-92 or equivalents.
b. Pour point is determined using the method described in ASTM D-97 or equivalents.
c. Viscosity index is determined using the method described in ASTM D-2270 or equivalents.
d. Thermal stability is determined by the following test procedure or 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 ± 6K (371 ± 6°C) for six hours. The specimen will be considered thermally stable if, on completion of the above procedure, all of the following conditions are met:

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

e. Autogenous ignition temperature is determined using the method described in ASTM E-659 or 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 micrometre and no more than 10% of the particles larger than 10 micrometre;
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;

   except:

   Abrasives;
c. Ceramic-ceramic "composite" materials with a glass or oxide-"matrix" and reinforced with fibres from any of the following systems:
   1. Si-N;
   2. Si-C;
   3. Si-Al-O-N; or
   4. Si-O-N;
d. Ceramic-ceramic "composite" materials, with or without a continuous metallic phase, containing finely dispersed particles or phases of any fibrous or whisker-like material, 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).

**1C008** Non-fluorinated polymeric substances, as follows:

a. 1. Bismaleimides;
   2. Aromatic polyamide-imides;
   3. Aromatic polyimides;
   4. Aromatic polyetherimides having a glass transition temperature ($T_g$) exceeding 503 K (230°C) as measured by the wet method;

   NOTE: 1C008.a does not control non-fusible compression moulding powders or moulded forms.

b. Thermoplastic liquid crystal copolymers having a heat distortion temperature exceeding 523 K (250°C) measured according to ASTM D-648, method A, or equivalents, with a load of 1.82 $N/mm^2$ and composed of:
   1. Either of the following:
      a. Phenylene, biphenylene or naphthalene; or
      b. Methyl, tertiary-butyl or phenyl substituted phenylene, biphenylene or naphthalene; and
   2. Any of the following acids:
      a. Terephthalic acid;
      b. 6-hydroxy-2 naphthoic acid; or
      c. 4-hydroxybenzoic acid;

c. Polyarylene ether ketones, as follows:
   1. Polyether ether ketone (PEEK);
   2. Polyether ketone ketone (PEKK);
   3. Polyether ketone (PEK);
   4. Polyether ketone ether ketone ketone (PEKEKK);

d. Polyarylene ketones;

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

f. Polybiphenylenethersulphone.

**1C009** Unprocessed fluorinated compounds, as follows:

a. Copolymers of vinylidene fluoride having 75% or more beta crystalline structure without stretching;
b. Fluorinated polyimides containing 30% or more of combined fluorine;
c. Fluorinated phosphazene elastomers containing 30% or more of combined fluorine.

**1C010** "Fibrous or filamentary materials" which may be used in organic "matrix", metallic "matrix" or carbon "matrix" "composite" structures or laminates, as follows:

N.B.: SEE ALSO 1C210.

a. Organic "fibrous or filamentary materials" (except polyethylene) with:
   1. A "specific modulus" exceeding $12.7 \times 10^6$ m; and
   2. A "specific tensile strength" exceeding $23.5 \times 10^4$ m;
b. Carbon "fibrous or filamentary materials" with:
   1. A "specific modulus" exceeding $12.7 \times 10^6$ m; and
   2. A "specific tensile strength" exceeding $23.5 \times 10^4$ m;

   Technical Note: Properties for materials described in 1C010.b. should be determined using Suppliers of Advance Composite Materials Association (SACMA) recommended methods SRM 12 to 17, or equivalent tow tests, such as Japanese Industrial Standard JIS-R-7601, Paragraph 6.6.2., and based on lot average.

   NOTE: 1C010.b. does not control fabric made from "fibrous or filamentary materials" for the repair of aircraft structures or laminates in which the size of individual sheets does not exceed 50 cm × 90 cm.
c. Inorganic "fibrous or filamentary materials" with:
   1. A "specific modulus" exceeding $2.54 \times 10^6$ m; and

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2. A melting, decomposition or sublimation point exceeding 1,922K (1,649°C) in an inert environment;

NOTE: 1C010.c. does not control:
1. Discontinuous, multiphase, polycrystalline alumina fibres in chopped fibre or random mat form, containing 3 weight percent or more silica, with a "specific modulus" of less than $10 \times 10^6$ m;
2. Molybdenum and molybdenum alloy fibres;
3. Boron fibres;
4. Discontinuous ceramic fibres with a melting, decomposition or sublimation point lower than 2,043 K (1,770°C) in an inert environment.

d. "Fibrous or filamentary materials":
1. Composed of any of the following:
    a. Polyetherimides specified in 1C008.a.; or
    b. Materials specified in 1C008.b., c., d., e. or f.; or
2. Composed of materials specified in 1C010.d.1.a. or b. and "commingled" with other fibres specified in 1C010.a.,b.or c.;

e. Resin- or pitch-impregnated fibres (prepregs), metal or carbon-coated fibres (preforms) or carbon fibre preforms, as follows:
N.B.: SEE ALSO 9A010
1. Made from "fibrous or filamentary materials" specified in 1C010.a., b. or c.;
2. Made from organic or carbon "fibrous or filamentary materials":
    a. With a "specific tensile strength" exceeding $17.7 \times 10^4$ m;
    b. With a "specific modulus" exceeding $10.15 \times 10^6$ m;
    c. Not specified in 1C010.a. or b.; and
    d. When impregnated with materials specified in 1C008 or 1C009.b., or with phenolic or epoxy resins, having a glass

transition temperature ($T_g$) exceeding 383 K (110°C).

NOTE: 1C010.e. does not control epoxy resin matrix impregnated carbon "fibrous or filamentary materials" (prepregs) for the repair of aircraft structures or laminates, in which the size of individual sheets of prepreg does not exceed 50 cm × 90 cm.

**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" and their subsystems.

1. NOTE: 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, infra red or ultra violet regions of the electromagnetic spectrum.
2. 1C101 does not include coatings when specially used for the thermal control of satellites.

**1C107**

Graphite and ceramic materials, as follows:

a. Fine grain recrystallised bulk graphites having a bulk density of 1.72 g/$cm^3$ or greater, measured at 288 K (15°C), and having a particle size of 100 micrometres or less, pyrolytic or fibrous reinforced graphites, usable for rocket nozzles and reentry vehicle nose tips;
b. Ceramic composite materials (dielectric constant less than 6 at frequencies from 100 Hz to 10,000 MHz), also usable for radomes, and bulk machinable silicon-carbide reinforced unfired ceramic, usable for nose tips.

**1C115**

Propellants and constituent chemicals for propellants, as follows:

a. Propulsive substances:
   1. Spherical aluminium powder, other than that specified in the Military Goods Controls, with particles of uniform diameter of less than

500 micrometre and an aluminium content of 97% by weight or greater;

2. Metal fuels, other than that specified in the Military Goods Controls, in particle sizes less than 500 micrometres, whether spherical, atomized, spheroidal, flaked or ground, consisting of 97% by weight or more of any of the following:
    a. Zirconium;
    b. Beryllium;
    c. Boron;
    d. Magnesium;
    e. Zinc;
    f. Alloys of the metals specified by a. to e. above; or
    g. Misch metal;
3. Liquid oxidisers, the following:
    a. Dinitrogen trioxide;
    b. Nitrogen dioxide/dinitrogen tetroxide;
    c. Dinitrogen pentoxide;

b. Polymeric substances:
1. Carboxy-terminated polybutadiene (CTPB);
2. Hydroxy-terminated polybutadiene (HTPB), other than that specified in the Military Goods Controls;
3. Polybutadiene-acrylic acid (PBAA);
4. Polybutadiene-acrylic acid-acrylonitrile (PBAN);

c. Other propellant additives and agents:
1. Butacene;
2. Triethylene glycol dinitrate (TEGDN);
3. 2-Nitrodiphenylamine.

NOTE: For propellants and constituent chemicals for propellants not specified here, see the Military Goods Controls.

**1C116**

Maraging steels (steels generally characterised by high nickel, very low carbon content and the use of substitutional elements or precipitates to produce age-hardening) having an ultimate tensile strength of 1500 MPa or greater, measured at 293 K (20°C), in the form of sheet, plate or tubing with a wall or plate thickness equal to or less than 5 mm.

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N.B.: SEE ALSO 1C216.

**1C117**

Tungsten, molybdenum and alloys of these metals in the form of uniform spherical or atomized particles of 500 micrometre diameter or less with a purity of 97% or greater for fabrication of rocket motor components i.e. heat shields, nozzle substrates, nozzle throats and thrust vector control surfaces.

**1C202**

Alloys, other than those specified in 1C002.a.2.c or d, as follows:

a. Aluminium alloys capable of an ultimate tensile strength of 460 MPa or more at 293 K (20°C), in the form of tubes or solid forms (including forgings) with an outside diameter of more than 75 mm;

b. Titanium alloys capable of an ultimate tensile strength of 900 MPa or more at 293 K (20°C) in the form of tubes or 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”, other than those specified in 1C010.a. or b., as follows:

a. Carbon or aramid “fibrous or filamentary materials” having a “specific modulus” of $12.7 \times 10^6$ m or greater or a “specific tensile strength” of $23.5 \times 10^4$ m or greater; or

b. Glass “fibrous or filamentary materials” having a “specific modulus” of $3.18 \times 10^6$ m or greater and a “specific tensile strength” of $7.62 \times 10^4$ m or greater.

**1C216**

Maraging steel, other than that specified in 1C116, capable of an ultimate tensile strength of 2,050 MPa or more, at 293 K (20°C);

except:

Forms in which no linear dimension exceeds 75 mm.

Technical Note: The phrase ‘maraging steel capable of’ encompasses maraging steel before or after heat treatment.

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|---|---|
| **1C225** | Boron and boron compounds, mixtures and loaded materials in which the boron-10 isotope is more than 20% by weight of the total boron content. |
| **1C226** | Tungsten, as follows: parts made of tungsten, tungsten carbide, or tungsten alloys (greater than 90% tungsten) having a mass greater than 20 kg and a hollow cylindrical symmetry (including cylinder segments) with an inside diameter greater than 100 mm but less than 300 mm;<br><br>except:<br><br>Parts specially designed for use as weights or gamma-ray collimators. |
| **1C227** | Calcium (high purity) containing both less than 1,000 parts per million by weight of metallic impurities other than magnesium and less than 10 parts per million of boron. |
| **1C228** | Magnesium (high purity) containing both less than 200 parts per million by weight of metallic impurities other than calcium and less than 10 parts per million of boron. |
| **1C229** | High purity (99.99% or greater) bismuth with very low silver content (less than 10 parts per million). |
| **1C230** | Beryllium metal, alloys containing more than 50% of beryllium by weight, compounds containing beryllium, and manufactures thereof;<br><br>except:<br>a. Metal Windows for X-ray machines;<br>b. Oxide shapes in fabricated or semi-fabricated forms specially designed for electronic component parts or as substrates for electronic circuits.<br><br>NOTE: This control applies to waste and scrap containing beryllium as defined here. |
| **1C231** | Hafnium metal, alloys and compounds of hafnium containing more than 60% hafnium by weight and manufactures thereof. |
| **1C232** | Helium in any form isotopically enriched in the helium-3 isotope, whether or not mixed with any other materials or contained in any equipment or device; |

except:

Products or devices containing less than 1 g of helium-3.

**1C233**

Lithium, as follows:

a. Metal, hydrides or alloys containing lithium enriched in the 6 isotope ($^{6}Li$) to a concentration higher than the one existing in nature (7.5% on an atom percentage basis);
b. Any other materials containing lithium enriched in the 6 isotope (including compounds, mixtures and concentrates); except:
$^{6}Li$ incorporated in thermoluminescent dosimeters.

**1C234**

Zirconium as follows: metal, alloys containing more than 50% zirconium by weight, and compounds in which the ratio of hafnium content to zirconium content is less than 1 part to 500 parts by weight, and manufactures wholly thereof;

except:

Zirconium in the form of foil having a thickness not exceeding 0.10 mm.

NOTE: This control applies to waste and scrap containing zirconium as defined here.

**1C235**

Tritium, tritium compounds, and mixtures containing tritium in which the ratio of tritium to hydrogen by atoms exceeds 1 part in 1000;

except:

A product or device containing not more than 40 Ci of tritium in any chemical or physical form.

**1C236**

Alpha-emitting radionuclides having an alpha half-life of 10 days or greater but less than 200 years, including equipment, compounds and mixtures containing these radionuclides with a total alpha activity of 1 curie per kilogram (37 GBq/kg) or greater;

except:

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|---|---|
| | Devices containing less than 100 millicuries (3.7 GBq) of alpha activity per device. |
| **1C237** | Radium-226;<br><br>except:<br><br>Radium contained in medical applicators. |
| **1C238** | Chlorine trifluoride ($ClF_3$). |
| **1C239** | High explosives, other than those specified in the Military Goods Controls, or substances or mixtures containing more than 2% thereof, with a crystal density greater than 1.8 gm per $cm^3$ and having a detonation velocity greater than 8,000 m/s.<br><br>N.B.: SEE ALSO MILITARY GOODS CONTROLS. |
| **1C350** | Chemicals, which may be used as precursors for toxic chemical agents, as follows:<br>1. Thiodiglycol (111-48-8)<br>2. Phosphorus oxychloride (10025-87-3)<br>3. Dimethyl methylphosphonate (756-79-6)<br>4. **SEE MILITARY GOODS CONTROLS FOR Methyl phosphonyldifluoride (676-99-3)**<br>5. Methyl phosphonyl dichloride (676-97-1)<br>6. Dimethylphosphite (868-85-9)<br>7. Phosphorus trichloride (7719-12-2)<br>8. Trimethyl phosphite (121-45-9)<br>9. Thionyl chloride (7719-09-7)<br>10. 3-Hydroxy-1-methylpiperidine (3554-74-3)<br>11. N,N-Diisopropyl-(beta)-aminoethyl chloride (96-79-7)<br>12. N,N-Diisopropyl-(beta)-aminoethane thiol (5842-07-9)<br>13. 3-Quinuclidinol (1619-34-7)<br>14. Potassium fluoride (7789-23-3)<br>15. 2-Chloroethanol (107-07-3)<br>16. Dimethylamine (124-40-3)<br>17. Diethyl ethylphosphonate (78-38-6)<br>18. Diethyl-N,N-dimethylphosphoramidate (2404-03-7)<br>19. Diethyl phosphite (762-04-9)<br>20. Dimethylamine hydrochloride (506-59-2)<br>21. Ethyl phosphinyl dichloride (1498-40-4)<br>22. Ethyl phosphonyl dichloride (1066-50-8)<br>23. Ethyl phosphonyl difluoride (753-98-0)<br>24. Hydrogen fluoride (7664-39-3) |

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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 methylphosphonite (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 (1341-49-7)
43. Sodium fluoride (7681-49-4)
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).

**1C351**

Human pathogens, zoonoses and "toxins":

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. Chikungunya virus
    2. Congo-Crimean haemorrhagic fever virus
    3. Dengue fever virus
    4. Eastern equine encephalitis virus
    5. Ebola virus
    6. Hantaan virus

7. Junin virus
8. Lassa fever virus
9. Lymphocytic choriomeningitis virus
10. Machupo virus
11. Marburg virus
12. Monkey pox virus
13. Rift Valley fever virus
14. Tick-borne encephalitis virus

    (Russian Spring-Summer encephalitis virus)
15. Variola virus
16. Venezuelan equine encephalitis virus
17. Western equine encephalitis virus
18. White pox
19. Yellow fever virus
20. Japanese encephalitis virus

b. Rickettsiae, 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. Coxiella burnetii
2. Rickettsia quintana
3. Rickettsia prowasecki
4. Rickettsia rickettsii

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. Chlamydia psittaci
6. Clostridium botulinum
7. Francisella tularensis
8. Pseudomonas mallei
9. Pseudomonas pseudomallei
10. Salmonella typhi
11. Shigella dysenteriae
12. Vibrio cholerae
13. Yersinia pestis

d. “Toxins”, as follows:
1. Botulinum toxins
2. Clostridium perfringens toxins
3. Conotoxin
4. Ricin

5. Saxitoxin
6. Shiga toxin
7. Staphylococcus aureus toxins
8. Tetrodotoxin
9. Verotoxin
10. Microcystin (Cyanginosin).

**1C352**

Animal 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. African swine fever virus;
   2. Avian influenza virus, which are:
      a. Uncharacterised; or
      b. Defined in EC Directive 92/40/EC (O.J. L.16 23.1.92 p.19) 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 H5 or H7 subtype for which nucleotide sequencing has demonstrated multiple basic amino acids at the cleavage site of haemagglutinin;
   3. Bluetongue virus;
   4. Foot and mouth disease virus;
   5. Goat pox virus;
   6. Porcine herpes virus (Aujeszky’s disease);
   7. Swine fever virus (Hog cholera virus);
   8. Lyssa virus;
   9. Newcastle disease virus;
   10. Peste des petits ruminants virus;
   11. Porcine enterovirus type 9;
   12. Rinderpest virus;
   13. Sheep pox virus;
   14. Teschen disease virus;
   15. Vesicular stomatitis virus;
b. Mycoplasma mycoides, 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.

**1C353** Genetically-modified "microorganisms", as follows:

a. Genetically modified "microorganisms" or genetic elements that contain nucleic acid sequences associated with pathogenicity and are derived from organisms specified in 1C351.a. to c. or 1C352 or 1C354;
b. Genetically modified "microorganisms" or genetic elements that contain nucleic acid sequences coding for any of the "toxins" specified in 1C351.d.

**1C354** Plant pathogens, as follows:

a. 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 campestris pv. citri including strains referred to as Xanthomonas campestris pv. citri types A,B,C,D,E or otherwise classified as Xanthomonas citri, Xanthomonas campestris pv. aurantifolia or Xanthomonas campestris pv. citrumelo;
b. 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 coffeanum var. virulans;
   2. Cochliobolus miyabeanus (Helminthosporium oryzae);
   3. Microcyclus ulei (syn. Dothidella ulei);
   4. Puccinia graminis (syn. Puccinia graminis f. sp. tritici);
   5. Puccinia striiformis (syn. Puccinia glumarum);
   6. Magnaporthe grisea (Pyricularia grisea/Pyricularia oryzae).

**1D** **Software**

| CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT | |
|---|---|
| **1D001** | "Software" specially designed or modified for the "development", "production" or "use" of goods specified in 1B001 to 1B003. |
| **1D002** | "Software" for the "development" of organic "matrix", metal "matrix" or carbon "matrix" laminates or "composites". |
| **1D101** | "Software" specially designed for the "use" of goods specified in 1B101. |
| **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, 1A003, 1B or 1C. |
| **1E002** | Other "technology":<br>a. "Technology" for the "development" or "production" of polybenzothiazoles or polybenzoxazoles;<br>b. "Technology" for the "development" or "production" of fluoroelastomer compounds containing at least one vinylether monomer;<br>c. "Technology" for the design or "production" of the following base materials or non-"composite" ceramic materials:<br>1. Base materials having all of the following characteristics:<br>a. Any of the following compositions:<br>1. Single or complex oxides of zirconium and complex oxides of silicon or aluminium;<br>2. Single nitrides of boron (cubic crystalline forms);<br>3. Single or complex carbides of silicon or boron; or<br>4. Single or complex nitrides of silicon; |

CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT

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

c. 1. Average particle size equal to or less than 5 micrometre and no more than 10% of the particles larger than 10 micrometre; or

NOTE: For zirconia, these limits are 1 micrometre and 5 micrometre respectively.

2. 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 micrometre; and
c. Continuous or chopped fibres less than 10 micrometre in diameter;

2. Non-“composite” ceramic materials (except abrasives) composed of the materials described in 1E002.c.1.;

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

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 d.

NOTE: 1E002.f. does not control “technology” for the repair of “civil aircraft” structures using carbon “fibrous or filamentary materials” and epoxy

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| | resins, contained in manufacturers' manuals. |
| **1E101** | "Technology" according to the General Technology Note for the "use" of goods specified in 1A102, 1B001, 1B101, 1B115, 1B116, 1C001, 1C101, 1C107, 1C115 to 1C117, 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 pyrolitically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1,573K (1,300°C) to 3,173 K (2,900°C) temperature range at pressures of 130 Pa to 20kPa.<br><br>NOTE: This item 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, 1A202, 1A225 to 1A227, 1B201, 1B225 to 1B231, 1C002.a.2.c or d, 1C010.b, 1C202, 1C210, 1C216, 1C225 to 1C239 or 1D201. |
| **1E202** | "Technology" according to the General Technology Note for the "development" or "production" of goods specified in 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** | **Equipment, Assemblies and Components**<br><br>Technical Notes to 2A001 to 2A006:<br>1. DN is the product of the bearing bore diameter in mm and the bearing rotational velocity in rpm. |

2. Operating temperatures include those temperatures obtained when a gas turbine engine has stopped after operation.

**2A001**

Ball bearings or solid roller bearings (except tapered roller bearings) having tolerances specified by the manufacturer in accordance with Annular Bearing Engineers Committee (ABEC) 7, ABEC 7P, ABEC 7T or ISO Standard Class 4 or better (or equivalents), and having any of the following characteristics:

a. Rings, balls or rollers made from monel or beryllium;
b. Manufactured for use at operating temperatures above 573 K (300°C) either by using special materials or by special heat treatment; or
c. With lubricating elements or component modifications that, according to the manufacturer's specifications, are specially designed to enable the bearings to operate at speeds exceeding 2.3 million DN.

**2A002**

Other ball bearings or solid roller bearings (except tapered roller bearings) having tolerances specified by the manufacturer in accordance with Annular Bearing Engineers Committee (ABEC) 9, ABEC 9P or ISO Standard Class 2 or better (or equivalents).

**2A003**

Solid tapered roller bearings, having tolerances specified by the manufacturer in accordance with American National Standards Institute (ANSI) / Anti-Friction Bearing Manufacturers Association (AFBMA) Class 00 (inch) or Class A (metric) or better (or equivalents) and having either of the following characteristics:

a. With lubricating elements or component modifications that, according to the manufacturer's specifications, are specially designed to enable the bearings to operate at speeds exceeding 2.3 million DN; or
b. Manufactured for use at operating temperatures below 219 K (−54°C) or above 423 K (150°C).

**2A004**

Gas-lubricated foil bearings manufactured for use at operating temperatures of 561 K (288°C) or higher and with a unit load capacity exceeding 1 MPa.

**2A005**

Active magnetic bearing systems.

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|---|---|
| **2A006** | Fabric-lined self-aligning or fabric-lined journal sliding bearings manufactured for use at operating temperatures below 219 K (−54°C) or above 423 K (150°C). |
| **2A225** | Crucibles made of materials resistant to liquid actinide metals, as follows:<br>a. Crucibles with a volume of between 150 ml and 8 litres and made of or coated with any of the following materials having a purity of 98% or greater:<br>1. Calcium fluoride ($CaF_2$);<br>2. Calcium zirconate (metazirconate) ($Ca_2ZrO_3$);<br>3. Cerium sulphide ($Ce_2S_3$);<br>4. Erbium oxide (erbia) ($Er_2O_3$);<br>5. Hafnium oxide (hafnia) ($HfO_2$);<br>6. Magnesium oxide (MgO);<br>7. Nitrided niobium-titanium-tungsten alloy (approximately 50% Nb, 30%Ti, 20%W);<br>8. Yttrium oxide (yttria) ($Y_2O_3$); or<br>9. Zirconium oxide (zirconia) ($ZrO_2$);<br>b. Crucibles with a volume of between 50 ml and 2 litres and made of or lined with tantalum, having a purity of 99.9% or greater;<br>c. Crucibles with a volume of between 50 ml and 2 litres and made of or lined with tantalum (having a purity of 98% or greater) coated with tantalum carbide, nitride or boride (or any combination of these). |
| **2A226** | Valves 5 mm or greater in diameter, with a bellows seal, wholly made of or lined with aluminum, aluminum alloy, nickel or alloy containing 60% or more nickel, either manually or automatically operated. |
| **2B** | **Test, Inspection and Production Equipment** |
| | NOTE: 2B001 to 2B009 do not control measuring interferometer systems, without closed or open loop feedback, containing a "laser" to measure slide movement errors of machine-tools, dimensional inspection machines or similar equipment. |
| **2B001** | "Numerical control" units, "motion control boards" specially designed for "numerical control" applications on machine tools, |

**CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT**

machine tools, and specially designed components therefor, as follows:

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.

   N.B.: 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. Axis nomenclature shall be in accordance with International Standard ISO 841, ‘Numerical Control Machines—Axis and Motion Nomenclature’.

a. “Numerical control” units for machine tools, as follows, and specially designed components therefor:

   NOTE: 2B001.a. does not control “numerical control” units:
   a. Modified for and incorporated in machines not specified in this item; or
   b. Specially designed for machines not specified in this item.
   1. Having more than four interpolating axes which can be coordinated simultaneously for “contouring control”;
   2. Having two, three or four interpolating axes which can be coordinated simultaneously for “contouring control” and:
      a. Capable of “real time processing” of data to modify, during the machining operation, tool path, feed rate and spindle data by either:
         1. Automatic calculation and modification of part programme data for machining in two or more axes by means of measuring cycles and access to source data; or
         2. “Adaptive control” with more than one physical

variable measured and processing by means of a computing model (strategy) to change one or more machining instructions to optimize the process;

b. Capable of receiving directly (on-line) and processing computer aided design (CAD) data for internal preparation of machine instructions; or

c. Capable, without modification, according to the manufacturer's technical specifications, of accepting additional boards which would permit an increase above the control levels specified in 2B001, in the number of interpolating axes which can be coordinated simultaneously for "contouring control", even if they do not contain these additional boards;

3. "Motion control boards" specially designed for machine tools and having any of the following characteristics:

1. Interpolation in more than four axes;

2. Capable of "real time processing" as described in 2B001.a.2.a.; or

3. Capable of receiving and processing CAD data as described in 2B001.a.2.b.;

4. Machine tools, as follows, for removing or cutting metals, ceramics or composites, which, according to the manufacturer's technical specifications, can be equipped with electronic devices for simultaneous "contouring control" in two or more axes:

1. Machine tools for turning, grinding, milling or any combination thereof which:

a. Have two or more axes which can be coordinated simultaneously for "contouring control"; and

b. Have any of the following characteristics:

1. Two or more contouring rotary axes;

   Technical Note: The c axis on jig grinders used to maintain grinding wheels normal to the work surface is not considered a contouring rotary axis.

2. One or more contouring "tilting spindles";

   NOTE: 2B001.c.1.b.2. applies to machine tools for grinding or milling only.

3. "Camming" (axial displacement) in one revolution of the spindle less (better) than 0.0006 mm total indicator reading (TIR);

   NOTE: 2B001.c.1.b.3. applies to machine tools for turning only.

4. "Run out" (out-of-true running) in one revolution of the spindle less (better) than 0.0006 mm TIR;

5. The positioning accuracies, with all compensations

**CATEGORY 0—NUCLEAR MATERIALS, FACILITIES AND EQUIPMENT**

available, are less (better) than:

a. 0.001° on any rotary axis; or

b. 1. 0.004 mm along any linear axis (overall positioning) for grinding machines;

2. 0.006 mm along any linear axis (overall positioning) for turning or milling machines; or

NOTE: 2B001.c.1.b.5. does not control milling or turning machine tools with a positioning accuracy along one axis, with all compensations available, equal to or more

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(worse) than 0.005 mm.

Technical Note:
The positioning accuracy of "numerically controlled" machine tools is to be determined and presented in accordance with ISO/DIS 230/2, paragraph 2.13, in conjunction with the requirements below:

a. Test conditions (paragraph 3):
   1. For 12 hours before and during measurements, the machine tool and accuracy measuring equipment will be kept at the same ambient temperature. During the premeasurement time the slides of the machine will be continuously

cycled in the same manner that the accuracy measurements will be taken;

2. The machine shall be equipped with any mechanical, electronic, or software compensation to be exported with the machine;
3. Accuracy of measuring equipment for the measurements shall be at least four times more accurate than the expected machine tool accuracy;
4. Power supply for slide drives shall be as follows:
   a. Line voltage

variation shall not exceed ±10% of nominal rated voltage;

b. Frequency variation shall not exceed ±2Hz of normal frequency;

c. Lineouts or interrupted service are not permitted;

b. Test programme (paragraph 4):

1. Feed rate (velocity of slides) during measurement shall be the rapid traverse rate;

N.B.: In the case of machine tools which generate optical quality surfaces, the feed rate shall be equal to or less than 50 mm per minute.

2. Measurements shall be made in an incremental manner from one limit of the axis travel to the other without returning to the starting position for each move to the target position;

3. Axes not being measured shall be retained at mid travel during test of an axis;

c. Presentation of test results

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(paragraph 2):
The results of the measurements must include:

1. positioning accuracy (A); and
2. The mean reversal error (B).

6.
a. A positioning accuracy less (better) than 0.007 mm; and
b. A slide motion from rest for all slides within 20% of a motion command input for inputs of less than 0.5 micrometre.

Technical Note: Minimum increment of motion test (slide motion from rest):

The test is conducted only if the machine tool is equipped with a control unit the minimum increment of which is less (better) than 0.5 micrometre. Prepare the machine for testing in accordance with ISO 230/2 paragraphs 3.1, 3.2, 3.3.

Conduct the test on each axis (slide) of the machine tool as follows:

a. Move the axis over at least 50% of the maximum travel in plus and minus directions twice at maximum feed rate, rapid traverse rate or jog control;
b. Wait at least 10 seconds;
c. With manual data input, input the minimum programmable increment of the control unit;
d. Measure the axis movement;
e. Clear the control unit with the servo null, reset or whatever clears any signal (voltage) in the servo loop;
f. Repeat steps b. to e. five times, twice in the same direction of the axis travel and

three times in the opposite direction of travel for a total of six test points;

g. If the axis movement is between 80% and 120% of the minimum programmable input for four of the six test points, the machine is controlled.

For rotary axes, the measurement is taken 200 mm from the centre of rotation.

Notes:

1.. 2B001.c.1. does not control cylindrical external, internal and external-internal grinding machines having all of the following characteristics:

a. Not centreless (shoe-type) grinding machines;

b. Limited to cylindrical grinding;

c. A maximum workpiece capacity of 150 mm outside diameter or length;

d. Only two axes which can be

coordinated simultaneously for "contouring control"; and

e. No contouring c axis.

2.. 2B001.c.1. does not control machines designed specifically as jig grinders having both of the following characteristics:

a. Axes limited to x, y, c and a, where the c axis is used to maintain the grinding wheel normal to the work surface and the a axis is configured to grind barrel cams; and

b. A spindle "run out" not less (not better) than 0.0006 mm.

3.. 2B001.c.1. does not control tool or cutter grinding machines having all of the following characteristics:

a. Shipped as a complete system with "software" specially designed for the production of tools or cutters;

b. No more than two

rotary axes which can be coordinated simultaneously for "contouring control";

c. "Run out" (out-of-true running) in one revolution of the spindle not less (not better) than 0.0006 mm TIR; and

d. The positioning accuracies, with all compensations available, are not less (not better) than:

1. 0.004 mm along any linear axis for overall positioning; or

2. 0.001° on any rotary axis.

2. Electrical discharge machines (EDM) of the wire feed type which have five or more axes which can be coordinated simultaneously for "contouring control";

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

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4. Machine tools for removing metals, ceramics or composites:
   a. By means of:
      1. Water or other liquid jets, including those employing abrasive additives;
      2. Electron beam; or
      3. "Laser" beam; and
   b. Having two or more rotary axes which:
      1. Can be coordinated simultaneously for "contouring control"; and
      2. Have a positioning accuracy of less (better) than 0.003°.

   Technical Note: Machines capable of being simultaneously coordinated for contouring control in two or more rotary axes or one or more "tilting spindles", are specified in this item regardless of the number of simultaneously coordinated contouring axes that can be controlled by the "numerical control" units attached to the machine.

**2B002**

Non-"numerically controlled" machine tools for generating optical quality surfaces, as follows:

a. Turning machines using a single point cutting tool and having all of the following characteristics:
   1. Slide positioning accuracy less (better) than 0.0005 mm per 300 mm of travel;
   2. Bidirectional slide positioning repeatability less (better) than 0.00025 mm per 300 mm of travel;
   3. Spindle "run out" and "camming" less (better) than 0.0004 mm TIR;
   4. Angular deviation of the slide movement (yaw, pitch and roll) less

(better) than 2 seconds of arc, TIR, over full travel; and

5. Slide perpendicularity less (better) than 0.001 mm per 300 mm of travel;

Technical Note: The bidirectional slide positioning repeatability (R) of an axis is the maximum value of the repeatability of positioning at any position along or around the axis determined using the procedure and under the conditions specified in part 2.11 of ISO 230/2: 1988.

b. Fly cutting machines having both of the following characteristics:
   1. Spindle “run out” and “camming” less (better) than 0.0004 mm TIR; and
   2. Angular deviation of slide movement (yaw, pitch and roll) less (better) than 2 seconds of arc, TIR, over full travel.

**2B003** “Numerically controlled” or manual machine tools specially designed for cutting, finishing, grinding or honing either of the following classes of bevel or parallel axis hardened ($R_c$=40 or more) gears, and specially designed components, controls and accessories therefor:

a. Hardened bevel gears finished to a quality of better than American Gear Manufacturers Association (AGMA) 13 (equivalent to ISO 1328 class 4); or
b. Hardened 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”, as follows, and specially designed dies, moulds, components, accessories and controls therefor:

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

a. Having a controlled thermal environment within the closed cavity and possessing a chamber cavity with an inside diameter of 406 mm or more; and
b. Having:
   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.

**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.d., and specially designed automated handling, positioning, manipulation and control components therefor:

a. "Stored programme controlled" chemical vapour deposition (CVD) production equipment with both of the following:
    1. Process modified for one of the following:
        a. Pulsating CVD;
        b. Controlled nucleation thermal decomposition (CNTD); or
        c. Plasma enhanced or plasma assisted CVD; and
    2. Either of the following:
        a. Incorporating high vacuum (equal to or less than 0.01 Pa) rotating seals; or
        b. Incorporating in situ coating thickness control;
b. "Stored programme controlled" ion implantation production equipment having beam currents of 5 mA or more;
c. "Stored programme controlled" electron beam physical vapour deposition (EB-PVD) production equipment incorporating:
    1. Power systems rated for over 80 kW;

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2. A liquid pool level "laser" control system which regulates precisely the ingots feed rate; and
3. A computer controlled rate monitor operating on the principle of photo-luminescence of the ionised atoms in the evaporant stream to control the deposition rate of a coating containing two or more elements;

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

e. "Stored programme controlled" sputter deposition production equipment capable of current densities of 0.1 mA/$mm^2$ or higher at a deposition rate of 15 micrometre/hr or more;

f. "Stored programme controlled" cathodic arc deposition production equipment incorporating a grid of electromagnets for steering control of the arc spot on the cathode;

g. "Stored programme controlled" ion plating production equipment allowing for the in situ measurement of either:
1. Coating thickness on the substrate and rate control; or
2. Optical characteristics;
NOTE: 2B005.g. does not control standard ion plating coating equipment for cutting or machining tools.

**2B006** Dimensional inspection or measuring systems or equipment, as follows:

a. Computer controlled, "numerically controlled" or "stored programme controlled" dimensional inspection machines, having both of the following characteristics:
1. Two or more axes; and
2. A one dimensional length "measurement uncertainty" equal to

or less (better) than (1.25 + L/1,000) micrometre tested with a probe with an "accuracy" of less (better) than 0.2 micrometre (L is the measured length in mm);

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

1. Linear measuring instruments having any of the following characteristics:

a. Non-contact type measuring systems with a "resolution" equal to or less (better) than 0.2 micrometre within a measuring range up to 0.2 mm;

b. Linear voltage differential transformer systems with both of the following characteristics:

1. "Linearity" equal to or less (better) than 0.1% within a measuring range up to 5 mm; and

2. Drift equal to or less (better) than 0.1% per day at a standard ambient test room temperature ±1 K; or

c. Measuring systems having both of the following characteristics:

1. Containing a "laser"; and

2. Maintaining, for at least 12 hours, over a temperature range of ±1 K around a standard temperature and at a standard pressure:

a. A "resolution" over their full scale of 0.1 micrometre or less (better); and

b. A "measurement uncertainty" equal to or less (better) than (0.2 + L/2,000) micrometre (L is the measured length in mm);

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

   NOTE: 2B006.b.2 does not control optical instruments, such as autocollimators, using collimated light to detect angular displacement of a mirror.

c. 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 micrometre per 5 mm; and
   2. "Angular position deviation" equal to or less (better) than 0.02°;

d. Equipment for measuring surface irregularities, by measuring optical scatter as a function of angle, with a sensitivity of 0.5 nm or less (better);
   Technical Notes:
   1. The probe used in determining the "measurement uncertainty" of a dimensional inspection system shall be as described in VDI/VDE 2617 Parts 2, 3 and 4.
   2. All measurement values in 2B006 represent permissible positive and negative deviations from the target value, i.e., not total band.
      1. NOTES: Machine tools which can be used as measuring machines are controlled if they meet or exceed the criteria specified for the machine tool function or the measuring machine function.
      2. A machine described in 2B006 is controlled if it exceeds the control threshold anywhere within its operating range.

**2B007** "Robots", as follows, 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;

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 (2½D).

b. Specially designed to comply with national safety standards applicable to explosive munitions environments; or
c. Specially designed or rated as radiation-hardened beyond that necessary to withstand normal industrial (i.e., non-nuclear industry) ionizing radiation.

**2B008** Assemblies, units or inserts specially designed for machine tools, or for equipment specified in 2B006 or 2B007, as follows:

a. Spindle assemblies, consisting of spindles and bearings as a minimal assembly, with radial ("run out") or axial ("camming") axis motion in one revolution of the spindle less (better) than 0.0006 mm TIR;
b. Linear position feedback units (e.g., inductive type devices, graduated scales, infrared systems or "laser" systems) having an overall "accuracy" less (better) than (800 + (600 × L × 10¯sup3;)) nm (L equals the effective length in mm);
c. Rotary position feedback units, e.g., inductive type devices, graduated scales, infrared systems or "laser" systems, having an "accuracy" less (better) than 0.00025°;
d. Slide way assemblies consisting of a minimal assembly of ways, bed and slide having all of the following characteristics:
    1. A yaw, pitch or roll of less (better) than 2 seconds of arc TIR (reference: ISO/DIS 230/1) over full travel;
    2. A horizontal straightness of less (better) than 2 micrometre per 300 mm length; and
    3. A vertical straightness of less (better) than 2 micrometre per 300 mm length;

e. Single point diamond cutting tool inserts, having all of the following characteristics:
   1. Flawless and chip-free cutting edge when magnified 400 times in any direction;
   2. Cutting radius from 0.1 to 5 mm inclusive; and
   3. Cutting radius out-of-roundness less (better) than 0.002 mm TIR.

**2B009**

Specially designed printed circuit boards with mounted components and "software" therefor, or "compound rotary tables" or "tilting spindles", capable of upgrading, according to the manufacturer's specifications, "numerical control" units, machine tools or feed-back devices to or above the levels specified in 2B001 to 2B008.

**2B104**

Equipment and process controls designed or modified for densification and pyrolysis of structural composite rocket nozzles and reentry vehicle nose tips.

NOTE: The only "isostatic presses" and furnaces specified in this item are as follows:

a. "Isostatic presses", other than those specified in 2B004, having all the following characteristics:
   1. Maximum working pressure of 69 MPa or greater;
   2. Designed to achieve and maintain a controlled thermal environment of 873 K (600°C) or greater; and
   3. Possessing a chamber cavity with an inside diameter of 254 mm or greater;
b. CVD Furnaces designed or modified for the densification of carbon-carbon composites.

**2B115**

Flow-forming machines, and specially designed components therefor,which:

N.B.: SEE ALSO ENTRY 2B215.

a. 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
b. With more than two axes which can be coordinated simultaneously for "contouring control".

Technical Note:

1. Machines combining the function of spin-forming and flow-forming are for the purpose of this item regarded as flow-forming machines.
2. 2B115 does not control machines that are not usable in the production of propulsion components and equipment (e.g. motor cases) for systems specified in 9A007.a.1.

**2B116**

Vibration test 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 10 g RMS or more over the entire range 20 Hz to 2000 Hz and imparting forces of 50kN (11,250 lbs), measured bare table, or greater;
b. Digital controllers, combined with specially designed vibration test software, with a real-time bandwidth greater than 5 kHz designed for use with vibration test systems in (a) above;
c. Vibration thrusters (shaker units),with or without associated amplifiers, capable of imparting a force of 50kN (11,250 lbs), measured ‘bare table’, or greater and usable in vibration test systems in (a.) above;
d. Test piece support structures and electronic units designed to combine multiple shaker units in a system capable of providing an effective combined force of 50kN, measured bare table, or greater, and usable in vibration systems in (a) above.

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

**2B204**

“Isostatic presses”, other than those in 2B004 or 2B104, capable of achieving a maximum working pressure of 69 MPa or greater and having a chamber cavity with an inside diameter in excess of 152 mm and specially designed dies, moulds and controls therefor.

**2B207**

“Robots” and “end-effectors”, other than those specified in 2B007,specially designed to comply with national safety standards

| | |
|---|---|
| | applicable to handling high explosives (for example, meeting electrical code ratings for high explosives) and specially designed controllers therefor. |
| **2B215** | Spin-forming and flow-forming machines, other than those specified in 2B115, and precision rotor-forming mandrels designed to form cylindrical rotors of inside diameter between 75 mm and 400 mm therefor, which:<br>a. According to the manufacturer's technical specification, can be equipped with "numerical control" units or a computer control; and<br>b. With two or more axes that can be coordinated simultaneously for "contouring control".<br><br>Technical Note: The only spin-forming machines controlled by this item are those combining the function of spin-forming and flow-forming. |
| **2B225** | Remote manipulators that provide mechanical translation of human operator actions by electrical, hydraulic or mechanical means to an operating arm and terminal fixture that can be used to provide remote actions in radiochemical separation operations and "hot cells", as follows:<br>a. Having a capability of penetrating 0.6 m or more of cell wall; or<br>b. Having a capability to bridge over the top of a cell wall with a thickness of 0.6 m or more. |
| **2B226** | Vacuum or controlled environment (inert gas) induction furnaces capable of operating above 1,123 K (850°C) and having induction coils 600 mm or less in diameter and specially designed power supplies therefor with an output rating of 5 kW or more.<br><br>N.B.: SEE ALSO 3B.<br><br>NOTE: This entry does not control furnaces designed for the processing of semiconductor wafers. |
| **2B227** | Vacuum and controlled atmosphere metallurgical melting and casting furnaces as follows; and specially configured computer control and monitoring systems therefor: |

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a. Arc remelt and casting furnaces with consumable electrode capacities between 1,000 $cm^3$ and 20,000 $cm^3$, capable of operating with melting temperatures above 1,973 K (1,700°C);
b. Electron beam melting and plasma atomization and melting furnaces, with a power of 50 kW or greater, capable of operating with melting temperatures above 1,473 K (1,200°C).

**2B228**

Rotor fabrication and assembly equipment and bellows-forming mandrels and dies, as follows:
a. Rotor assembly equipment for assembly of gas centrifuge rotor tube sections, baffles and end caps, including associated 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: Normally such equipment will consist 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 (bellows made of high-strength aluminium alloys, maraging steel or high strength filamentary materials). The bellows have all of the following dimensions:
   1. 75 mm to 400 mm inside diameter;
   2. 12.7 mm or more in length; and
   3. Single convolution depth more than 2 mm.

**2B229**

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. A swing or journal diameter of 75 mm or more;
   2. Mass capability of from 0.9 to 23 kg ; and

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|  |  |
|---|---|
|  | 3. Capable of balancing speed of revolution more than 5,000 rpm;<br>b. Centrifugal balancing machines designed for balancing hollow cylindrical rotor components and having all of the following characteristics:<br>1. A journal diameter of 75 mm or more;<br>2. Mass capability of from 0.9 to 23 kg;<br>3. Capable of balancing to a residual imbalance of 0.01 kg mm/kg per plane or better; and<br>4. Belt drive type. |
| **2B230** | Instruments capable of measuring pressures up to 13 kPa to an accuracy of better than 1% (full-scale), with corrosion-resistant pressure-sensing elements constructed of nickel, nickel alloys, phosphor bronze, stainless steel, aluminium or aluminium alloys. |
| **2B231** | Vacuum pumps with an input throat size of 380 mm or greater with a pumping speed of 15,000 litres/s or greater and capable of producing an ultimate vacuum better than 13 mPa.<br><br>Technical Note: The ultimate vacuum is determined at the input of the pump with the input of the pump blocked off. |
| **2B232** | Multistage light gas gun or other high-velocity gun systems (coil, electromagnetic, electrothermal or other advanced systems) capable of accelerating projectiles to 2 km/s or greater. |
| **2B350** | Chemical manufacturing facilities and equipment, as follows:<br>a. Reaction vessels or reactors, with or without agitators, with total internal (geometric) volume greater than 0.1 $m^3$ (100 litres) and less than 20 $m^3$ (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:<br>1. Alloys with more than 25% nickel and 20% chromium by weight;<br>2. Fluoropolymers;<br>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; or
7. Zirconium or zirconium alloys;

b. Agitators for use in reaction vessels or reactors 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;
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; or
7. Zirconium or zirconium alloys;

c. Storage tanks, containers or receivers with a total internal (geometric) volume greater than 0.1 $m^3$ (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;
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; or
7. Zirconium or zirconium alloys;

d. Heat exchangers or condensers with a heat transfer surface area of less than 20 $m^2$, 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;
3. Glass (including vitrified or enamelled coatings or glass lining);
4. Graphite;

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5. Nickel or alloys with more than 40% nickel by weight;
6. Tantalum or tantalum alloys;
7. Titanium or titanium alloys; or
8. Zirconium or zirconium alloys;

e. Distillation or absorption columns of internal diameter greater than 0.1 m, 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;
3. Glass (including vitrified or enamelled coatings or glass lining);
4. Graphite;
5. Nickel or alloys with more than 40% nickel by weight;
6. Tantalum or tantalum alloys;
7. Titanium or titanium alloys; or
8. Zirconium or zirconium 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. Multiple seal valves incorporating a leak detection port, bellows-seal valves, non-return (check) valves or diaphragm valves, 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;
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; or
7. Zirconium or zirconium alloys;

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;
3. Glass (including vitrified or enamelled coatings or glass lining);
4. Graphite;
5. Nickel or alloys with more than 40% nickel by weight;
6. Tantalum or tantalum alloys;
7. Titanium or titanium alloys; or
8. Zirconium or zirconium alloys;

i. Multiple-seal, canned drive, magnetic drive, bellows or diaphragm pumps, with manufacturer's specified maximum flow-rate greater than 0.6 $m^3$/hour, or vacuum pumps with manufacturer's specified maximum flow-rate greater than 5 $m^3$/hour (under standard temperature (273 K (0°C)) and pressure (101.3kPa) conditions), 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;
4. Fluoropolymers;
5. Glass (including vitrified or enamelled coatings or glass lining);
6. Graphite;
7. Nickel or alloys with more than 40% nickel by weight;
8. Tantalum or tantalum alloys;
9. Titanium or titanium alloys; or
10. Zirconium or zirconium alloys;

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.

**2B351**

Toxic gas monitoring systems, as follows; and dedicated detectors therefor:

a. Designed for continuous operation and usable for the detection of chemical warfare agents, chemicals specified in 1C350 or organic compounds containing phosphorus, sulphur, fluorine or chlorine, at concentrations of less than 0.3 $mg/m^3$; or
b. Designed for the detection of cholinesterase-inhibiting activity.

**2B352**

Biological equipment, 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 (Geneva, 1983).
b. Fermenters, capable of operation without the propagation of aerosols, having all the following characteristics:
   1. Capacity of 300 litres or more;
   2. Double or multiple sealing joints within the steam containment area; and
   3. Capable of in-situ sterilisation in a closed state;

   Technical Note: Fermenters include 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. Double or multiple 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-flow filtration equipment, designed for continuous separation without the propagation of aerosols, having both of the following characteristics:
   1. Equal to or greater than 5 square metres; and
   2. Capable of in-situ sterilization;

e. Steam sterilisable freeze drying equipment with a condenser capacity exceeding 50 kg of ice in 24 hours and less than 1,000 kg of ice in 24 hours;

f. Equipment that incorporates or is contained in P3 or P4 containment housing, as follows:
   1. Independently ventilated protective full or half suits;
   2. Biological safety cabinets or isolators, which allow manual operations to be performed within, whilst providing an environment equivalent to Class III biological protection;

      Note: In this entry, isolators include flexible isolators, dry boxes, anaerobic chambers and glove boxes.

g. Chambers designed for aerosol challenge testing with pathogenic “microorganisms” or “toxins” and having a capacity of $1m^3$ or greater.

**2C** **Materials**

None

**2D** **Software**

**2D001** “Software” specially designed or modified for the “development”, “production” or “use” of equipment specified in 2A001 to 2A007 or 2B001 to 2B009.

**2D002** Specific “software”, as follows:

a. “Software” to provide “adaptive control” and having both of the following characteristics:
   1. For “flexible manufacturing units” (FMUs) which consist at least of equipment described in b.1. and b.2. of the definition of “flexible manufacturing unit”; and
   2. Capable of generating or modifying, in “real time processing”,

"programmes" or data by using the signals obtained simultaneously by means of at least two detection techniques, such as:

a. Machine vision (optical ranging);
b. Infrared imaging;
c. Acoustical imaging (acoustical ranging);
d. Tactile measurement;
e. Inertial positioning;
f. Force measurement;
g. Torque measurement;

NOTE: 2D002.a. does not control "software" which only provides rescheduling of functionally identical equipment within "flexible manufacturing units" using pre-stored part programmes and a pre-stored strategy for the distribution of the part programmes.

b. "Software" for electronic devices other than those described in 2B001.a. or b., which provides the "numerical control" capability of the equipment specified in 2B001.

**2D101** "Software" specially designed for the "use" of equipment specified in 2B104, 2B115 or 2B116.

N.B.: SEE ALSO 9D004.

**2D201** "Software" specially designed for the "use" of equipment specified in 2B204, 2B207, 2B215, 2B227 or 2B229.

**2E** Technology

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

**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":
   1. For the "development" of interactive graphics as an integrated part in "numerical control" units for

preparation or modification of part programmes;

2. For the "development" of generators of machine tool instructions (e.g., part programmes) from design data residing inside "numerical control" units;
3. For the "development" of integration "software" for incorporation of expert systems for advanced decision support of shop floor operations into "numerical control" units;

b. "Technology" for metal-working manufacturing processes, as follows:
   1. "Technology" for the design of tools, dies or fixtures specially designed for the following processes:
      a. "Superplastic forming";
      b. "Diffusion bonding";
      c. "Direct-acting hydraulic pressing";
   2. Technical data consisting of process methods or parameters as listed below used to control:
      a. "Superplastic forming" of aluminium alloys, titanium alloys or "superalloys":
         1. Surface preparation;
         2. Strain rate;
         3. Temperature;
         4. Pressure;
      b. "Diffusion bonding" of "superalloys" or titanium alloys:
         1. Surface preparation;
         2. Temperature;
         3. Pressure;
      c. "Direct-acting hydraulic pressing" of aluminium alloys or titanium alloys:
         1. Pressure;
         2. Cycle time;
      d. "Hot isostatic densification" of titanium alloys, aluminium alloys or "superalloys":
         1. Temperature;
         2. Pressure;
         3. Cycle time;

c. "Technology" for the "development" or "production" of hydraulic stretch-

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forming machines and dies therefor, for the manufacture of airframe structures;

d. "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;

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

TABLE—DEPOSITION TECHNIQUES

| 1. Coating Process (1)* | 2. Substrate | 3. Resultant Coating |
|---|---|---|
| **A.** Chemical Vapour Deposition (CVD) | "Superalloys" | Aluminides for internal passages |
| | Ceramics and low expansion glasses(14) | Silicides |
| | | Carbides |
| | | Dielectric layers (15) |
| | Carbon-carbon, ceramic and metal "matrix" "composites" | Silicides |
| | | Carbides |
| | | Refractory metals |
| | | Mixtures thereof (4) |
| | | Dielectric layers (15) |
| | | Aluminides |
| | | Alloyed aluminides (2) |
| | Cemented tungsten carbide (16), silicon carbide | Carbides |
| | | Tungsten |
| | | Mixtures thereof (4) |
| | | Dielectric layers (15) |
| | Molybdenum and molybdenum alloys | Dielectric layers (15) |
| | Beryllium and beryllium alloys | Dielectric layers (15) |

| 1. Coating Process (1)* | 2. Substrate | 3. Resultant Coating |
|---|---|---|
| | Sensor window materials (9) | Dielectric layers (15) |
| **B.** Thermal-Evaporation Physical Vapour Deposition (TE-PVD) | | |
| **1.** Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD) | “Superalloys” | Alloyed silicides |
| | | Alloyed aluminides (2) |
| | | MCrA1X (5) |
| | | Modified zirconia (12) |
| | | Silicides |
| | | Aluminides |
| | | Mixtures thereof (4) |
| | Ceramics and low expansion glasses (14) | Dielectric layers (15) |
| | Corrosion resistant steel (7) | MCrA1X (5) |
| | | Modified zirconia (12) |
| | | Mixtures thereof (4) |
| | Carbon-carbon, ceramic and metal “matrix” “composites” | Silicides |
| | | Carbides |
| | | Refractory metals |
| | | Mixtures thereof (4) |
| | | Dielectric layers (15) |
| | Cemented tungsten carbide (16), silicon carbide | Carbides |
| | | Tungsten |
| | | Mixtures thereof (4) |
| | | Dielectric layers (15) |
| | Molybdenum and molybdenum alloys | Dielectric layers (15) |
| | Beryllium and beryllium alloys | Dielectric layers (15) |
| | | Borides |
| | Sensor window materials (9) | Dielectric layers (15) |

| 1. Coating Process (1)* | 2. Substrate | 3. Resultant Coating |
| --- | --- | --- |
| | Titanium alloys (13) | Borides<br><br>Nitrides |
| **B.2.** Ion assisted resistive heating Physical Vapour Deposition (Ion Plating | Ceramics and low expansion glasses (14) | Dielectric layers (15) |
| | 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) |
| **B.3.** Physical Vapour Deposition: “laser”evaporation | Ceramics and low expansion glasses (14) | Silicides<br><br>Dielectric layers (15) |
| | 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)<br><br>Diamond-like carbon |
| **B.4.** Physical Vapour Deposition: cathodic arc discharge | “Superalloys” | Alloyed silicides<br><br>Alloyed aluminides (2)<br><br>MCrA1X (5) |
| | Polymers (11) and organic “matrix” “composites” | Borides<br><br>Carbides<br><br>Nitrides |
| **C.** Pack cementation (see A above for out-of-pack cementation) (10) | Carbon-carbon, ceramic and metal “matrix” “composites” | Silicides<br><br>Carbides<br><br>Mixtures thereof (4) |
| | Titanium alloys (13) | Silicides |

| 1. Coating Process (1)* | 2. Substrate | 3. Resultant Coating |
|---|---|---|
| | | 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 Ni-Cr-Al—bentonite |
| | | 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 |
| | Corrosion resistant steel (7) | Modified zirconia (12) |
| | | Mixtures thereof (4) |
| | Titanium alloys (13) | Carbides |
| | | Aluminides |
| | | Silicides |
| | | Alloyed aluminides (2) |
| | | Abradable Nickel-Graphite |
| | | Abradable Ni-Cr-Al—bentonite |

| 1. Coating Process (1)* | 2. Substrate | 3. Resultant Coating |
| --- | --- | --- |
| | | Abradable Al-Si-Polyester |
| **E.** Slurry Deposition | Refractory metals and alloys (8) | Fused silicides<br>Fused aluminides<br>except<br>for resistance heating elements |
| | Carbon-carbon, ceramic and metal “matrix” “composites” | Silicides<br>Carbides<br>Mixtures thereof (4) |
| **F.** Sputter Deposition | “Superalloys” | Alloyed silicides<br>Alloyed aluminides (2)<br>Noble metal modified aluminides (3)<br>MCrA1X (5)<br>Modified zirconia (12)<br>Platinum<br>Mixtures thereof (4) |
| | Ceramics and low expansion glasses (14) | Silicides<br>Platinum<br>Mixtures thereof (4)<br>Dielectric layers (15) |
| | Titanium alloys (13) | Borides<br>Nitrides<br>Oxides<br>Silicides<br>Aluminides<br>Alloyed aluminides (2)<br>Carbides |
| | Carbon-carbon, ceramic and metal “matrix” “composites” | Silicides |

| 1. Coating Process (1)* | 2. Substrate | 3. Resultant Coating |
|---|---|---|
| | | Carbides |
| | | Refractory metals |
| | | Mixtures thereof (4) |
| | | Dielectric layers (15) |
| | Cemented tungsten carbide (16), silicon carbide | Carbides |
| | | Tungsten |
| | | Mixtures thereof (4) |
| | | Dielectric layers (15) |
| | Molybdenum and molybdenum alloys | Dielectric layers (15) |
| | Beryllium and beryllium alloys | Borides |
| | | Dielectric layers (15) |
| | Sensor window materials (9) | Dielectric layers (15) |
| | 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 |

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. Mixtures consist of infiltrated material, graded compositions, co-deposits and multilayer deposits and are obtained by one or more of the coating processes specified in the Table.

5. MCrAlX refers to a coating alloy where M equals cobalt, iron, nickel or combinations thereof and X equals hafnium, yttrium, silicon, tantalum in any amount or other intentional additions over 0.01 weight percent in various proportions and combinations;

   except:
   a. CoCrAlY coatings which contain less than 22 weight percent of chromium, less than 7 weight percent of aluminium and less than 2 weight percent of yttrium;
   b. CoCrAlY coatings which contain 22 to 24 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.5 to 0.7 weight percent of yttrium; or
   c. NiCrAlY coatings which contain 21 to 23 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.9 to 1.1 weight percent of yttrium.
6. The term 'aluminium alloys' refers to alloys having an ultimate tensile strength of 190 MPa or more measured at 293 K (20°C).
7. The term 'corrosion resistant steel' refers to AISI (American Iron and Steel Institute) 300 series or equivalent national standard steels.
8. Refractory metals consist of 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 and the following metal halides: potassium iodide, potassium fluoride, or sensor window materials of more than 40 mm diameter for thallium bromide and thallium chlorobromide.
10. "Technology" for single-step pack cementation of solid airfoils is not specified in 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, etc., 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 to aerospace alloys having an ultimate tensile strength of 900 MPa or more measured at 293 K (20°C).
14. Low-expansion glasses refers to glasses which have a coefficient of thermal expansion of $1 \times 10^{-7}\ K^{-1}$ or less measured at 293 K (20°C).
15. Dielectric layers are coatings constructed of multi-layers of insulator materials in which the interference properties of a design composed of materials of various refractive indices are used to reflect, transmit or absorb various wavelength bands. Dielectric layers refers to more than four dielectric layers or dielectric/metal "composite" layers.
16. Cemented tungsten carbide does not include cutting and forming tool materials consisting of tungsten carbide/(cobalt, nickel), titanium carbide/(cobalt, nickel), chromium carbide/nickel-chromium and chromium carbide/nickel.

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.

   N.B.: Energy for this decomposition or chemical reaction process may be provided by the heat of the substrate, a glow discharge plasma, or "laser" irradiation.
   1. CVD includes the following processes: directed gas flow out-of-pack deposition, pulsating CVD, controlled nucleation thermal decomposition (CNTD), plasma enhanced or plasma assisted CVD processes.
   2. Pack denotes a substrate immersed in a powder mixture.
   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. Resistive Heating PVD employs electrically resistive heating sources capable of producing a controlled and uniform flux of evaporated coating species;
3. "Laser" Evaporation uses either pulsed or continuous wave "laser" beams to heat 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.

c. 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 to be deposited 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.

d. 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.

e. 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 carried out underwater.
   1. N.B.: Low pressure means less than ambient atmospheric pressure.
   2. High velocity refers to nozzle-exit gas velocity exceeding 750 m/s calculated at 293 K (20°C) at 0.1 MPa.

f. 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.

g. 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.
   1. N.B.: 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 vapourisation of non-metallic coating materials.
   2. Low-energy ion beams (less than 5 keV) can be used to activate the deposition.

h. 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.

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| **2E101** | "Technology" according to the General Technology Note for the "use" of equipment or "software" specified in 2B004, 2B104, 2B115, 2B116 or 2D101. |

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| **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, 2B204, 2B207, 2B215, 2B225 to 2B232 or 2D201. |
| **2E301** | "Technology" required for the "use" of goods specified in 2B350 to 2B352. |

**CATEGORY 3— ELECTRONICS**

| | |
|---|---|
| **3A** | **Equipment, Assemblies and Components** |
| **3A** | NOTES:<br>1. The control status of equipment, devices and components described in 3A001 or 3A002, other than those described in 3A001.a.3. to 10. or 3A001.a.12., which are specially designed or which have the same functional characteristics as other equipment, are determined by the control status of the other equipment.<br>2. The control status of integrated circuits described in 3A001.a.3. to 9. or 3A001.a.12., which are unalterably programmed or designed for a specific function, is determined by the control status of the other equipment.<br>N.B.: When the manufacturer or applicant cannot determine the control status of the other equipment, the control status is determined in 3A001.a.3. to 9. or 3A001.a.12.<br>If the integrated circuit is a silicon-based "microcomputer microcircuits" or microcontroller microcircuit described in 3A001.a.3. having an operand (data) word length of 8 bit or less, the control status of the integrated circuit is determined in 3A001.a.3. |
| **3A001** | Electronic devices and components:<br>1. General purpose integrated circuits, as follows:<br><br>NOTES:<br>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. |

2. Integrated circuits include the following types:
“Monolithic integrated circuits”;
“Hybrid integrated circuits”;
“Multichip integrated circuits”;
“Film type integrated circuits”, including silicon-on-sapphire integrated circuits;
“Optical integrated circuits”.

1. Integrated circuits, designed or rated as radiation hardened to withstand either of the following:
   a. A total dose of $5 \times 10^5$ rads(Si) or higher; or
   b. A dose rate upset of $5 \times 10^8$ rads(Si)/s or higher;
2. Integrated circuits described in 3A001.a.3. to 10. or 3A001.a.12., as follows:
   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 (minus;55°C) to 398 K (125°C);

   NOTE: 3A001.a.2. does not apply to integrated circuits for civil automobile or railway train applications.
3. “Microprocessor microcircuits”, “microcomputer microcircuits” and microcontroller microcircuits, having any of the following:

   NOTE: 3A001.a.3. includes digital signal processors, digital array processors and digital coprocessors.
   a. An arithmetic logic unit with an access width of 32 bit or more and a “composite theoretical performance” (CTP) of 80 million theoretical operations per second (Mtops) or more;
   b. Manufactured from a compound semiconductor and

operating at a clock frequency exceeding 40 MHz; or

c. More than one data or instruction bus or serial communication port for external interconnection in a parallel processor with a transfer rate exceeding 2.5 Mbyte/s;

4. Electrically erasable programmable read-only memories (EEPROMs), static random-access memories (SRAMs) and storage integrated circuits manufactured from a compound semiconductor, as follows:
   a. EEPROMs with a storage capacity:
      1. Exceeding 16 Mbit per package for flash memory types; or
      2. Exceeding either of the following limits for all other EEPROM types:
         a. 4 Mbit per package; or
         b. 1 Mbit per package and having a maximum access time of less than 80 ns;
   b. SRAMs with a storage capacity:
      1. Exceeding 4 Mbit per package; or
      2. Exceeding 1 Mbit per package and having a maximum access time of less than 20 ns;
   c. Storage integrated circuits manufactured from a compound semiconductor;
5. Analogue-to-digital and digital-to-analogue converter integrated circuits, as follows:
   a. Analogue-to-digital converters having any of the following:
      1. A resolution of 8 bit or more, but less than 12 bit, with a total conversion time to maximum resolution of less than 10 ns;

2. A resolution of 12 bit with a total conversion time to maximum resolution of less than 200 ns; or
3. A resolution of more than 12 bit with a total conversion time to maximum resolution of less than 2 microseconds;

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

6. Electro-optical or "optical integrated circuits" for "signal processing" having all of the following:
   a. One or more internal "laser" diodes;
   b. One or more internal light detecting elements; and
   c. Optical waveguides;
7. Field programmable gate arrays having either of the following:
   a. An equivalent usable gate count of more than 30,000 (2 input gates); or
   b. A typical "basic gate propagation delay time" of less than 0.4 ns;
8. Field programmable logic arrays having either of the following:
   a. An equivalent usable gate count of more than 30,000 (2 input gates); or
   b. A toggle frequency exceeding 133 MHz;
9. Neural network integrated circuits;
10. Custom integrated circuits for which either 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 144 terminals;
   b. A typical "basic gate propagation delay time" of less than 0.4 ns; or
   c. An operating frequency exceeding 3 GHz;

11. Digital integrated circuits, other than those described in 3A001.a.3. to 10. or 3A001.a.12., based upon any compound semiconductor and having either of the following:
    a. An equivalent gate count of more than 300 (2 input gates); or
    b. A toggle frequency exceeding 1.2 GHz;
12. Fast Fourier Transform (FFT) processors having any of the following:
    a. A rated execution time for a 1024 point complex FFT of less than 1 ms;
    b. A rated execution time for an N-point complex FFT of other than 1,024 points of less than N $\log_2$ N/10,240 ms, where N is the number of points; or
    c. A butterfly throughput of more than 5.12 MHz;

2. Microwave or millimetre wave devices:
   1. Electronic vacuum tubes and cathodes, as follows:

      NOTES:
      1. For frequency agile magnetron tubes, see the Military Goods Controls.
      2. 3A001.b.1. does not specify tubes designed or rated to operate in the Standard Civil Telecommunications Bands at frequencies not exceeding 31 GHz.

      a. Travelling wave tubes, pulsed or continuous wave, as follows:
         1. Operating at frequencies higher than 31 GHz;
         2. Having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;
         3. Coupled cavity tubes, or derivatives thereof with an "instantaneous bandwidth" of more than 7% or a peak power exceeding 2.5 kW;

4. Helix tubes, or derivatives thereof, with 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. "Space qualified";

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

c. Impregnated cathodes for electronic tubes, with either of the following:
   1. Having a turn on time to rated emission of less than 3 seconds; or
   2. Producing a continuous emission current density at rated operating conditions exceeding 5 A/cm$^2$;

2. Microwave integrated circuits or modules containing "monolithic integrated circuits" operating at frequencies exceeding 3 GHz;

   NOTE: 3A001.b.2. does not specify circuits or modules for equipment designed or rated to operate in the Standard Civil Telecommunications Bands at frequencies not exceeding 31 GHz.

3. Microwave transistors rated for operation at frequencies exceeding 31 GHz;

4. Microwave solid state amplifiers, as follows:
   a. Operating at frequencies exceeding 10.5 GHz and

having an "instantaneous bandwidth" of more than half an octave;

b. Operating at frequencies exceeding 31 GHz;

5. Electronically or magnetically tunable band-pass or band-stop filters having more than 5 tunable resonators capable of tuning across a 1.5:1 frequency band ($f_{max}/f_{min}$) in less than 10 microseconds with:
   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. Microwave assemblies capable of operating at frequencies exceeding 31 GHz;
7. Mixers and converters designed to extend the frequency range of equipment described in 3A002.c., 3A002.e. or 3A002.f. beyond the limits stated therein;

3. Acoustic wave devices, as follows, and specially designed components therefor:
   1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices (i.e., "signal processing" devices employing elastic waves in materials), having any of the following:
      a. A carrier frequency exceeding 2.5 GHz;
      b. A carrier frequency of 2.5 GHz or less, and:
         1. A frequency side-lobe rejection exceeding 55 dB;
         2. A product of the maximum delay time and the bandwidth (time in microseconds and bandwidth in MHz) of more than 100; or
         3. A dispersive delay of more than 10 microseconds; or
      c. A carrier frequency exceeding 1 GHz and a bandwidth of 250 MHz or more;
   2. Bulk (volume) acoustic wave devices (i.e., "signal processing"

devices employing elastic waves) which permit direct processing of signals at frequencies exceeding 1 GHz;

3. Acoustic-optic "signal processing" devices employing interaction between acoustic waves (bulk wave or surface wave) and light waves which permit the direct processing of signals or images, including spectral analysis, correlation or convolution;

4. Electronic devices or circuits containing components, manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents, with any of the following:
   1. Electromagnetic amplification:
      a. At frequencies equal to or less than 31 GHz with a noise figure of less than 0.5 dB; or
      b. At frequencies exceeding 31 GHz;
   2. 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
   3. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000;
5. High energy devices, as follows:
   1. Batteries, as follows:

      NOTE: 3A001.e.1. does not specify batteries with volumes equal to or less than 27 $cm^3$ (e.g., standard C-cells or R14 batteries).

      a. Primary cells and batteries having an energy density exceeding 480 Wh/kg and rated for operation in the temperature range from below 243 K (−30°C) to above 343 K (70°C);
      b. Rechargeable cells and batteries having an energy density exceeding 150 Wh/kg after 75 charge/discharge

cycles at a discharge current equal to C/5 hours (C being the nominal capacity in ampere hours) when operating in the temperature range from below 253 K (−20°C) to above 333 K (60°C);

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

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

2. High energy storage capacitors, as follows:

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

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

b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) having all of the following:
 1. A voltage rating equal to or more than 5 kV;
 2. An energy density equal to or more than 50 J/kg;
 3. A total energy equal to or more than 100 J; and

4. A charge/discharge cycle life equal to or more than 10,000;

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

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

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

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

4. Circuits or systems for electromagnetic energy storage, containing components manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents, having all of the following:
   a. Resonant operating frequencies exceeding 1 MHz;
   b. A stored energy density of 1 MJ/m$^3$ or more; and
   c. A discharge time of less than 1 ms;

5. Flash discharge type X-ray systems, and tubes therefor, having all of the following:

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

   a. A peak power exceeding 500 MW;

b. An output voltage exceeding 500 kV; and
c. A pulse width of less than 0.2 microsecond;

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

**3A002**

General purpose electronic equipment:

a. Recording equipment, as follows, and specially designed test tape therefor:
   1. Analogue instrumentation magnetic tape recorders, including those permitting the recording of digital signals (e.g., using a high density digital recording (HDDR) module), having any of the following:
      a. A bandwidth exceeding 4 MHz per electronic channel or track;
      b. A bandwidth exceeding 2 MHz per electronic channel or track and having more than 42 tracks; or
      c. A time displacement (base) error, measured in accordance with applicable Inter Range Instrumentation Group (IRIG) or Electronic Industries Association (EIA) documents, of less than ± 0.1 microsecond;
   2. Digital video magnetic tape recorders having a maximum digital interface transfer rate exceeding 180 Mbit/s;

      except:

      Those specially designed for television recording using a signal format standardized or recommended by the International Radio Consultative Committee (CCIR) or the International Technical Commission (IEC) for civil television applications;
   3. Digital instrumentation magnetic tape data recorders employing

helical scan techniques or fixed head techniques, having either of the following characteristics:

a. A maximum digital interface transfer rate exceeding 175 Mbit/s; or

b. "Space qualified";

NOTE: 3A002.a.3. does not specify analogue magnetic tape recorders equipped with HDDR conversion electronics and configured to record only digital data.

c. Equipment, with a maximum digital interface transfer rate exceeding 175 Mbit/s, designed to convert digital video magnetic tape recorders for use as digital instrumentation data recorders;

d. Waveform digitisers and transient recorders with both of the following:

N.B.: SEE ALSO 3A202

a. Digitising rates equal to or more than 200 million samples per second and a resolution of 10 bits or more; and

b. A continuous throughput of 2 Gbits/s or more;

Technical Note: For those instruments with a parallel bus architecture, the continuous throughput rate is the highest word rate multiplied by the number of bits in a word.
In 3A002.a.5., "Continuous throughput" means 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;

4. "Frequency synthesiser" "electronic assemblies" having a "frequency switching time" from one selected

frequency to another of less than 1 ms;

5. "Signal analysers", as follows:
    1. Capable of analysing frequencies exceeding 31 GHz;
    2. "Dynamic signal analysers" with a "real-time bandwidth" exceeding 25.6 kHz;

        except:

        Those using only constant percentage bandwidth filters (also known as octave or fractional octave filters);
6. Frequency synthesised signal generators producing output frequencies, the accuracy and short term and long term stability of which are controlled, derived from or disciplined by the internal master frequency, and having any of the following:
    1. A maximum synthesised frequency exceeding 31 GHz;
    2. A "frequency switching time" from one selected frequency to another of less than 1 ms; or
    3. A single sideband (SSB) phase noise better than—$(126+20\log_{10}F-20\log_{10}f)$ in dBc/Hz, where F is the off-set from the operating frequency in Hz and f is the operating frequency in MHz;

        NOTE: 3A002.d. does not specify 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.
7. Network analysers with a maximum operating frequency exceeding 31 GHz;

NOTE: 3A002.e. does not specify "swept frequency network analysers" with a maximum operating frequency not exceeding 40 GHz and which do not contain a data bus for remote control interfacing.

8. Microwave test receivers with both of the following:
    1. A maximum operating frequency exceeding 31 GHz; and
    2. Capable of measuring amplitude and phase simultaneously;
9. Atomic frequency standards having either of the following characteristics:
    1. Long term stability (aging) less (better) than $1\times10^{-11}$/month; or

       NOTE: 3A002.g.1. does not specify non-"space qualified" rubidium standards.
    2. "Space qualified";
10. Emulators for microcircuits specified in 3A001.a.3. or 3A001.a.9.;

    NOTE: 3A002.h. does not specify emulators designed for a "family" which contains at least one device not specified in 3A001.a.3. or 3A001.a.9.

**3A101**

Electronic equipment, devices and components, other than those specified in 3A001, as follows:

a. Analog-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.

**3A201**

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

a. Capacitors with the following characteristics:
   1. Voltage rating greater than 1.4 kV, energy storage greater than 10 J, capacitance greater than 0.5 uF and series inductance less than 50 nH; or
   2. Voltage rating greater than 750 V, capacitance greater than 0.25 uF and series inductance less than 10 nH;
b. Superconducting solenoidal electromagnets with all of the following characteristics:
   1. Capable of creating magnetic fields of more than 2 teslas (20 kilogauss);
   2. With an L/D ratio (length divided by inner diameter) greater than 2;
   3. With an inner diameter of more than 300 mm; and
   4. With a magnetic field uniform to better than 1% over the central 50% of the inner volume;

      NOTE: 3A201.b. does not specify 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 with peak energy of 500 keV or greater, as follows;

   except:

   Accelerators that are component parts of devices designed for purposes other than electron beam or X-ray radiation (electron microscopy, for example) and those designed for medical purposes:
   1. Having an accelerator peak electron energy of 500 keV or greater but less than 25 MeV and with a figure

of merit (K) of 0.25 or greater, where K is defined as:

K=1.7×103V2.65Q,

where

V is the peak electron energy in million electron volts and Q is the total accelerated charge in coulombs if the accelerator beam pulse duration is less than or equal to 1 microsecond; if the accelerator beam pulse duration is greater than 1 microsecond, Q is the maximum accelerated charge in 1 microsecond [Q equals the integral of i with respect to t, over the lesser of 1 microsecond or the time duration of the beam pulse (Q = [integral] idt), where i is beam current in amperes and t is time in seconds]; or

2. Having an accelerator peak electron energy of 25 MeV or greater and a peak power greater than 50 MW. [Peak power = (peak potential in volts) × (peak beam current in amperes)]
    a. Technical Notes: Time duration of the beam pulse —In machines, based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1 microsecond or the duration of the bunched beam packet resulting from one microwave modulator pulse.
    b. Peak beam current—In machines based on microwave accelerating cavities, the peak beam current is the average current in the time duration of a bunched beam packet.

**3A202** Oscilloscopes and transient recorders other than those specified in 3A002.a.5., as follows; and specially designed components therefor:

a. Non-modular analogue oscilloscopes having a bandwidth of 1 GHz or greater;

b. Modular analogue oscilloscope systems having either of the following characteristics:
   1. A mainframe with a bandwidth of 1 GHz or greater; or
   2. Plug-in modules with an individual bandwidth of 4 GHz or greater;
c. Analogue sampling oscilloscopes for the analysis of recurring phenomena with an effective bandwidth greater than 4 GHz;
d. Digital oscilloscopes and transient recorders, using analogue-to-digital conversion techniques, capable of storing transients by sequentially sampling single-shot inputs at successive intervals of less than 1 ns (greater than 1 giga-sample per second), digitizing to 8 bits or greater resolution and storing 256 or more samples.

NOTE: Specially designed components specified in this item are the following, for analogue oscilloscopes:
1. Plug-in units;
2. External amplifiers;
3. Pre-amplifiers;
4. Sampling devices;
5. Cathode ray tubes.

Technical Note: 'Bandwidth' is defined as the band of frequencies over which the deflection on the cathode ray tube does not fall below 70.7% of that at the maximum point measured with a constant input voltage to the oscilloscope amplifier.

**3A225**

Frequency changers (also known as converters or inverters) or generators, other than those specified in 0B001.c.11., having all of the following characteristics:
a. A multiphase output capable of providing a power of 40 W or more;
b. Capable of operating in the frequency range between 600 and 2,000 Hz;
c. Total harmonic distortion below 10%; and
d. Frequency control better than 0.1%.

**3A226**

Direct current high-power supplies capable of continuously producing, over a time period of 8 hours, 100 V or greater with current output of 500 A or greater and with current or voltage regulation better than 0.1%.

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| **3A227** | High-voltage direct current power supplies capable of continuously producing, over a time period of 8 hours, 20,000 V or greater with current output of 1 A or greater and with current or voltage regulation better than 0.1%. |
| **3A228** | Switching devices, as follows:<br>a. Cold-cathode tubes (including gas krytron tubes and vacuum sprytron tubes), whether gas filled or not, operating similarly to a spark gap, containing three or more electrodes, and having all of the following characteristics:<br>1. Anode peak voltage rating of 2,500 V or more;<br>2. Anode peak current rating of 100 A or more; and<br>3. Anode delay time of 10 microsecond or less;<br>b. Triggered spark-gaps having an anode delay time of 15 microsecond or less and rated for a peak current of 500 A or more;<br>c. Modules or assemblies with a fast switching function having all of the following characteristics:<br>1. Anode peak voltage rating greater than 2,000 V;<br>2. Anode peak current rating of 500 A or more; and<br>3. Turn-on time of 1 microsecond or less. |
| **3A229** | Firing sets and equivalent high-current pulse generators (for controlled detonators), as follows:<br><br>N.B.: SEE ALSO MILITARY GOODS CONTROLS.<br>a. Explosive detonator firing sets designed to drive multiple controlled detonators specified in 3A232;<br>b. Modular electrical pulse generators (pulsers) designed for portable, mobile or ruggedized use (including xenon flash-lamp drivers) having all the following characteristics:<br>1. Capable of delivering their energy in less than 15 microsecond;<br>2. Having an output greater than 100 A;<br>3. Having a rise time of less than 10 microsecond into loads of less than 40 ohms (rise time is the time interval from 10% to 90% current |

amplitude when driving a resistive load);
4. Enclosed in a dust-tight enclosure;
5. No dimension greater than 254 mm;
6. Weight less than 25 kg; and
7. Specified for use over an extended temperature range (223 K [−50° C] to 373 K [100° C]) or specified as suitable for aerospace use.

**3A230** High-speed pulse generators with output voltages greater than 6 volts into a less than 55 ohm resistive load, and with pulse transition times less than 500 picoseconds.

Technical Note: In this item, 'pulse transition time' is defined as the time interval between 10% and 90% voltage amplitude.

**3A231** Neutron generator systems, including tubes, designed for operation without an external vacuum system and utilizing electrostatic acceleration to induce a tritium-deuterium nuclear reaction.

**3A232** Detonators and multipoint initiation systems, as follows:

N.B.: SEE ALSO MILITARY GOODS CONTROLS.

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

   NOTE: This item does not specify detonators using only primary explosives, such as lead azide.

Technical Note: The detonators of concern all utilise a small electrical conductor (bridge, bridge wire or foil) that explosively vapourises when a fast, high-current electrical pulse is passed through it. In nonslapper types, the exploding conductor starts a chemical detonation in a contacting high-explosive material such as PETN (Pentaerythritoltetranitrate). In slapper detonators, the explosive vapourisation of the electrical conductor drives a flyer or slapper across a gap and the impact of the slapper on an explosive starts a chemical detonation. The slapper in some designs is driven by a magnetic force. The term exploding foil detonator may refer to either an EB or a slapper-type detonator. Also, the word initiator is sometimes used in place of the word detonator.

**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 which have a source chamber constructed from, lined with or plated with materials resistant to $UF_6$;
e. Molecular beam mass spectrometers as follows:
   1. Which have a source chamber constructed from, lined with or plated with stainless steel or molybdenum and have a cold trap capable of cooling to 193 K (−80°C) or less; or
   2. Which have a source chamber constructed from, lined with or plated with materials resistant to $UF_6$; or
f. Mass spectrometers equipped with a microfluorination ion source designed for use with actinides or actinide fluorides.

**3B** **Test, Inspection and Production Equipment**

**3B** Equipment for the manufacture or testing of semiconductor devices or materials, as follows, and specially designed components and accessories therefor:

**3B001** "Stored programme controlled" equipment for epitaxial growth, as follows:

a. Capable of producing a layer thickness uniform to less than ±2.5% across a distance of 75 mm or more;
b. Metal organic chemical vapour deposition (MOCVD) reactors specially designed for compound semiconductor crystal growth by the chemical reaction between materials specified in 3C003 or 3C004;
c. Molecular beam epitaxial growth equipment using gas sources.

**3B002** “Stored programme controlled” equipment designed for ion implantation, having any of the following:
a. An accelerating voltage exceeding 200 keV;
b. Specially designed and optimized to operate at an accelerating voltage of less than 10 keV;
c. Direct write capability; or
d. Capable of high energy oxygen implant into a heated semiconductor material “substrate”.

**3B003** “Stored programme controlled” anisotropic plasma dry etching equipment, as follows:
a. With cassette-to-cassette operation and load-locks, and having either of the following:
    1. Magnetic confinement; or
    2. Electron cyclotron resonance (ECR);
b. Specially designed for equipment specified in 3B005 and having either of the following:
    1. Magnetic confinement; or
    2. Electron cyclotron resonance (ECR).

**3B004** “Stored programme controlled” plasma enhanced CVD equipment, as follows:
a. With cassette-to-cassette operation and load-locks, and having either of the following:
    1. Magnetic confinement; or
    2. Electron cyclotron resonance (ECR);
b. Specially designed for equipment specified in 3B005 and having either of the following:
    1. Magnetic confinement; or
    2. Electron cyclotron resonance (ECR).

**3B005**

"Stored programme controlled" automatic loading multi-chamber central wafer handling systems, having interfaces for wafer input and output, to which more than two pieces of semiconductor processing equipment are to be connected, to form an integrated system in a vacuum environment for sequential multiple wafer processing.

NOTE: This item does not specify automatic robotic wafer handling systems not designed to operate in a vacuum environment.

**3B006**

"Stored programme controlled" lithography equipment, as follows:

a. Align and expose step and repeat equipment for wafer processing using photo-optical or X-ray methods, having either of the following:
   1. A light source wavelength shorter than 400nm; or
   2. Capable of producing a pattern with a minimum resolvable feature size of 0.7 micrometre or less when calculated by the following formula:

      MRF=(wavelengthinmicrometre)×(K factor)numerical aperture

      where:
         'MRF' is the minimum resolvable feature size;
         the 'K factor' = 0.7; and
         'wavelength' is the exposure light source wavelength;
b. Equipment specially designed for mask making or semiconductor device processing using deflected focussed electron beam, ion beam or "laser" beam, with any of the following:
   1. A spot size smaller than 0.2 micrometre;
   2. Capable of producing a pattern with a feature size of less than 1 micrometre; or
   3. An overlay accuracy of better than ± 0.20 micrometre (3 sigma).

**3B007**

Masks or reticles, as follows:

a. For integrated circuits specified in 3A001;
b. Multi-layer masks with a phase shift layer.

**3B008**

"Stored programme controlled" test equipment, specially designed for testing semiconductor devices and unencapsulated dice, as follows:

a. For testing S-parameters of transistor devices at frequencies exceeding 31 GHz;

b. For testing integrated circuits capable of performing functional (truth table) testing at a pattern rate of more than 40 MHz;

NOTE: 3B008.b. does not specify test equipment specially designed for testing:

1. "Electronic assemblies" or a class of "electronic assemblies" for home or entertainment applications;
2. Non-controlled electronic components, "electronic assemblies" or integrated circuits.

c. For testing microwave integrated circuits at frequencies exceeding 3 GHz;

NOTE: 3B008.c. does not specify test equipment specially designed for testing microwave integrated circuits for equipment designed or rated to operate in the Standard Civil Telecommunication Bands at frequencies not exceeding 31 GHz.

d. Electron beam systems designed for operation at or below 3 keV, or "laser" beam systems, for the non-contactive probing of powered-up semiconductor devices, with both of the following:

1. Stroboscopic capability with either beam-blanking or detector strobing; and
2. An electron spectrometer for voltage measurement with a resolution of less than 0.5 V.

NOTE: 3B008.d. does not specify scanning electron microscopes;

except:

When specially designed and instrumented for the non-contactive probing of powered-up semiconductor devices.

**3C** **Materials**

| | |
|---|---|
| **3C001** | Hetero-epitaxial materials consisting of a "substrate" with stacked epitaxially grown multiple layers of:<br>a. Silicon;<br>b. Germanium; or<br>c. III/V compounds of gallium or indium.<br><br>Technical Note: III/V compounds are polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev's periodic classification table (gallium arsenide, gallium-aluminium arsenide, indium phosphide, etc.). |
| **3C002** | Resist materials, as follows, and "substrates" coated with controlled resists:<br>a. Positive resists for semiconductor lithography specially adjusted (optimised) for use at wavelengths below 370 nm;<br>b. All resists, for use with electron beams or ion beams, with a sensitivity of 0.01 microcoulomb/$mm^2$ or better;<br>c. All resists, for use with X-rays, with a sensitivity of 2.5 mJ/$mm^2$ or better;<br>d. All resists optimized for surface imaging technologies, including silylated resists.<br><br>Technical Note: Silylation techniques are defined as processes incorporating oxidation of the resist surface to enhance performance for both wet and dry developing. |
| **3C003** | Organo-inorganic compounds as follows:<br>a. Organo-metallic compounds of aluminium, gallium or indium, having a purity (metal basis) better than 99.999%;<br>b. Organo-arsenic, organo-antimony and organo-phosphorus compounds having a purity (inorganic element basis) better than 99.999%.<br><br>NOTE: 3C003 only specifies 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 if diluted in neutral gases. |

NOTE: 3C004 does not specify hydrides containing 20% molar or more of inert gases or hydrogen.

| | |
|---|---|
| **3D** | **Software** |
| **3D001** | "Software" specially designed for the "development" or "production" of equipment specified in 3A001.b to 3A002.h or 3B. |
| **3D002** | "Software" specially designed for the "use" of "stored programme controlled" equipment specified in 3B. |
| **3D003** | Computer-aided-design (CAD) "software" for semiconductor devices or integrated circuits, having any of the following:<br>a. Design rules or circuit verification rules;<br>b. Simulation of the physically laid out circuits; or<br>c. Lithographic processing simulators for design.<br><br>Technical Note: A lithographic processing simulator is a "software" package used in the design phase to define the sequence of lithographic, etching and deposition steps for translating masking patterns into specific topographical patterns in conductors, dielectrics or semiconductor material.<br><br>NOTE: 3D003 does not specify "software" specially designed for schematic entry, logic simulation, placing and routing, layout verification or pattern generation tape.<br>N.B.: Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as "technology". |
| **3D101** | "Software" specially designed for the "use" of equipment specified in 3A101 b. |
| **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;<br><br>NOTE: 3E001 does not specify "technology" for the "development" or "production" of:<br>a. Microwave transistors operating at frequencies below 31 GHz; |

b. Integrated circuits specified in 3A001.a.3. to 12., having both of the following characteristics:
   1. Using technology of one micrometre or more; and
   2. Not incorporating multi-layer structures.

   N.B.: This Note does not preclude the export of multilayer technology for devices incorporating a maximum of two metal layers and two polysilicon layers.

**3E002**

Other "technology" for the "development" or "production" of:

a. Vacuum microelectronic devices;
b. Hetero-structure semiconductor devices such as high electron mobility transistors (HEMT), hetero-bipolar transistors (HBT), quantum well or super lattice devices;
c. "Superconductive" electronic devices;
d. Substrates of films of diamond for electronic components.

**3E101**

"Technology" according to the General Technology Note for the "use" of equipment or "software" specified in 3A001.a.1 or 2, 3A101 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.e.5, 3A201, 3A202, 3A225 to 3A233.

## CATEGORY 4— COMPUTERS

NOTES:

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

   N.B.:
   1. 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).

2. For the control status of “software” which provides routing or switching of “datagram” or “fast select” packets (i.e., packet by packet route selection) or of “software” specially designed for packet switching, see Category 5 (Part 1—Telecommunications).

2. Computers, related equipment or “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** **Equipment, Assemblies and Components**

**4A001** Electronic computers and related equipment, as follows, and “electronic assemblies” and specially designed components therefor:

N.B.: SEE ALSO 4A101.

a. Specially designed to have either of the following characteristics:
   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 apply to computers specially designed for civil automobile or railway train applications.
   2. Radiation hardened to exceed any of the following specifications:
      a. Total Dose $5 \times 10^5$ Rads (Si);
      b. Dose Rate Upset $5 \times 10^8$ Rads (Si)/sec; or
      c. Single Event Upset $1 \times 10^{-7}$ Error/bit/day;
         NOTE: For equipment designed or rated for transient ionising radiation, see the Military Goods Controls.
b. Having characteristics or performing functions exceeding the limits in Category 5 (Part 2—“Information Security”).

**4A002**

"Hybrid computers", as follows, and "electronic assemblies" and specially designed components therefor:

N.B.: SEE ALSO ENTRY 4A102.

a. Containing "digital computers" specified in 4A003;
b. Containing analogue-to-digital converters having any of the following characteristics:
    1. 32 channels or more; and
    2. A resolution of 14 bits (plus sign bit) or more with a conversion rate of 200,000 conversions/s or more.

**4A003**

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

1. NOTES: 4A003 includes vector processors, array processors, digital signal processors, logic processors, and equipment for "image enhancement" or "signal processing".
2. The control status of the "digital computers" or related equipment described in 4A003 is governed 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
        1. N.B.: 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.
        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 specified in 4E.

a. Designed or modified for “fault tolerance”;

NOTE: For the purposes of 4A003.a, “digital computers” and related equipment are not considered to be designed or modified for “fault tolerance” if they use:

1. Error detection or correction algorithms in “main storage”;
2. The interconnection of two “digital computers” so that, if the active central processing unit fails, an idling but mirroring central processing unit can continue the system’s functioning;
3. The interconnection of two central processing units by data channels or by use of shared storage to permit one central processing unit to perform other work until the second central processing unit fails, at which time the first central processing unit takes over in order to continue the system’s functioning; or
4. The synchronisation of two central processing units by “software” so that one central processing unit recognises when the other central processing unit fails and recovers tasks from the failing unit.

b. “Digital computers” having a “composite theoretical performance” (CTP) exceeding 260 million theoretical operations per second (Mtops);

c. “Electronic assemblies” specially designed or modified to be capable of enhancing performance by aggregation of “computing elements” so that the “Composite theoretical performance” of the aggregation exceeds the limit in 4A003.b.;

1. NOTES: 4A003.c. applies only to “electronic assemblies” and programmable interconnections not exceeding the limit in 4A003.b., when shipped as unintegrated

"electronic assemblies". It does not apply to "electronic assemblies" inherently limited by nature of their design for use as related equipment specified in 4A003.d.,e. or f.

2. 4A003.c. does not specify "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit of 4A003.b.

d. Graphics accelerators or graphics coprocessors exceeding a "3-D Vector Rate" of 1,600,000;

e. Equipment performing analogue-to-digital conversions exceeding the limits in 3A001.a.5.;

f. Equipment containing "terminal interface equipment" exceeding the limits in 5A001.b.3.

NOTE: For the purposes of 4A003.f., "terminal interface equipment" includes "local area network" interfaces, modems and other communications interfaces. "Local area network" interfaces are evaluated as "network access controllers".

g. Equipment specially designed to provide for the external interconnection of "digital computers" or associated equipment which allows communications at data rates exceeding 80 Mbytes/s.

NOTE: 4A003.g. does not control internal interconnection equipment (e.g. backplanes, buses) or passive interconnection equipment.

**4A004** Computers, as follows, and specially designed related equipment, "electronic assemblies" and components therefor:

a. "Systolic array computers";

b. "Neural computers";

c. "Optical computers".

**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 systems specified in 9A004 or 9A104.

**4A102** "Hybrid computers" specially designed for modelling, simulation or design integration of systems specified in 9A004 or 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 the “development”, “production”, or “use” of equipment described in other Categories is dealt with in the appropriate Category. The control status of “software” for equipment described in this Category is dealt with herein. |
| **4D001** | “Software” specially designed or modified for the “development”, “production” or “use” of equipment, materials or “software” specified in 4A001 to 4A004, or 4D. |
| **4D002** | “Software” specially designed or modified to support “technology” specified in 4E. |
| **4D003** | Specific “software”, as follows:<br>a. Operating system “software”, “software” development tools and compilers specially designed for “multi-data-stream processing” equipment, in “source code”;<br>b. “Expert systems” or “software” for “expert system” inference engines providing both:<br>1. Time dependent rules; and<br>2. Primitives to handle the time characteristics of the rules and the facts;<br>c. “Software” having characteristics or performing functions exceeding the limits in Category 5 (Part 2—“Information Security”);<br>d. Operating systems specially designed for “real time processing” equipment which guarantees a “global interrupt latency time” of less than 20 microseconds. |
| **4E** | **Technology** |
| **4E001** | “Technology” according to the General Technology Note, for the “development”, “production” or “use” of equipment, or “software” specified in 4A or 4D. |
| **4E002** | Other technology, as follows: |

a. "Technology" for the "development" or "production" of equipment designed for "multi-data-stream processing" where the "composite theoretical performance (CTP)" exceeds 120 Mtops;

b. "Technology" "required" for the "development" or "production" of magnetic hard disk drives with a "maximum bit transfer rate" exceeding 47 Mbit/s.

4. Technical Note

"COMPOSITE THEORETICAL PERFORMANCE" (CTP)

Abbreviations used in this Note

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

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

**Outline of the CTP calculation method**

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

**1.** Calculate the effective calculating rate R for each CE;

**2.** Apply the word length adjustment (L) to the effective calculating rate (R), resulting in a Theoretical Performance (TP) for each CE;

**3.** If there is more than one CE, combine the TPs resulting in a CTP for the aggregation.

Details for these steps are given in the following sections.

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

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

The following table shows the method of calculating the effective calculating rate (R) for each CE:

Step 1: The effective calculating rate R

| For CEs implementing<br><br>Note: Every CE must be evaluated independently | Effective calculating rate, R |
|---|---|
| XP only<br><br>($R_{xp}$) | 13*(txpadd)<br><br>if no add is implemented use:<br><br>1(txpmult)<br><br>If neither add nor multiply is implemented use the fastest available arithmetic operation as follows:<br><br>13*txp<br><br>See Notes X & Z |
| FP only<br><br>($R_{fp}$) | Max<br><br>1,tfpadd1tfpmult<br><br>See Notes X & Y |
| Both FP and XP<br><br>(R) | Calculate both<br><br>$R_{xp}$, $R_{fp}$ |
| For simple logic processors not implementing any of the specified arithmetic operations. | 13*tlog<br><br>Where<br>$t_{log}$ is the execute time of the XOR, or for logic hardware not implementing the XOR, the fastest simple logic operation.<br><br>See Notes X & Z |
| For special logic processors not using any of the specified arithmetic or logic operations. | R=R'*WL/64<br><br>Where<br>R' is the number of results per second, WL is the number of bits upon which the logic operation occurs, and 64 is a factor to normalize to a 64 bit operation. |

**Note W:**

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

**Note X:**

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

t=cycle timethe number of identical arithmetic operations per machine cycle

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

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

**Note Y:**

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

Rfp=1tfpdivide

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

Rfp=1tfprecipsubr;ocal

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

**Note Z:**

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

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

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

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

Step 2: TP for each supported operand length WL

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

TP=R*L,

where

L = (1/3 + WL/96)

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

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

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

Select the maximum resulting value of TP for:

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

Step 3: CTP for aggregations of CEs, including CPUs

For a CPU with a single CE,

CTP=TP

(for CEs performing both fixed and floating point operations

TP=max (TPfp,TPxp)

)

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

**Note 1:**

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

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

**Note 2:**

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

**Note 3:**

Simultaneous operations are assumed to exist when the computer manufacturer claims concurrent, parallel or simultaneous operation or execution in a manual or brochure for the computer.

**Note 4:**

CTP values are not to be aggregated for CE combinations (inter) connected by local area networks, Wide Area Networks, Input/Output shared connections/devices, Input/Output controllers and any communication interconnection implemented by software.

**Note 5:**

CTP values must be aggregated for multiple CEs specially designed to enhance performance by aggregation, operating simultaneously and sharing memory,—or multiple memory/CE—combinations operating simultaneously utilising specially designed hardware.

This aggregation does not apply to assemblies described by entry 4A003d

CTP=TP1+C2*TP2+…+Cn*TPn,

where

the TPs are ordered by value, with $TP_1$ being the highest, $TP_2$ being the second highest, …, and $TP_n$ being the lowest. $C_i$ is a coefficient determined by the strength of the interconnection between CEs, as follows:

For multiple CEs operating simultaneously and sharing memory:

C2=C3=C4=…=Cn=0.75

**Note 1:**

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

Ci=0.75(m)1/2

(i=2,…,n)

where

m = number of CEs or groups of CEs sharing access.

provided:

(1) The TPi of each CE or group of CEs does not exceed 30 Mtops;

(2) The CEs or groups of CEs share access to main memory (excluding cache memory) over a single channel; and

(3) Only one CE or group of CEs can have use of the channel at any given time.

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

**Note 2:**

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

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

Ci=0.75*ki(i=2,…,32)(see note below)=0.60*ki(i=33,…,64)=0.45*ki(i=65,…,256)=0.30*ki(i>256)

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

where

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

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

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

TP1≥TP2≥…≥TPn

, and

in the case of $TP_i$ = TPsubi;$+_1$ from the largest to smallest; i.e.:

Ci≥Ci+1

**Note:**

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

## CATEGORY 5— TELECOMMUNICATIONS AND "INFORMATION SECURITY"

## Part 1—TELECOMMUNICATIONS

**NOTES:**

**1.** The control status of components, "lasers", test and production equipment, materials and "software" therefor, which are specially designed for telecommunications equipment or systems is defined in this Category.

(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** **Equipment, Assemblies and Components**

**5A001**

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 arising from a nuclear explosion;
2. Specially hardened to withstand gamma, neutron or ion radiation;
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 3. do not apply to equipment on board satellites.

b. Telecommunication transmission equipment or systems, and specially designed components and accessories therefor, having any of the following characteristics, functions or features:

NOTE: Telecommunication transmission equipment:

a. Categorised as follows, or combinations thereof:

1. Radio equipment (e.g., transmitters, receivers and transceivers);
2. Line terminating equipment;
3. Intermediate amplifier equipment;
4. Repeater equipment;
5. Regenerator equipment;
6. Translation encoders (transcoders);
7. Multiplex equipment (statistical multiplex included);
8. Modulators/ demodulators (modems);
9. Transmultiplex equipment (see CCITT Rec. G.701);
10. “Stored programme controlled” digital crossconnection equipment;
11. “Gateways” and bridges;
12. “Media access units”; and

b. Designed for use in single or multi-channel communication via:
   1. Wire (line);
   2. Coaxial cable;
   3. Optical fibre cable;
   4. Electromagnetic radiation;
   5. Underwater acoustic wave propagation.

1. Employing digital techniques, including digital processing of analogue signals, and designed to operate at a "digital transfer rate" at the highest multiplex level exceeding 45 Mbit/s or a "total digital transfer rate" exceeding 90 Mbit/s;

   NOTE: 5A001.b.1. does not control equipment specially designed to be integrated and operated in any satellite system for civil use.

2. Being "stored programme controlled" digital cross connect equipment with a "digital transfer rate" exceeding 8.5 Mbit/s per port;
3. Being equipment containing:
   a. Modems using the "bandwidth of one voice channel" with a "data signalling rate" exceeding 28,800 bits/s;
   b. "Communication channel controllers" with a digital output having a "data signalling rate" exceeding 2.1 Mbit/s per channel; or
   c. "Network access controllers" and their related common medium having a "digital transfer rate" exceeding 156 Mbit/s;

      NOTE: If any non-controlled equipment contains a "network access controller", it cannot have any type of telecommunications interface;

      except:

      Those described in, but not controlled by, 5A001.b.3.

4. Employing a "laser" and having any of the following characteristics:
    a. A transmission wavelength exceeding 1000 nm;
    b. Employing analogue techniques and having a bandwidth exceeding 45 MHz;
    c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques);
    d. Employing wavelength division multiplexing techniques; or
    e. Performing "optical amplification";
5. Being radio equipment operating at input or output frequencies exceeding:
    a. 31 GHz for satellite-earth station applications;
    b. 26.5 GHz for other applications;

    NOTE: 5A001.b.5.b. does not specify equipment for civil use conforming with an International Telecommunications Union (ITU) allocated band between 26.5 and 31 GHz.
6. Being radio equipment:
    a. Employing quadrature-amplitude-modulation (QAM) techniques above level 4 if the "total digital transfer rate" exceeds 8.5 Mbit/s;
    b. Employing quadrature-amplitude-modulation (QAM) techniques above level 16 if the "total digital transfer rate" is equal to or less than 8.5 Mbit/s; or
    c. Employing other digital modulation techniques and having a "spectral efficiency" exceeding 3 bit/sec/Hz;

    NOTE:
    1. 5A001.b.6. does not specify equipment

specially designed to be integrated and operated in any satellite system for civil use.

2. 5A001.b.6. does not specify radio relay equipment for operation in an International Telecommunications Union (ITU) allocated band:
   a. 1. Not exceeding 960 Mhz; or
      2. With a "total digital transfer rate" not exceeding 8.5 Mbits/s; and
   b. Having a "spectral efficiency" not exceeding 4 bits/sec/Hz.

7. Being radio equipment operating in the 1.5 to 87.5 MHz band and having either of the following characteristics:
   a. 1. Automatically predicting and selecting frequencies and "total digital transfer rates" per channel to optimize the transmission; and
      2. Incorporating a linear power amplifier configuration having a capability to support multiple signals simultaneously at an output power of 1 kW or more in the 1.5 to 30 MHz frequency range or 250 W or more in the 30 to 87.5 MHz frequency range, over an "instantaneous bandwidth" of one octave or more and with an output harmonic and distortion content of better than —80 dB; or

b. Incorporating adaptive techniques providing more than 15 dB suppression of an interfering signal;

8. Being radio equipment employing “spread spectrum” or “frequency agility” (frequency hopping) techniques having either of the following characteristics:
   a. User programmable spreading codes; or
   b. A total transmitted bandwidth which is 100 or more times the bandwidth of any one information channel and in excess of 50 kHz;
9. Being digitally controlled radio receivers having more than 1,000 channels, which:
   a. Search or scan automatically a part of the electromagnetic spectrum;
   b. Identify the received signals or the type of transmitter; and
   c. Have a “frequency switching time” of less than 1 ms;
10. Providing functions of digital “signal processing” as follows:
    a. Voice coding at rates of less than 2,400 bit/s;
    b. Employing circuitry which incorporates “user-accessible programmability” of digital “signal processing” circuits exceeding the limits of 4A003.b.;
11. Being underwater communications systems having any of the following characteristics:
    a. An acoustic carrier frequency outside the range from 20 to 60 kHz;
    b. Using an electromagnetic carrier frequency below 30 kHz; or
    c. Using electronic beam steering techniques;

c. “Stored programme controlled” switching equipment and related signalling systems, having any of the following characteristics, functions or features, and specially designed components and accessories therefor:

NOTE: Statistical multiplexers with digital input and digital output which provide switching are treated as "stored programme controlled" switches.

1. "Common channel signalling";

   NOTE: Signalling systems in which the signalling channel is carried in and refers to no more than 32 multiplexed channels forming a trunk line of no more than 2.1 Mbit/s, and in which the signalling information is carried in a fixed, time division multiplexed channel without the use of labelled messages, are not considered to be "common channel signalling" systems.
2. Containing "Integrated Services Digital Network" (ISDN) functions and having either of the following:
   a. Switch-terminal (e.g., subscriber line) interfaces with a "digital transfer rate" at the highest multiplex level exceeding 192,000 bit/s, including the associated signalling channel (e.g., 2B +D); or
   b. The capability that a signalling message received by a switch on a given channel that is related to a communication on another channel may be passed through to another switch;

      NOTE: 5A001.c.2. does not preclude:
      1. The evaluation and appropriate actions taken by the receiving switch;
      2. Unrelated user message traffic on a D channel of "ISDN".
3. Multi-level priority and pre-emption for circuit switching;

   NOTE: 5A001.c.3. does not specify single-level call pre-emption.
4. "Dynamic adaptive routing";

5. Routing or switching of “datagram” packets;
6. Routing or switching of “fast select” packets;

NOTE: The restrictions in 5A001.c.5. and 6. do not apply to networks using only “network access controllers” or to “network access controllers” themselves.

7. Designed for automatic hand-off of cellular radio calls to other cellular switches or for automatic connection to a centralized subscriber data base common to more than one switch;
8. Being packet switches, circuit switches and routers with ports or lines exceeding either:
   a. A “data signalling rate” of 64,000 bit/s per channel for a “communications channel controller”; or

      NOTE: 5A001.c.8.a. does not preclude the multiplexing over a composite link of communications channels not specified in 5A001.c.8.a.

   b. A “digital transfer rate” of 33 Mbit/s for a “network access controller” and related common medium;
9. “Optical switching”;
10. Employing “Asynchronous Transfer Mode” (ATM) techniques;
11. Containing “stored programme controlled” digital crossconnect equipment with a “digital transfer rate” exceeding 8.5 Mbit/s per port;

d. Centralized network control having both of the following characteristics:
1. Receives data from the nodes; and
2. Processes these data in order to provide control of traffic not requiring operator decisions, thereby performing “dynamic adaptive routing”;

NOTE: 5A001.d. does not preclude control of traffic as a function of predictable statistical traffic conditions.

e. Optical fibre communication cables, optical fibres and accessories, as follows:

1. Optical fibres or cables of more than 50 m in length having either of the following characteristics:

a. Designed for single mode operation; or

b. For optical fibres, specified by the manufacturer as being capable of withstanding a Proof Test tensile stress of $2 \times 10^9$ N/m$^2$ or more;

Technical Note: Proof Test: On-line or off-line production screen testing that dynamically applies a prescribed tensile stress over a 0.5 to 3 m length of fibre at a running rate of 2 to 5 m/s while passing between capstans approximately 150 mm in diameter. The ambient temperature is a nominal 293 K (20° C) and relative humidity of 40%.

N.B.: Equivalent national standards may be used for executing the Proof Test.

2. Optical fibre cables and accessories designed for underwater use (for fibre-optic hull penetrators or connectors, see 8A002.c.);

f. Phased array antennae, operating above 10.5 GHz, containing active elements and distributed components, and designed to permit electronic control of beam shaping and pointing.

NOTE: This sub-item does not specify landing systems with instruments meeting International Civil Aviation Organisation (ICAO) standards (microwave landing systems (MLS)).

**5A101** Telemetering and telecontrol equipment usable for “missiles”.

NOTE: This item does not control equipment specially designed to be used for remote control of model planes, boats or vehicles and having an electric field strength of not more than

200 microvolts per metre at a distance of 500 metres.

**5B1** **Test, Inspection and Production Equipment**

**5B001**

a. Equipment, and specially designed components and accessories therefor, specially designed for:
   1. Development of equipment, materials, functions or features specified in 5A001, 5B001, 5C001, 5D001 or 5E001, including measuring or test equipment;
   2. Production of equipment, materials, functions or features specified in 5A001, 5B001, 5C001, 5D001 or 5E001, including measuring, test or repair equipment;
   3. Use of equipment, materials, functions or features exceeding any of the least stringent control criteria applicable in 5A001, 5B001, 5C001, 5D001 or 5E001, including measuring, repair or test equipment;

   NOTE: 5B001.a. does not control optical fibres and "optical fibre preform" characterisation equipment not using semiconductor "lasers".
b. Other equipment as follows:
   1. Bit error rate (BER) test equipment designed or modified to test the equipment specified in 5A001.b.1.;
   2. Data communication protocol analyzers, testers and simulators specially designed for functions specified in 5A001;
   3. Stand alone "stored programme controlled" radio transmission media simulators/channel estimators specially designed for testing equipment specified in 5A001.b.5.

**5C1** **Materials**

**5C001**

Preforms of glass or of any other material optimized for the manufacture of optical fibres specified in 5A001.e.

**5D1** **Software**

**5D001**

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or materials specified in 5A001, 5B001 or 5C001;

b. "Software" specially designed or modified to support "technology" specified in 5E001;

c. Specific "software" as follows:

1. "Generic software", other than in machine-executable form, specially designed or modified for the "use" of "stored programme controlled" digital switching equipment or systems;
2. "Software", other than in machine-executable form, specially designed or modified for the "use" of digital cellular radio equipment or systems;
3. "Software" specially designed or modified to provide characteristics, functions or features of equipment specified in 5A001 or 5B001;
4. "Software" which provides the capability of recovering "source code" of telecommunications "software" specified in this Category;
5. "Software" specially designed for the "development" or "production" of "software" specified in 5D001.

(For "software" for "signal processing" see also 4D. and 6D.)

**5E1** **Technology**

**5E001**

a. "Technology" according to the General Technology Note for the "development", "production" or "use" (excluding operation) of equipment, systems, materials or "software" specified in 5A001, 5B001, 5C001 or 5D001;

b. Specific technologies, as follows:

1. "Required" "technology" for the "development" or "production" of telecommunications equipment specially designed to be used on board satellites;
2. "Technology" for the "development" or "use" of laser communication techniques with the capability of automatically acquiring and tracking signals and maintaining communications through exoatmosphere or sub-surface (water) media;
3. "Technology" for the processing and application of coatings to

optical fibre specially designed to make it suitable for underwater use;

4. "Technology" for the "development" or "production" of equipment employing "Synchronous Digital Hierarchy" (SDH) or "Synchronous Optical Network" (SONET) techniques;
5. "Technology" for the "development" or "production" of "switch fabric" exceeding 64,000 bit/s per information channel other than for digital cross connect integrated in the switch;
6. "Technology" for the "development" or "production" of centralized network control;
7. "Technology" for the "development" or "production" of digital cellular radio systems;
8. "Technology" for the "development" or "production" of "Integrated Services Digital Network" (ISDN);
9. "Technology" for the "development" of QAM techniques, for radio equipment, above level 4.

**5E101** "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment specified in 5A101.

Part 2—"INFORMATION SECURITY"

NOTE: The control status of "information security" equipment, "software", systems, application specific "electronic assemblies", modules, integrated circuits, components or functions is defined in this Category even if they are components or "electronic assemblies" of other equipment.

**5A2** **Equipment, Assemblies and Components**

**5A002** Systems, equipment, application specific "electronic assemblies", modules or integrated circuits for "information security", as follows, and other specially designed components therefor:

a. Designed or modified to use "cryptography" employing digital techniques to ensure "information security";

b. Designed or modified to perform cryptanalytic functions;

c. Designed or modified to use "cryptography" employing analogue techniques to ensure "information security";

except:

1. Equipment using "fixed" band scrambling not exceeding 8 bands and in which the transpositions change not more frequently than once every second;
2. Equipment using "fixed" band scrambling exceeding 8 bands and in which the transpositions change not more frequently than once every ten seconds;
3. Equipment using "fixed" frequency inversion and in which the transpositions change not more frequently than once every second;
4. Facsimile equipment;
5. Restricted audience broadcast equipment;
6. Civil television equipment;

d. Designed or modified to suppress the compromising emanations of information-bearing signals;

NOTE: 5A002.d. does not specify equipment specially designed to suppress emanations for health or safety reasons.

e. Designed or modified to use cryptographic techniques to generate the spreading code for "spread spectrum" or the hopping code for "frequency agility" systems;

f. Designed or modified to provide certified or certifiable "multilevel security" or user isolation at a level exceeding Class B2 of the Trusted Computer System Evaluation Criteria (TCSEC) or equivalent;

g. Communications cable systems designed or modified using mechanical, electrical or electronic means to detect surreptitious intrusion.

NOTE: 5A002 does not control:

a. "Personalized smart cards" using "cryptography" restricted for use only in equipment or systems, as follows:

1. Excluded from control under 5A002.c.1. to c.6.;
2. Excluded from control under b., c. or e. of this Note;
3. a. Access control equipment, such as automatic teller machines, self-service statement printers or point of sale terminals, which protects password or personal identification numbers (PIN) or similar data to prevent unauthorised access to facilities but does not allow for encryption of files or text, except as directly related to the password or PIN protection;
   b. Data authentication equipment which calculates a Message Authentication Code (MAC) or similar result to ensure no alteration of text has taken place, or to authenticate users, but does not allow for encryption of data, text or other media other than that needed for the authentication;
   c. Cryptographic equipment specially designed, developed or modified for use in machines for banking or money transactions, such as automatic teller machines, self-service statement printers, point of sale terminals, or equipment for the encryption of interbanking transactions, and intended for use only in such applications;
   d. Portable (personal) or mobile radiotelephones for civil use, e.g., for

use with commercial civil cellular radiocommunications systems, containing encryption;

b. Equipment containing "fixed" data compression or coding techniques;

c. Receiving equipment for radio broadcast, pay television or similar restricted audience television of the consumer type, without digital encryption and where digital decryption is limited to the video, audio or management functions;

d. Portable (personal) or mobile radiotelephones for civil use, e.g., for use with commercial civil cellular radiocommunications systems, containing encryption, when accompanying their users;

e. Decryption functions specially designed to allow the execution of copy-protected "software", provided the decryption functions are not user-accessible.

**5B2** **Test, Inspection and Production Equipment**

**5B002**

a. Equipment specially designed for:

1. The development of equipment or functions specified in 5A002, 5B002, 5D002 or 5E002, including measuring or test equipment;
2. The production of equipment or functions specified in 5A002, 5B002, 5D002 or 5E002, including measuring, test, repair or production equipment;

b. Measuring equipment specially designed to evaluate and validate the "information security" functions specified in 5A002 or 5D002.

**5C2** **Materials**

NONE

**5D2** **Software**

**5D002**

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" specified in 5A002, 5B002 or 5D002;

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 or 5B002;
2. "Software" to certify "software" specified in 5D002.c.1.;
3. "Software" designed or modified to protect against malicious computer damage, e.g., viruses;

NOTE: 5D002 does not control:

a. "Software" "required" for the "use" of equipment excluded from control under the Note to 5A002;

b. "Software" providing any of the functions of equipment excluded from control under the Note to 5A002.

**5E2** **Technology**

**5E002** "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment or "software" specified in 5A002, 5B002 or 5D002.

## CATEGORY 6— SENSORS AND LASERS

**6A** **Equipment, Assemblies and Components**

**6A001** **Acoustics**

a. Marine acoustic systems, equipment or specially designed components therefor, as follows:

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

NOTE: 6A001.a.1. does not control:

a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding ± 10°, and limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;

b. Acoustic beacons, as follows:

1. Acoustic emergency beacons;
2. Pingers specially designed for relocating or returning to an underwater position.

a. Wide-swath bathymetric survey systems for sea bed topographic mapping:

1. Designed:
   a. To take measurements at an angle exceeding 10° from the vertical; and
   b. To measure depths exceeding 600 m below the water surface; and
2. Designed:
   a. To incorporate multiple beams any of which is less than 2°; or
   b. To provide data accuracies of better than 0.5% of water depth across the swath averaged over the individual measurements within the swath;

b. Object detection or location systems having any of the following:

1. A transmitting frequency below 10 kHz;
2. Sound pressure level exceeding 224 dB (reference 1 micropascal 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 micropascal 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 withstand pressure during normal operation at depths exceeding 1,000 m and having transducers:
    a. Dynamically compensated for pressure; or
    b. Incorporating other than lead zirconate titanate as the transduction element; or
6. Designed to operate with an unambiguous display range exceeding 5,120 m;

c. Acoustic projectors, including transducers, incorporating piezoelectric, magnetostrictive, electrostrictive, electrodynamic or hydraulic elements operating individually or in a designed combination, having any of the following:

    NOTES:

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

2. 6A001.a.1.c. does not control sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosives) sources.

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

   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. Designed to withstand pressure during normal operation at depths exceeding 1,000 m; or
4. Side-lobe suppression exceeding 22 dB;

d. Acoustic systems, equipment and specially designed components for determining the position of surface vessels or underwater vehicles designed:

NOTES: 6A001.a.1.d. includes equipment using coherent "signal processing" between two or more beacons and the hydrophone unit carried by the surface vessel or underwater vehicle, or capable of automatically correcting speed-of-sound propagation errors for calculation of a point.

1. To operate at a range exceeding 1,000 m with a positioning accuracy of less than 10 m rms (root mean square) when measured at a range of 1,000 m; or
2. To withstand pressure at depths exceeding 1,000 m;

2. Passive (receiving, whether or not related in normal application to separate active equipment) systems, equipment or specially designed components therefor, as follows:
   a. Hydrophones (transducers) with any of the following characteristics:
      1. Incorporating continuous flexible sensors or assemblies of discrete sensor elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;
      2. Having any of the following sensing elements:
         a. Optical fibres;
         b. Piezoelectric polymers; or
         c. Flexible piezoelectric ceramic materials;
      3. Hydrophone sensitivity better than 180 dB at any depth with no acceleration compensation;
      4. When designed to operate at depths not exceeding 35 m, hydrophone sensitivity better than −186 dB with acceleration compensation;

5. When designed for normal operation at depths exceeding 35 m, hydrophone sensitivity better than −192 dB with acceleration compensation;
6. When designed for normal operation at depths exceeding 100 m, hydrophone sensitivity better than −204 dB; or
7. Designed for operation at depths exceeding 1,000 m;

   Technical Note: Hydrophone sensitivity is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydrophone sensor, without a pre-amplifier, is placed in a plane wave acoustic field with an rms pressure of 1 micropascal. For example, a hydrophone of −160 dB (reference 1 V per micropascal) 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 with any of the following:
   1. Hydrophone group spacing of less than 12.5 m;
   2. Hydrophone group spacing of 12.5 m to less than 25 m and designed or able to be modified to operate at depths exceeding 35 m; or

Technical Note: 'Able to be modified' in 6A001.a.2.b.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. Hydrophone group spacing of 25 m or more and designed to operate at depths exceeding 100 m;
4. Heading sensors controlled by 6A001.a.2.d.;
5. Non-metallic strength members or longitudinally reinforced array hoses;
6. An assembled array of less than 40 mm in diameter;
7. Multiplexed hydrophone group signals; or
8. Hydrophone characteristics specified in 6A001.a.2.a.;

c. Processing equipment, specially designed for towed acoustic hydrophone arrays, with either of the following:
   1. A Fast Fourier or other transform of 1,024 or more complex points in less than 20 ms with no "user-accessible programmability"; or
   2. Time or frequency domain processing and

correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes with “user-accessible programmability”;

d. Heading sensors having an accuracy of better than ±0.5°; and

1. Designed to be incorporated within the array hosing and to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35m; or
2. Designed to be mounted external to the array hosing and having a sensor unit capable of operating with 360° roll at depths exceeding 35 m;

b. Terrestrial geophones capable of conversion for use in marine systems, equipment or specially designed components specified in 6A001.a.2.a.;

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

**6A002** **Optical sensors**

N.B.: SEE ALSO 6A102.

a. Optical detectors, as follows:

NOTE: 6A002.a. does not control germanium or silicon photodevices.

1. “Space-qualified” solid-state detectors having any of the following:

a. 1. A peak response in the wavelength range exceeding 10 nm but not exceeding 300 nm; and

2. A response of less than 0.1% relative to the peak response at a wavelength exceeding 400 nm;

b. 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; or

c. A peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

2. Image intensifier tubes and specially designed components therefor, as follows:

a. Image intensifier tubes having all of the following:

1. A peak response in the wavelength range exceeding 400 nm but not exceeding 1,050 nm;

2. A microchannel plate for electron image amplification with a hole pitch (centre-to-centre spacing) of less than 25 micrometres; and

3. a. An S-20, S-25 or multialkali photocathode; or

b. A GaAs or GaInAs photocathode;

b. Specially designed components, as follows:

1. Fibre optic image inverters;

2. Microchannel plates having both of the following characteristics:

a. 1,5000 or more hollow tubes per plate; and

b. Hole pitch (centre-to-centre spacing) of less than 25 micrometres;

3. GaAs or GaInAs photocathodes;

3. Non-“space-qualified” “focal plane arrays”, having any of the following:

Technical Note: Linear or two-dimensional multi-element detector arrays are referred to as “focal plane arrays”.

NOTES:

1. 6A002.a.3. includes photoconductive arrays and photovoltaic arrays.
2. 6A002.a.3. does not specify silicon “focal plane arrays”, multi-element (not to exceed 16 elements) encapsulated photoconductive cells or pyroelectric detectors using any of the following:
   - a. Lead sulphide;
   - 2 b. Triglycine sulphate and variants;
   - c. Lead-lanthanum-zirconium titanate and variants;
   - d. Lithium tantalate;
   - e. Polyvinylidene fluoride and variants;
   - f. Strontium barium niobate and variants; or
   - g. Lead selenide.

a. 1. Individual elements with a peak response within the wavelength range exceeding 900 nm but not exceeding 1,050 nm; and

2. A response “time constant” of less than 0.5 ns;

b. 1. Individual elements with a peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,200 nm; and

2. A response “time constant” of 95 ns or less; or

c. Individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

4. Non-“space-qualified” single-element or non-focal-plane multi-element semiconductor photodiodes or phototransistors having both of the following:

a. A peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm; and

b. A response “time constant” of 0.5 ns or less;

b. “Multispectral imaging sensors” designed for remote sensing applications, having either of the following characteristics:

1. An Instantaneous-Field-Of-View (IFOV) of less than 200 microradians; or

2. Specified for operation in the wavelength range exceeding 400 nm but not exceeding 30,000 nm; and

a. Providing output imaging data in digital format; and

b. 1. “Space-qualified”; or

2. Designed for airborne operation, using other than silicon detectors, and having an IFOV of less than 2.5 milliradians;

c. Direct view imaging equipment operating in the visible or infrared spectrum, incorporating either of the following:

1. Image intensifier tubes specified in 6A002.a.2.; or

2. “Focal plane arrays” specified in 6A002.a.3.;

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

NOTE: 6A002.c. does not specify the following equipment incorporating other than GaAs or GaInAs photocathodes:

a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;

b. Medical equipment;

c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;

d. Flame detectors for industrial furnaces;

e. Equipment specially designed for laboratory use.

d. Special support components for optical sensors, as follows:

1. “Space-qualified” cryocoolers;

2. Non-“space-qualified” cryocoolers with a cooling source temperature below 218 K (−55°C), as follows:

a. Closed cycle 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 with bore (outside) diameters of less than 8 mm;

3. Optical sensing fibres:

a. Specially fabricated either compositionally or structurally, or modified by coating, to be acoustically, thermally, inertially, electromagnetically or nuclear radiation sensitive; or

b. Modified structurally to have a “beat length” of less than 50 mm (high birefringence).

**6A003** **Cameras**

N.B.: SEE ALSO 6A203.

a. Instrumentation cameras, as follows:
   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 per second;
      NOTE: 6A003.a.1. does not control cinema recording cameras for normal civil purposes.
   2. Mechanical high speed cameras, in which the film does not move, capable of recording at rates exceeding 1,000,000 frames per second 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 with writing speeds exceeding 10 mm per microsecond;
   4. Electronic framing cameras having a speed exceeding 1,000,000 frames per second;
   5. Electronic cameras having:
      a. An electronic shutter speed (gating capability) of less than 1 microsecond per full frame; and
      b. A read out time allowing a framing rate of more than 125 full frames per second;

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 any of the following:
      a. More than $4 \times 10^6$ “active pixels” per solid state array for monochrome (black and white) cameras;
      b. More than $4 \times 10^6$ “active pixels” per solid state array for colour cameras incorporating three solid state arrays; or

c. More than $12 \times 10^6$ "active pixels" for solid state array colour cameras incorporating one solid state array;

2. Scanning cameras and scanning camera systems:
   a. Incorporating linear detector arrays with more than 8,192 elements per array; and
   b. Having mechanical scanning in one direction;
3. Incorporating image intensifiers specified in 6A002.a.2.a.;
4. Incorporating focal plane arrays specified in 6A002.a.3.;

N.B.: For cameras specially designed or modified for underwater use, see 8A002.d. and 8A002.e.

**6A004** **Optics**

a. Optical mirrors (reflectors), as follows:
   1. "Deformable mirrors" with 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 with an average "equivalent density" of less than 30 kg/m$^2$ and a total weight exceeding 10 kg;
   3. Lightweight "composite" or foam mirror structures with an average "equivalent density" of less than 30 kg/m$^2$ and a total weight 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) with 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 either of the following:
   1. Exceeding 100cm$^3$ in volume; or

2. Exceeding 80 mm in diameter or length of major axis and 20 mm in thickness (depth);

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

1. Lightweighted to less than 20% "equivalent density" compared with a solid blank of the same aperture and thickness;
2. Substrates, substrates with surface coatings (single-layer or multi-layer, metallic or dielectric, conducting, semiconducting or insulating) or with protective films;
3. Segments or assemblies of mirrors designed to be assembled in space into an optical system with a collecting aperture equivalent to or larger than a single optic 1 metre in diameter;
4. 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 filters, as follows:

1. For wavelengths longer than 250 nm, comprised of multi-layer optical coatings and having either of the following:
   a. Bandwidths equal to or less than 1 nm Full Width Half Intensity (FWHI) and peak transmission of 90% or more; or
   b. Bandwidths equal to or less than 0.1 nm FWHI and peak transmission of 50% or more;

   NOTE: 6A004.d.1. does not control optical filters with fixed air gaps or Lyot-type filters.
2. For wavelengths longer than 250 nm, having all of the following:
   a. Tunable over a spectral range of 500 nm or more;
   b. Instantaneous optical bandpass of 1.25 nm or less;
   c. Wavelength resettable within 0.1 ms to an accuracy of 1 nm or better within the tunable spectral range; and

d. A single peak transmission of 91% or more;

3. Optical opacity switches (filters) with a field of view of 30° or wider and a response time equal to or less than 1 ns;

e. Optical control equipment, as follows:

1. Specially designed to maintain the surface figure or orientation of the “space-qualified” components specified in 6A004.c.1. or 3.;
2. Having steering, tracking, stabilization or resonator alignment bandwidths equal to or more than 100 Hz and an accuracy of 10 microradians or less;
3. Gimbals having a maximum slew exceeding 5°, a bandwidth equal to or more than 100 Hz, and either of the following:

a. 1. Exceeding 0.15 m but not exceeding 1 m in diameter or major axis length;

2. Capable of angular accelerations exceeding 2 radians/$s^2$; and

3. Having angular pointing errors equal to or less than 200 microradians; or

b. 1. Exceeding 1 m in diameter or major axis length;

2. Capable of angular accelerations exceeding 0.5 radians/$s^2$; and

3. Having angular pointing errors equal to or less than 200 microradians;

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;

f. “Fluoride fibre” cable, or optical fibres therefor, having an attenuation of less than 4 dB/km in the wavelength range exceeding 1,000 nm but not exceeding 3,000 nm.

**6A005** “Lasers”, components and optical equipment, as follows:

N.B.: SEE ALSO 6A205.

1. NOTES: Pulsed "lasers" include those that run in a continuous wave (CW) mode with pulses superimposed.
2. Pulse-excited "lasers" include those that run in a continuously excited mode with pulse excitation superimposed.
3. The control status of Raman "lasers" is determined by the parameters of the pumping source "lasers". The pumping source "lasers" can be any of the "lasers" described below.

a. Gas "lasers", as follows:
    1. Excimer "lasers" having any of the following:
        a. An output wavelength not exceeding 150 nm and:
            1. An output energy exceeding 50 mJ per pulse; or
            2. An average or CW output power exceeding 1 W;
        b. An output wavelength exceeding 150 nm but not exceeding 190 nm and:
            1. An output energy exceeding 1.5 J per pulse; or
            2. An average or CW output power exceeding 120 W;
        c. An output wavelength exceeding 190 nm but not exceeding 360 nm and:
            1. An output energy exceeding 10 J per pulse; or
            2. An average or CW output power exceeding 500 W; or
        d. An output wavelength exceeding 360 nm and:
            1. An output energy exceeding 1.5 J per pulse; or
            2. An average or CW output power exceeding 30 W;
    2. Metal vapour "lasers", as follows:
        a. Copper (Cu) "lasers" with an average or CW output power exceeding 20 W;

b. Gold (Au) “lasers” with an average or CW output power exceeding 5 W;
c. Sodium (Na) “lasers” with an output power exceeding 5 W;
d. Barium (Ba) “lasers” with an average or CW output power exceeding 2 W;

3. Carbon monoxide (CO) “lasers” having either:
   a. An output energy exceeding 2 J per pulse and a pulsed “peak power” exceeding 5 kW; or
   b. An average or CW output power exceeding 5 kW;
4. Carbon dioxide ($CO_2$) “lasers” having any of the following:
   a. A CW output power exceeding 10 kW;
   b. A pulsed output with a “pulse duration” exceeding 10 microseconds and:
      1. An average output power exceeding 10 kW; or
      2. A pulsed “peak power” exceeding 100 kW; or
   c. A pulsed output with a “pulse duration” equal to or less than 10 microseconds and:
      1. A pulse energy exceeding 5 J per pulse and “peak power” exceeding 2.5 kW; or
      2. An average output power exceeding 2.5 kW;
5. “Chemical lasers”, as follows:
   a. Hydrogen Fluoride (HF) “lasers”;
   b. Deuterium Fluoride (DF) “lasers”;
   c. “Transfer lasers”:
      1. Oxygen Iodine ($O_2$-I) “lasers”;
      2. Deuterium Fluoride-Carbon dioxide (DF-$CO_2$) “lasers”;
6. Gas discharge and ion “lasers”, i.e., krypton ion or argon ion “lasers”, as follows:
   a. An output energy exceeding 1.5 J per pulse and a pulsed

"peak power" exceeding 50 W; or

b. An average or CW output power exceeding 50 W; or

7. Other gas "lasers", except nitrogen "lasers", having any of the following:

a. An output wavelength not exceeding 150 nm and:

1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

2. An average or CW output power exceeding 1 W;

b. An output wavelength exceeding 150 nm but not exceeding 800 nm and:

1. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or

2. An average or CW output power exceeding 30 W;

c. An output wavelength exceeding 800 nm but not exceeding 1,400 nm and:

1. An output energy exceeding 0.25 J per pulse and a pulsed "peak power" exceeding 10 W; or

2. An average or CW output power exceeding 10 W; or

d. An output wavelength exceeding 1400 nm and an average or CW output power exceeding 1 W;

b. Semiconductor "lasers", as follows:

Technical Note: Semiconductor "lasers" are commonly called "laser" diodes.

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

1. Individual, single-transverse mode semiconductor "lasers" having:
   a. An average output power exceeding 100 mW; or
   b. A wavelength exceeding 1,050 nm;
2. Individual, multiple-transverse mode semiconductor "lasers", or arrays of individual semiconductor "lasers", having:
   a. An output energy exceeding 500 microjoules per pulse and a pulsed "peak power" exceeding 10 W;
   b. An average or CW output power exceeding 10 W; or
   c. A wavelength exceeding 1050 nm;

c. Solid state "lasers", as follows:
   1. "Tunable" "lasers" having any of the following:

      NOTE: 6A005.c.1. includes titanium-sapphire (Ti: $Al_2O_3$), thulium-YAG (Tm: YAG), thulium-YSGG (Tm: YSGG), alexandrite (Cr: $BeAl_2O_4$) and colour centre "lasers".
      a. An output wavelength less than 600 nm and:
         1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
         2. An average or CW output power exceeding 1 W;
      b. An output wavelength of 600 nm or more but not exceeding 1,400 nm and:
         1. An output energy exceeding 1 J per pulse and a pulsed "peak power" exceeding 20 W; or
         2. An average or CW output power exceeding 20 W; or
      c. An output wavelength exceeding 1,400 nm and:
         1. An output energy exceeding 50 mJ per

pulse and a pulsed "peak power" exceeding 1 W; or

2. An average or CW output power exceeding 1 W;

2. Non-"tunable" "lasers", as follows:

NOTE: 6A005.c.2. includes atomic transition solid state "lasers".

a. Ruby "lasers" having an output energy exceeding 20 J per pulse;

b. Neodymium glass "lasers", as follows:

1. "Q-switched lasers" having:

a. An output energy exceeding 20 J but not exceeding 50 J per pulse and an average output power exceeding 10 W; or

b. An output energy exceeding 50 J per pulse;

2. Non-"Q-switched lasers" having:

a. An output energy exceeding 50 J but not exceeding 100 J per pulse and an average output power exceeding 20 W; or

b. An output energy exceeding 100 J per pulse;

c. Neodymium-doped (other than glass) "lasers", as follows, with an output wavelength exceeding 1,000 nm but not exceeding 1,100 nm:

NOTE: For Neodymium-doped (other than glass) "lasers" having an output wavelength not exceeding 1,000 nm or exceeding 1,100 nm, see 6A005.c.2.d.

1. Pulse excited, mode-locked, "Q-switched lasers" with a "pulse duration" of less than 1 ns and:
   a. A "peak power" exceeding 5 GW;
   b. An average output power exceeding 10 W; or
   c. A pulsed energy exceeding 0.1 J;
2. Pulse-excited, "Q-switched lasers", with a pulse duration equal to or more than 1 ns, and:
   a. A single-transverse mode output with:
      1. A "peak power" exceeding 100 MW;
      2. An average output power exceeding 20 W; or
      3. A pulsed energy exceeding 2 J; or
   b. A multiple-transverse mode output with:
      1. A "peak power" exceeding 200 MW;
      2. An average output power exceeding 50 W; or
      3. A pulsed energy exceeding 2 J;
3. Pulse-excited, non-"Q-switched lasers", having:
   a. A single-transverse mode output with:
      1. "peak power" exceeding 500 kW; or

2. An average output power exceeding 150 W; or

b. A multiple-transverse mode output with:

1. A “peak power” exceeding 1 MW; or

2. An average power exceeding 500 W;

c. Continuously excited “lasers” having:

a. A single-transverse mode output with:

1. A “peak power” exceeding 500 kW; or

2. An average or CW output power exceeding 150 W; or

b. A multiple-transverse mode output with:

1. A “peak power” exceeding 1 MW; or

2. An average or CW output power exceeding 500 W;

4. Other non-“tunable” “lasers”, having any of the following:
   1. A wavelength less than 150 nm and:
      a. An output energy exceeding 50 mJ per pulse and a pulsed “peak power” exceeding 1 W; or
      b. An average or CW output power exceeding 1 W;
   2. A wavelength of 150 nm or more but not exceeding 800 nm and:
      a. An output energy exceeding 1.5 J per pulse and a pulsed “peak power” exceeding 30 W; or
      b. An average or CW output power exceeding 30 W;
   3. A wavelength exceeding 800 nm but not exceeding 1,400 nm, as follows:
      a. “Q-switched lasers” with:
         1. An output energy exceeding 0.5 J per pulse and a pulsed

"peak power" exceeding 50 W; or

2. An average output power exceeding: 10 W for single-mode "lasers"; 30 W for multimode "lasers";

b. Non-"Q-switched lasers" with:

1. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 50 W; or

2. An average or CW output power exceeding 50 W; or

4. A wavelength exceeding 1,400 nm and:

a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

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

pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

4. Free electron "lasers";
5. 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";
6. Optical equipment, as follows:
   1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront with:
      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 1000 Hz and phase discrimination of at least 20% of the beam's wavelength;
   2. "Laser" diagnostic equipment capable of measuring "Super-High Power Laser" (SHPL) system angular beam steering errors of equal to or less than 10 microradians;
   3. Optical equipment, assemblies or 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 micrometre, whichever is the smaller;

4. Projection telescopes specially designed for use with SHPL systems.

NOTE: For shared aperture optical elements capable of operating in SHPL applications, see the Military Goods Controls.

**6A006** "Magnetometers", "magnetic gradiometers", "intrinsic magnetic gradiometers" and compensation systems, and specially designed components therefor, as follows:

NOTE: 6A006 does not control instruments specially designed for biomagnetic measurements for medical diagnostics, unless they incorporate unembedded sensors specified in 6A006.h.

a. "Magnetometers" using "superconductive", optically pumped or nuclear precession (proton/Overhauser) technology having a "noise level" (sensitivity) lower (better) than 0.05 nT rms per square root Hz;
b. Induction coil "magnetometers" having a "noise level" (sensitivity) lower (better) than:
    1. 0.05 nT rms per square root Hz at frequencies of less than 1 Hz;
    2. $1 \times 10^{-3}$ nT rms per square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; or
    3. $1 \times 10^{-4}$ nT rms per square root Hz at frequencies exceeding 10 Hz;
c. Fibre optic "magnetometers" having a "noise level" (sensitivity) lower (better) than 1 nT rms per square root Hz;
d. "Magnetic gradiometers" using multiple "magnetometers" specified in 6A006.a., b. or c.;
e. Fibre optic "intrinsic magnetic gradiometers" having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.3 nT/m rms per square root Hz;

f. "Intrinsic magnetic gradiometers", using technology other than fibre-optic technology, having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.015 nT/m rms per square root Hz;

g. Magnetic compensation systems for magnetic sensors designed for operation on mobile platforms;

h. "Superconductive" electromagnetic sensors, containing components manufactured from "superconductive" materials, as follows:

   1. Designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents (including Josephson effect devices or "superconductive" quantum interference devices (SQUIDS));
   2. Designed for sensing electromagnetic field variations at frequencies of 1 kHz or less; and
   3. Having any of the following characteristics:
      a. Incorporating thin-film SQUIDS with a minimum feature size of less than 2 micrometres and with associated input and output coupling circuits;
      b. Designed to operate with a magnetic field slew rate exceeding $1 \times 10^6$ magnetic flux quanta per second;
      c. Designed to function without magnetic shielding in the earth's ambient magnetic field; or
      d. Having a temperature coefficient less (smaller) than 0.1 magnetic flux quantum/K.

**6A007** Gravity meters (gravimeters) and gravity gradiometers, as follows:

N.B.: SEE ALSO 6A107.

a. Gravity meters for ground use having a static accuracy of less (better) than 10 microgal;

NOTE: 6A007.a. does not control ground gravity meters of the quartz element (Worden) type.

b. Gravity meters for mobile platforms for ground, marine, submersible, space or airborne use having:
   1. A static accuracy of less (better) than 0.7 milligal; and
   2. An in-service (operational) accuracy of less (better) than 0.7 milligal with a time-to-steady-state registration of less than 2 minutes under any combination of attendant corrective compensations and motional influences;

c. Gravity gradiometers.

**6A008** Radar systems, equipment and assemblies having any of the following characteristics, and specially designed components therefor:

N.B.: SEE ALSO 6A108.

NOTE: 6A008 does not specify:

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

a. Operating at frequencies from 40 GHz to 230 GHz and having an average output power exceeding 100 mW;
b. Having a tunable bandwidth exceeding + 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) or sidelooking airborne (SLAR) radar mode;
e. Incorporating “electronically steerable phased array antennae”;
f. Capable of heightfinding non-cooperative targets;

NOTE: 6A008.f. does not specify precision approach radar equipment (PAR) conforming with ICAO standards.;

g. Designed specially for airborne (balloon or airframe mounted) operation and having Doppler signal processing for the detection of moving targets;

h. Employing processing of radar signals using:
   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 "software" specially designed for the "use" thereof, provided:
      1. It has a maximum "instrumented range" of 500 km or less;
      2. It is configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres;
      3. It contains no provisions for remote control of the radar scan rate from the enroute ATC centre; and
      4. It is to be permanently installed.

   N.B. The "use" "software" must be limited to "object code" and the minimum amount of "source code" necessary for installation, operation or maintenance.

j. "Laser" radar or Light Detection and Ranging (LIDAR) equipment, having either of the following:
   1. "Space-qualified"; or
   2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 microradians;

NOTE: 6A008.j. does not specify LIDAR equipment specially designed for surveying or for meteorological observation.

k. Having signal processing sub-systems using "pulse compression" with:
   1. A "pulse compression" ratio exceeding 150; or
   2. A pulse width of less than 200 ns; or

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

      NOTE: 6A008.l.1. does not specify conflict alert capability in ATC systems, or marine or harbour radar.
   2. Calculation of target velocity from primary radar having non-periodic (variable) scanning rates;
   3. Processing for automatic pattern recognition (feature extraction) and comparison with target characteristic data bases (waveforms or imagery) to identify or classify targets; or
   4. Superposition and correlation, or fusion, of target data from two or more "geographically dispersed" and "interconnected radar sensors" to enhance and discriminate targets.

      NOTE: 6A008.l.4. does not specify systems, equipment and assemblies used for marine traffic control.

**6A102**

Radiation hardened detectors, other than those specified in 6A002, for use in 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 (Si).

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.

**6A107** Specially designed components for gravity meters and gravity gradiometers specified in 6A007.b. and 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 systems specified in 9A004 or 9A104;
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 3 milliradians (0.5 mils);
        b. Range of 30 km or greater with a range resolution better than 10 m rms;
        c. Velocity resolution better than 3 m/s.

**6A202** Photomultiplier tubes with a photocathode area of greater than 20 $cm^2$ having an anode pulse rise time of less than 1 ns.

**6A203** Cameras and components, other than those specified in 6A003, as follows:

a. Mechanical rotating mirror cameras and specially designed components therefor, as follows:
    1. Mechanical framing cameras with recording rates greater than 225,000 frames per second;
    2. Streak cameras with writing speeds greater than 0.5 mm per microsecond;

    Technical Note: Components of such cameras include specially designed synchronizing electronics and specially designed rotor assemblies (consisting of turbines, mirrors and bearings).

b. Electronic streak and framing cameras and tubes, as follows:
   1. Electronic streak cameras capable of 50 ns or less time resolution and streak tubes therefor;
   2. Electronic (or electronically shuttered) framing cameras capable of 50 ns or less frame exposure time;
   3. Framing tubes and solid-state imaging devices for use with cameras specified in 6A203.b.2., as follows:
      a. Proximity focused image intensifier tubes having the photocathode deposited on a transparent conductive coating to decrease photocathode sheet resistance;
      b. Gate silicon intensifier target (SIT) videcon tubes, where a fast system allows gating the photoelectrons from the photocathode before they impinge on the SIT plate;
      c. Kerr or pockel cell electro-optical shuttering; or
      d. Other framing tubes and solid-state imaging devices having a fast-image gating time of less than 50 ns specially designed for cameras specified in 6A203.b.2.

c. Radiation-hardened TV cameras specially designed or rated as radiation hardened to withstand greater than $5 \times 10^4$ grays (Si)($5 \times 10^6$ rad (Si)) without operational degradation and specially designed lenses used therein.

**6A205** “Lasers”, other than those specified in 6A005, as follows:

a. Argon ion lasers with greater than 40 W average output power operating at wavelengths between 400 nm and 515 nm;

b. Tunable pulsed single-mode dye oscillators capable of an average power output of greater than 1 W, a repetition rate greater than 1 kHz, a pulse less than 100 ns, and a wavelength between 300 nm and 800 nm;

c. Tunable pulsed dye laser amplifiers and oscillators, with an average power output of greater than 30W, a repetition rate greater than 1 kHz, a pulse width less than 100 ns, and a wavelength between 300 nm and 800 nm;

except:

Single mode oscillators;

d. Pulsed carbon dioxide lasers with a repetition rate greater than 250 Hz, an average power output of greater than 500 W, and a pulse of less than 200 ns operating at wavelengths between 9000 nm and 11000 nm;

e. Para-hydrogen Raman shifters designed to operate at 16 micrometre output wavelength and at a repetition rate greater than 250 Hz.

**6A225** Velocity interferometers for measuring velocities in excess of 1 km/s during time intervals of less than 10 microsecond (VISARs, Doppler laser interferometers (DLIs), etc.).

**6A226** Pressure sensors, as follows:

a. Manganin gauges for pressures greater than 100 kilobars; or

b. Quartz pressure transducers for pressures greater than 100 kilobars.

**6B** Test, Inspection and Production Equipment

**6B004**

a. Equipment for measuring absolute reflectance to an accuracy of +0.1% of the reflectance value;

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

NOTE: 6B004 does not control microscopes.

**6B005** Specially designed or modified equipment, including tools, dies, fixtures or gauges, as follows, and other specially designed components and accessories therefor:

a. For the manufacture or inspection of:

1. Free electron "laser" magnet wigglers;
2. Free electron "laser" photo injectors;

b. For the adjustment, to required tolerances, of the longitudinal magnetic field of free electron "lasers".

**6B007** Equipment to produce, align and calibrate land-based gravity meters with a static accuracy of better than 0.1 milligal.

**6B008** Pulse radar cross-section measurement systems having transmit pulse widths of 100 ns or less and specially designed components therefor.

**6B108** Systems specially designed for radar cross section measurement usable for "missiles" and their subsystems.

**6C** **Materials**

**6C002** Optical Sensors:

a. Elemental tellurium (Te) of purity levels equal to or more than 99.9995%;

b. Single crystals of cadmium telluride (CdTe), cadmium zinc telluride (CdZnTe) or mercury cadmium telluride (HgCdTe) of any purity level, including epitaxial wafers thereof;

c. "Optical fibre preforms" specially designed for the manufacture of high birefringence fibres specified in 6A002.d.3.

**6C004** Optics:

1. Zinc selenide (ZnSe) and zinc sulphide (ZnS) "substrate blanks" produced by the chemical vapour deposition process:
   1. Larger than 100 $cm^3$ in volume; or
   2. Larger than 80 mm in diameter with a thickness equal to or more than 20 mm;
2. Boules of the following electro-optic materials:
   1. Potassium titanyl arsenate (KTA);
   2. Silver gallium selenide ($AgGaSe_2$); or
   3. Thallium arsenic selenide ($Tl_3AsSe_3$, also known as TAS);
3. Non-linear optical materials having:
   1. Third order susceptibility (chi 3) equal to or less than 1 $W/m^2$; and
   2. A response time of less than 1 ms;

4. “Substrate blanks” of silicon carbide or beryllium beryllium (Be/Be) deposited materials exceeding 300 mm in diameter or major axis length;
5. Low optical absorption materials, as follows:
    1. Bulk fluoride compounds containing ingredients with a purity of 99.999% or better;

       NOTE: 6C004.e.1. specifies fluorides of zirconium or aluminium and variants.
    2. Bulk fluoride glass made from compounds specified in 6C004.e.1.;
6. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride ($ZrF_4$) and hafnium fluoride ($HfF_4$) with:
    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 $5 \times 10^{-6}$;
7. Synthetically produced diamond material with an absorption of less than $10^{-5}$ $cm^{-1}$ for wavelengths exceeding 200 nm but not exceeding 14,000 nm;
8. “Optical fibre preforms” made from bulk fluoride compounds containing ingredients with a purity of 99.999% or better, specially designed for the manufacture of “fluoride fibres” specified in 6A004.f.

**6C005** Synthetic crystalline “laser” host material in unfinished form, as follows:
a. Titanium doped sapphire;
b. Alexandrite.

**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., or 6A008 or 6B008.

**6D003** Other “software”, as follows:
a. 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;

b. 1. "Software" specially designed for magnetic compensation systems for magnetic sensors designed to operate on mobile platforms;
2. "Software" specially designed for magnetic anomaly detection on mobile platforms;

c. "Software" specially designed to correct motional influences of gravity meters or gravity gradiometers;

d. 1. Air Traffic Control "software" application "programmes" hosted on general purpose computers located at Air Traffic Control centres and capable of any of the following:
   a. Processing and displaying more than 150 simultaneous "system tracks";
   b. Accepting radar target data from more than four primary radars; or
   c. Automatically handing over primary radar target data (if not correlated with secondary surveillance radar (SSR) data) from the host ATC centre to another ATC centre;
2. "Software" for the design or "production" of radomes which:
   a. Are specially designed to protect the "electronically steerable phased array antennae" specified in 6A008.e.; and
   b. Limit the average side-lobe level increase by less than 13 dB for frequencies equal to or higher than 2 GHz.

**6D102** "Software" specially designed for the "use" of goods specified in 6A108.

**6D103** "Software" which processes post-flight, recorded data, obtained from the systems specified in 6A108.b., enabling determination of vehicle position throughout its flight path.

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| **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. 1. Optical surface coating and treatment “technology” required to achieve uniformity of 99.5% or better for optical coatings 500 mm or more in diameter or major axis length and with a total loss (absorption and scatter) of less than $5 \times 10^{-3}$;

2. Optical fabrication technologies, as follows:

a. For serially producing optical components at a rate exceeding 10 $m^2$ of surface area per year on any single spindle and with:

1. An area exceeding 1 $m^2$; and
2. A surface figure exceeding lambda/10 rms at the designed wavelength;

b. Single point diamond turning techniques producing surface finish accuracies of better than 10 nm rms on non-planar surfaces exceeding 0.5 $m^2$;

(N.B.: See also 2E003.d.)

b. 1. “Technology” for optical filters with a bandwidth equal to or less than 10 nm, a field of view (FOV) exceeding 40° and a resolution exceeding 0.75 line pairs per milliradian;

2. “Technology” “required” for the “development”, “production” or “use” of specially designed diagnostic instruments or targets in test facilities for “Super High Power Lasers” (SHPL) testing or testing or

evaluation of materials irradiated by SHPL beams;

c. “Technology” “required” for the “development” or “production” of fluxgate “magnetometers” or fluxgate “magnetometer” systems having a noise level:
   1. Less than 0.05 nT rms per square root Hz at frequencies of less than 1 Hz; or
   2. $1 \times 10^{-3}$ nT rms per square root Hz at frequencies of 1 Hz or more.

**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: This item 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.1.c., 6A005.a.2.a., 6A005.c.1.b., 6A005.c.2.c.2., 6A005.c.2.d.2.b., 6A202, 6A203, 6A205, 6A225 or 6A226.

## Category 7 NAVIGATION AND AVIONICS

**7A** **Equipment, Assemblies and Components**

**7A001** Accelerometers designed for use in inertial navigation or guidance systems and having any of the following characteristics, and specially designed components therefor:

N.B.: SEE ALSO 7A101.

a. A “bias” “stability” of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year;

b. A “scale factor” “stability” of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year;

c. Specified to function at linear acceleration levels exceeding 100 g;

**7A002** Gyros having any of the following characteristics, and specially designed components therefor:

N.B.: SEE ALSO 7A102.

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

**7A003** Inertial navigation systems (gimballed and strapdown) and inertial equipment for attitude, guidance or control having any of the following characteristics, and specially designed components therefor:

N.B.: SEE ALSO 7A103.

a. For “aircraft”:
   1. Navigation error (free inertial) of 0.8 nautical mile per hour (50% Circular Error Probable (CEP)) or less (better) subsequent to normal alignment;
   2. Not certified for use on “civil aircraft” by “civil aviation authorities”; or
   3. Specified to function at linear acceleration levels exceeding 10 g;
b. For land or “spacecraft”:
   1. Navigation error (free inertial) of 0.8 nautical mile per hour (50% CEP) or less (better) subsequent to normal alignment; or
   2. Specified to function at linear acceleration levels exceeding 10 g.

**7A004** Gyro-astro compasses, and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, with an azimuth accuracy of equal to or less (better) than 5 seconds of arc.

N.B.: SEE ALSO 7A104.

**7A005** Global Positioning Satellite (GPS) receiving equipment having either of the following characteristics, and specially designed components therefor:

N.B.: SEE ALSO 7A105.

a. Employing encryption/decryption; or
b. A null-steerable antenna;

**7A006** Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz inclusive, having either of the following characteristics:

N.B.: SEE ALSO 7A106.
a. 7A106 Power Management; or
b. Using phase shift key modulation.

(For automatic pilots of underwater vehicles, see category 8, for radar, see Category 6.)

**7A101** Accelerometers, other than those specified in entry 7A001, with a threshold of 0.05 g or less, or a linearity error within 0.25% of full scale output, or both, which are designed for use in inertial navigation systems or in guidance systems of all types and specially designed components therefor.

NOTE: 7A101 does not specify accelerometers which are specially designed and developed as MWD (Measurement While Drilling) Sensors for use in downhole well service operations.

**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.

**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 specified in 7A001, 7A002, 7A101 or 7A102 and systems incorporating such equipment;
b. Integrated flight instrument systems, which include gyrostabilisers or automatic pilots, designed or modified for use in systems specified in 9A004 or 9A104.

**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** Global Positioning Systems (GPS) or similar satellite receivers, other than those specified

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| | in 7A005, capable of providing navigation information under the following operational conditions and designed or modified for use in systems specified in 9A004 or 9A104;<br>a. At speeds in excess of 515 m/s; and<br>b. At altitudes in excess of 18 km. |
| **7A106** | Altimeters, other than those specified in 7A006, of radar or laser radar type, designed or modified for use in systems specified in 9A004 or 9A104. |
| **7A115** | Passive sensors for determining bearing to specific electromagnetic source (direction finding equipment) or terrain characteristics, designed or modified for use in systems specified in 9A004 or 9A104.<br><br>NOTE: This item includes sensors for the following equipment:<br>a. Terrain contour mapping equipment;<br>b. Imaging sensor equipment;<br>c. Interferometer equipment. |
| **7A116** | Flight control systems, as follows; designed or modified for systems specified in 9A004 or 9A104:<br>a. Hydraulic, mechanical, electro-optical, electro-mechanical or fly by wire types;<br>b. Attitude control equipment. |
| **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. except: equipment for Maintenance Level I or Maintenance Level II.<br>Technical Notes:<br>1. Maintenance Level I<br>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.<br>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.

N.B.: Maintenance Level II does not include the removal of specified accelerometers or gyro sensors from the SRA.

**7B002** Equipment, as follows, specially designed to characterize mirrors for ring "laser" gyros:

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., including:

a. Gyro tuning test stations;
b. Gyro dynamic balance stations;
c. Gyro run-in/motor test stations;
d. Gyro evacuation and fill stations;
e. Centrifuge Fixture for Gyro bearing;
f. Accelerometer axis align stations;

**7B102** Reflectometers specially designed to characterise mirrors, for "laser" gyros, having a measurement accuracy of 50 ppm or less (better).

**7B103** Specially designed "production facilities" for equipment specified by 7A117.

**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 “use” of any inertial navigation equipment or Attitude Heading Reference Systems (AHRS) (except: gimballed AHRS) including inertial equipment not specified in 7A003 or 7A004.

Technical Note: AHRS generally differ from inertial navigation systems (INS) in that an AHRS provides attitude 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 or 7A004;
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 by continuously combining inertial data with any of the following navigation data:
    1. Doppler radar velocity;
    2. Global Positioning Satellite (GPS) references; or
    3. Terrain data base;
c. “Source code” for integrated avionics or mission systems which combine sensor data and employ knowledge-based expert systems;
d. “Source code” for the “development” of:
    1. Digital flight management systems for flight path optimization;
    2. Integrated propulsion and flight control systems;
    3. Fly-by-wire or fly-by-light control systems;
    4. Fault-tolerant or self-reconfiguring “active flight control systems”;
    5. Airborne automatic direction finding equipment;
    6. Air data systems based on surface static data;
    7. Raster-type head-up displays or three dimensional displays.

**7D101** “Software” specially designed for the “use” of equipment specified in 7A001 to 7A006,

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| | 7A101 to 7A106, 7A115, 7B002, 7B003, 7B102 or 7B103. |
| **7D102** | Integration "software" for the equipment specified in 7A003 or 7A103. |
| **7D103** | "Software" specially designed for modelling or simulation of the "guidance sets" specified in 7A117 or for their design integration with the systems specified in 9A004 or 9A104.<br><br>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. or 7D. |
| **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;<br><br>except:<br><br>For 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 (see Technical Notes to 7B001). |
| **7E004** | Other "technology", as follows:<br>a. "Technology" for the "development" or "production" of:<br>1. Airborne automatic direction finding equipment operating at frequencies exceeding 5 MHz;<br>2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;<br>3. Raster-type head-up displays or three dimensional displays for "aircraft";<br>4. Inertial navigation systems or gyro-astro compasses containing |

accelerometers or gyros specified in 7A001 or 7A002;

b. "Development" "technology", as follows, for "active flight control systems" (including fly-by-wire or fly-by-light):

1. Configuration design for interconnecting multiple microelectronic processing elements (on-board computers) to achieve "real time processing" for control law implementation;
2. Control law compensation for sensor location or dynamic airframe loads, i.e., compensation for sensor vibration environment or for variation of sensor location from the centre of gravity;
3. Electronic management of data redundancy or systems redundancy for fault detection, fault tolerance, fault isolation or reconfiguration;

   NOTE: 7E004.b.3. does not specify "technology" for the design of physical redundancy.
4. Flight controls which permit inflight reconfiguration of force and moment controls for real time autonomous air vehicle control;
5. Integration of digital flight control, navigation and propulsion control data into a digital flight management system for flight path optimization;

   except:

   "Development" "technology" for aircraft flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches;
6. Full authority digital flight control or multi sensor mission management systems incorporating knowledge-based expert systems;
   (For "technology" for Full Authority Digital Engine Control (FADEC), see 9E003.a.10.)

c. "Technology" for the "development" of helicopter systems, as follows:

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

**7E101** "Technology" according to the General Technology Note for the "use" of equipment specified in 7A001 to 7A006, 7A101 to 7A106, 7A115 to 7A117, 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 a. and b. above.

**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** **Equipment, Assemblies and Components**

**8A001** Submersible vehicles or surface vessels, as follows:

NOTE: For the control status of equipment for submersible vehicles, see:

Category 5 "Information Security" for encrypted communication equipment;
Category 6 for sensors;
Categories 7 and 8 for navigation equipment;
Category 8.A. for underwater equipment.

a. Manned, tethered submersible vehicles designed to operate at depths exceeding 1000 m;
b. Manned, untethered submersible vehicles:
    1. Designed to “operate autonomously” and having a lifting capacity of:
        a. 10% or more of their weight in air; and
        b. 15 kN or more;
    2. Designed to operate at depths exceeding 1000 m; or
    3. a. Designed to carry a crew of 4 or more;
        b. Designed to “operate autonomously” for 10 hours or more;
        c. Having a “range” of 25 nautical miles or more; and
        d. Having a length of 21 m or less;
c. Unmanned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m:
    1. Designed for self-propelled manoeuvre using propulsion motors or thrusters specified in 8A002.a.2.; or
    2. Having a fibre optic data link;
d. Unmanned, untethered submersible vehicles:
    1. Designed for deciding a course relative to any geographical reference without real-time human assistance;
    2. Having an acoustic data or command link; or
    3. Having a fibre optic data or command link exceeding 1,000 m;
e. Ocean salvage systems with a lifting capacity exceeding 5 MN for salvaging objects from depths exceeding 250 m and having either of the following:
    1. Dynamic positioning systems capable of position keeping within 20 m of a given point provided by the navigation system; or
    2. Seafloor navigation and navigation integration systems for depths exceeding 1,000 m with positioning accuracies to within 10 m of a predetermined point;

f. Surface-effect vehicles (fully skirted variety) with a maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1.25 m (Sea State 3) or more, a cushion pressure exceeding 3,830 Pa, and a light-ship-to-full-load displacement ratio of less than 0.7;

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 with:

   1. A full load displacement exceeding 500 tonnes with a maximum design speed, fully loaded, exceeding 35 knots in a significant wave height of 3.25 m (Sea State 5) or more; or

   2. A full load displacement exceeding 1500 tonnes with a maximum design speed, fully loaded, exceeding 25 knots in a significant wave height of 4 m (Sea State 6) or more;

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

**8A002**

Systems or equipment, as follows:
NOTE: For underwater communications systems, see Category 5.—Telecommunications.

a. Systems or equipment, specially designed or modified for submersible vehicles, designed to operate at depths exceeding 1000 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;

b. Systems specially designed or modified for the automated control of the motion of equipment for submersible vehicles specified in 8A001 using navigation data and having closed loop servo-controls to:

1. Enable a vehicle to move within 10 m of a predetermined point in the water column;
2. Maintain the position of the vehicle within 10 m of a predetermined point in the water column; or
3. Maintain the position of the vehicle within 10 m while following a cable on or under the seabed;

c. Fibre optic hull penetrators or connectors;

d. Underwater vision systems, as follows:

1. a. Television systems (comprising camera, lights, monitoring and signal transmission equipment) having a limiting resolution when measured in air of more than 500 lines and specially designed or modified for remote operation with a submersible vehicle; or

   b. Underwater television cameras having a limiting resolution when measured in air of more than 700 lines;

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

2. Systems, specially designed or modified for remote operation with an underwater vehicle, employing techniques to minimise the effects of back scatter, including range-gated illuminators or “laser” systems;
3. Low light level television cameras specially designed or modified for underwater use containing:

a. Image intensifier tubes specified in 6A002.a.2.a.; and
b. More than 150000 "active pixels" per solid state area array;

e. Photographic still cameras specially designed or modified for underwater use, having a film format of 35 mm or larger, and:
1. Annotating the film with data provided by a source external to the camera;
2. Having autofocussing or remote focussing specially designed for underwater use;
3. Having automatic back focal distance correction; or
4. Having automatic compensation control specially designed to permit an underwater camera housing to be usable at depths exceeding 1,000 m;

f. Electronic imaging systems, specially designed or modified for underwater use, capable of storing digitally more than 50 exposed images;

g. Light systems, as follows, specially designed or modified for underwater use:
1. Stroboscopic light systems capable of a light output energy of more than 300 J per flash;
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 stored programme computer:
1. Having 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. Capable of exerting a force of 250 N or more or a torque of 250 Nm or more and using titanium based alloys or "fibrous or filamentary" "composite" materials in their structural members;

i. Remotely controlled articulated manipulators specially designed or modified for use with submersible vehicles:

1. Having systems which control the manipulator using the information from sensors which measure the torque or force applied to an external object, or tactile sense between the manipulator and an external object; or
2. Controlled by proportional master-slave techniques or by using a dedicated stored programme computer, and having 5 degrees of freedom of movement or more;

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

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

a. Chemical scrubber or absorber systems specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;
b. Systems specially designed to use a monoatomic gas;
c. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; and
d. Specially designed exhaust systems that do not exhaust continuously the products of combustion;

3. Fuel cell air independent power systems with an output exceeding 2 kW having either of the following:
   a. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; or
   b. Systems specially designed:
      1. To pressurise the products of reaction or for fuel reformation;
      2. To store the products of the reaction; and
      3. To discharge the products of the reaction against a pressure of 100 kPa or more;

k. Skirts, seals and fingers, as follows:
   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.;
   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 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., g., h. or i.;

o. 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., g., h. or i.:

   a. Supercavitating, super-ventilated, partially-submerged or surface piercing propellers rated at more than 7.5 MW;

   b. Contrarotating propeller systems rated at more than 15 MW;

   c. Systems employing pre-swirl or post-swirl techniques for smoothing the flow into a propeller;

   d. Light-weight, high capacity (K factor exceeding 300) reduction gearing;

   e. Power transmission shaft systems, incorporating “composite” material components, capable of transmitting more than 1 MW;

2. Water-screw propeller, power generation or transmission systems for use on vessels, as follows:

   a. Controllable-pitch propellers and hub assemblies rated at more than 30 MW;

   b. Internally liquid-cooled electric propulsion engines with a power output exceeding 2.5 MW;

   c. “Superconductive” propulsion engines, or permanent magnet electric propulsion engines, with a power output exceeding 0.1 MW;

d. Power transmission shaft systems, incorporating “composite” material components, capable of transmitting more than 2 MW;

e. Ventilated or base-ventilated propeller systems rated at more than 2.5 MW;

3. Noise reduction systems for use on vessels of 1,000 tonnes displacement or more, as follows:

a. Noise reduction systems that attenuate at frequencies below 500 Hz and consist of compound acoustic mounts for the acoustic isolation of diesel engines, diesel generator sets, gas turbines, gas turbine generator sets, propulsion motors or propulsion reduction gears, specially designed for sound or vibration isolation, having an intermediate mass exceeding 30% of the equipment to be mounted;

b. Active noise reduction or cancellation systems, or magnetic bearings, specially designed for power transmission systems, and incorporating electronic control systems capable of actively reducing equipment vibration by the generation of anti-noise or anti-vibration signals directly to the source;

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

**8B** **Test, Inspection and Production Equipment**

**8B001** Water tunnels, having a background noise of less than 100 dB (reference 1 micropascal, 1 Hz) in the frequency range from 0 to 500 Hz, designed for measuring acoustic fields generated by a hydro-flow around propulsion system models.

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| **8C** | **Materials** |
| **8C001** | Syntactic foam for underwater use:<br>a. Designed for marine depths exceeding 1,000 m; and<br>b. With a density less than 561 kg/$m^3$.<br><br>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:<br>a. "Technology" for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction;<br>b. "Technology" for the overhaul or refurbishing of equipment specified in 8A001, or 8A002.b., j., o. or p. |

**CATEGORY 9 PROPULSION SYSTEMS, SPACE VEHICLES, AND RELATED EQUIPMENT**

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| **9A** | **Equipment, Assemblies and Components** |
| **9A001** | Aero gas turbine engines incorporating any of the technologies specified in 9E003.a., as follows:<br><br>N.B.: SEE ALSO 9A101.<br>a. Not certified for the specific "civil aircraft" for which they are intended;<br>b. Not certified for civil use by "civil aviation authorities";<br>c. Designed to cruise at speeds exceeding Mach 1.2 for more than thirty minutes. |

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| **9A002** | Marine gas turbine engines with an ISO standard continuous power rating of 24,245 kW or more and a specific fuel consumption of less than 0.219 kg/kWh at any point in the power range from 35 to 100%, and specially designed assemblies and components therefor.<br><br>NOTE: The term 'marine gas turbine engines' includes those industrial, or aero-derivatives, gas turbine engines adapted for marine propulsion or shipboard power generation. |
| **9A003** | Specially designed assemblies and components, incorporating any of the technologies specified in 9E003.a., for the following gas turbine engine propulsion systems:<br>a. Specified in 9A001; or<br>b. Whose design or production origins are unknown to the manufacturer.<br><br>NOTE: 9A003 does not specify multiple domed combustors operating at average burner outlet temperatures equal to or less than 1813 K (1540°C). |
| **9A004** | Space launch vehicles or "spacecraft" (not including their payloads).<br><br>N.B.: SEE ALSO 9A104.<br><br>(For the control status of goods contained in "spacecraft" payloads, see the appropriate Categories.) |
| **9A005** | Liquid rocket propulsion systems containing any of the systems or components specified in 9A006.<br><br>N.B.: SEE ALSO 9A105 and 9A119. |
| **9A006** | Systems or components, as follows, specially designed for liquid rocket propulsion systems:<br><br>N.B.: SEE ALSO 9A106 and 9A108.<br>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;<br>b. Cryogenic containers or closed-cycle refrigeration systems capable of providing temperatures of 100 K (−173°C) or less for "aircraft" capable of |

sustained flight at speeds exceeding Mach 3, launch vehicles or "spacecraft";

c. Slush hydrogen storage or transfer systems;

d. High pressure (exceeding 17.5 MPa) turbo pumps, pump components or their associated gas generator or expander cycle turbine drive systems;

e. High-pressure (exceeding 10.6 MPa) thrust chambers and nozzles therefor;

f. Propellant storage systems using the principle of capillary containment or positive expulsion (i.e., with flexible bladders).

**9A007** Solid rocket propulsion systems with any of the following:

N.B.: SEE ALSO 9A119.

a. 1. Total impulse capacity exceeding 1.1 MNs; or

2. 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;

b. 1. Stage mass fractions exceeding 88%; and

2. Propellant solid loadings exceeding 86%;

c. Any of the components specified in 9A008; or

d. 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.

**9A008** Components, as follows, specially designed for solid rocket propulsion systems:

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;

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

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

c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0.075 mm/s;

d. Movable nozzle or secondary fluid injection thrust vector control systems capable of:
   1. Omni-axial movement exceeding + 5°;
   2. Angular vector rotations of 20°/s or more; or
   3. Angular vector accelerations of 40°/$s^2$ or more.

Technical Note: For the purposes of 9A007.d. and 9A008.a., a strong mechanical bond means bond strength equal to or more than propellant strength.

**9A009** Hybrid rocket propulsion systems with:

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 or structures, for launch vehicles or launch vehicle propulsion systems, manufactured using metal "matrix" "composite", organic "composite", ceramic "matrix" or intermetallic reinforced materials specified in 1C007 or 1C010.

N.B.: SEE ALSO 1A002 and 9A110.

**9A011** Ramjet, scramjet or combined cycle engines and specially designed components therefor.

N.B.: SEE ALSO 9A111 and 9A118.

**9A101** Lightweight turbojet and turbofan engines (including turbocompound engines) usable in "missiles", other than those specified in 9A001, as follows;

a. Engines having both of the following characteristics:
   1. Maximum thrust value greater than 1,000 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 0.13kg/N/hr or less (at sea level static and standard conditions); or
b. Engines designed or modified for use in “missiles”.

**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, having a total impulse capacity of 1.1 MNs or greater;
b. Liquid propellant rocket engines usable in missiles with a range of 300 km or greater, other than those specified in 9A005 or 9A105.a., having a total impulse capacity of 0.841 MNs or greater.

**9A106** Systems or components, other than those specified in 9A006, usable in “missiles”, as follows, specially designed for liquid rocket propulsion systems:
a. Ablative liners for thrust or combustion chambers;
b. Rocket nozzles;
c. Thrust vector control sub-systems;

Technical Note: Examples of methods of achieving thrust vector control specified in 9A106.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.

d. Liquid and slurry propellant (including oxidisers) control systems, and specially designed components therefor, designed or modified to operate in vibration environments of more than 10 g rms between 20 Hz and 2,000 Hz.

NOTE: The only servo valves and pumps specified in this item, are the following:

a. Servo valves designed for flow rates of 24 litres per minute or greater, at an absolute pressure of 7 MPa or greater, that have an actuator response time of less than 100 ms;
b. Pumps, for liquid propellants, with shaft speeds equal to or greater than 8,000 rpm or with discharge pressures equal to or greater than 7 MPa.

**9A107**

Solid propellant rocket engines, usable in missiles with a range of 300 km or greater, other than those specified in 9A007, having total impulse capacity of 0.841 MNs or greater.

N.B.: SEE ALSO 9A119.

**9A108**

Components, other than those specified in 9A008, usable in "missiles", as follows, specially designed for solid rocket propulsion systems:

a. Rocket motor cases, "interior lining" and "insulation" therefor;
b. Rocket nozzles;
c. Thrust vector control sub-systems.

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, usable in "missiles", other than those specified in 9A009, and specially designed components therefor.

N.B.: SEE ALSO 9A119.

**9A110**

Composite structures, laminates and manufactures thereof, other than those specified in entry 9A010, specially designed for use in the systems specified in entries 9A004 or 9A104 or the subsystems specified in entries 9A005, 9A007, 9A105.a., 9A106 to 9A108, 9A116 or 9A119, and resin impregnated fibre prepregs and metal coated fibre preforms therefor, made either with organic matrix or metal matrix utilising fibrous or filamentary reinforcements having a specific tensile

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| | strength greater than $7.62 \times 10^4$ m and a specific modulus greater than $3.18 \times 10^6$ m.<br><br>N.B.: SEE ALSO 1A002.<br><br>NOTE: The only resin impregnated fibre prepregs specified in entry 9A110 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. |
| **9A111** | Pulse jet engines, usable in “missiles”, and specially designed components therefor.<br><br>N.B.: SEE ALSO 9A011 and 9A118. |
| **9A115** | Launch support equipment, designed or modified for systems specified in 9A004 or 9A104, as follows:<br>a. Apparatus and devices for handling, control, activation or launching;<br>b. Vehicles for transport, handling, control, activation or launching. |
| **9A116** | Reentry vehicles, usable in “missiles”, and equipment designed or modified therefor, as follows:<br>a. Reentry vehicles;<br>b. Heat shields and components therefor fabricated of ceramic or ablative materials;<br>c. Heat sinks and components therefor fabricated of light-weight, high heat capacity materials;<br>d. Electronic equipment specially designed for reentry vehicles. |
| **9A117** | Staging mechanisms, separation mechanisms, and interstages, usable in “missiles”. |
| **9A118** | Devices to regulate combustion usable in engines, which are usable in “missiles”, specified in 9A011 or 9A111. |
| **9A119** | Individual rocket stages, usable in missiles with a range of 300 km or greater, other than those specified in 9A005, 9A007, 9A009, 9A105, 9A107 and 9A109. |
| **9B** | **Test, Inspection and Production Equipment** |
| **9B001** | Specially designed equipment, tooling or fixtures, as follows, for manufacturing or measuring gas turbine blades, vanes or tip shroud castings: |

a. Automated equipment using non-mechanical methods for measuring airfoil wall thickness;
b. Tooling, fixtures or measuring equipment for the “laser”, water jet or ECM/EDM hole drilling processes specified in 9E003.c.;
c. Directional solidification or single crystal casting equipment;
d. Ceramic cores or shells;
e. Ceramic core manufacturing equipment or tools;
f. Ceramic core leaching equipment;
g. Ceramic shell wax pattern preparation equipment;
h. Ceramic shell burn out or firing equipment.

**9B002** On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for the development of gas turbine engines, assemblies or components incorporating technologies specified in 9E003.a.

**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 specially designed parts or accessories therefor.

**9B004** Tools, dies or fixtures for the solid state joining of gas turbine “superalloy” or titanium components.

**9B005** On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for use with the following wind tunnels or devices:

N.B.: SEE ALSO 9B105

a. Wind tunnels designed for speeds of Mach 1.2 or more;

except:

Those specially designed for educational purposes and having a test section size (measured laterally) of less than 250 mm;

Technical Note: ‘Test section size’ in 9B005.a. means the diameter of the circle, or the side of a square, or the longest side of a 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;

c. Wind tunnels or devices, other than two-dimensional sections, capable of simulating Reynolds number flows exceeding $25 \times 10^6$.

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| **9B006** | Specially designed acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 micropascals) with a rated output of 4 kW or more at a test cell temperature exceeding 1273 K (1000°C), and specially designed transducers, strain gauges, accelerometers, thermocouples or quartz heaters therefor. |
| **9B007** | Equipment specially designed for inspecting the integrity of rocket motors using non-destructive test (NDT) techniques other than planar X-ray or basic physical or chemical analysis.<br><br>(For radiographic equipment, see 3A001.e 5.) |
| 9B008 | Transducers specially designed for the direct measurement of the wall skin friction of the test flow with a stagnation temperature exceeding 833 K (560°C). |
| **9B009** | Tooling specially designed for producing turbine engine powder metallurgy rotor components capable of operating at stress levels of 60%percnt; of ultimate tensile strength (UTS) or more and metal temperatures of 873 K (600°C) or more. |
| **9B105** | Wind tunnels for speeds of Mach 0.9 or more, usable for “missiles” and their subsystems.<br><br>N.B.: SEE ALSO 9B005 |
| **9B106** | Environmental chambers and anechoic chambers, as follows:<br>a. Environmental chambers capable of simulating the following flight conditions:<br>1. Vibration environments of 10 g RMS or greater between 20 Hz and 2,000 Hz and imparting forces of 5 kN or greater; and<br>2. Altitudes of 15,000 m or greater; or |

3. Temperature of at least 223 K (−50°C) to 398 K (+ 125°C).

b. Anechoic 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 microPa) or with a rated power output of 4 kW or greater; and
2. Altitudes of 15,000 m or greater; or
3. Temperature of at least 223 K (−50°C) to 398 K (+ 125°C).

**9B115** Specially designed "production equipment" for the systems, sub-systems and components specified in 9A005 to 9A009, 9A011, 9A101, 9A105 to 9A109, 9A111, 9A116 to 9A119.

**9B116** Specially designed "production facilities" for the systems, sub-systems, and components specified in 9A004 to 9A009, 9A011, 9A101, 9A104 to 9A109, 9A111, 9A116 to 9A119.

**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 90 kN of thrust; or
b. Capable of simultaneously measuring the three axial thrust components.

**9C** **Materials**

None

**9D** **Software**

**9D001** "Software" required for the "development" of equipment or "technology" specified in 9A., 9B. or 9E003.

**9D002** "Software" required for the "production" of equipment specified in 9A. or 9B.

**9D003** "Software" required for the "use" of full authority digital electronic engine controls (FADEC) for propulsion systems specified in 9A. or equipment specified in 9B., as follows:

a. "Software" in digital electronic controls for propulsion systems, aerospace test facilities or air breathing aero-engine test facilities;
b. Fault-tolerant "software" used in FADEC systems for propulsion systems and associated test facilities.

**9D004** Other "software", as follows:

a. “Software”, other than that specified in 2D101, specially designed for vibration test equipment using real time digital controls with individual exciters (thrusters) with a maximum thrust exceeding 100 kN;
b. 2D or 3D viscous “software” validated with wind tunnel or flight test data required for detailed engine flow modelling;
c. “Software” required for the “development” or “production” of real time full authority electronic test facilities for engines or components specified in 9A.;
d. “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;
e. “Software” specially designed to control directional solidification or single crystal casting;
f. “Software” in “source code”, “object code” or machine code required for the “use” of active compensating systems for rotor blade tip clearance control;

NOTE: 9D004.f. does not specify “software” embedded in non-specified equipment or required for maintenance activities associated with the calibration or repair or updates to the active compensating clearance control system.

**9D101** “Software” specially designed for the “use” of goods specified in 9B105, 9B106, 9B116 or 9B117.

**9D103** “Software” specially designed for modelling, simulation or design integration of the systems specified in 9A004 or 9A104, or the subsystems specified in 9A005, 9A007, 9A105.a., 9A106, 9A108, 9A116 or 9A119.

NOTE: “Software” specified in 9D103 remains controlled when combined with specially designed hardware specified in 4A102.

**9E** **Technology**

**9E001** “Technology” according to the General Technology Note for the “development” of

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| | equipment or "software" specified in 9A001.c., 9A004 to 9A011, 9B. or 9D. |
| **9E002** | "Technology" according to the General Technology Note for the "production" of equipment specified in 9A001.c., 9A004 to 9A011 or 9B.<br><br>NOTE: "Development" or "production" "technology" specified in 9E. for gas turbine engines remains controlled when used as "use" technology for repair, rebuild and overhaul.<br><br>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.<br><br>(For "technology" for the repair of controlled structures, laminates or materials, see 1E002.f.) |
| **9E003** | Other "technology", as follows:<br>a. "Technology" "required" for the "development" or "production" of the following gas turbine engine components or systems:<br>1. Directionally solidified gas turbine blades, vanes or tip shrouds rated to operate at gas path temperatures exceeding 1,593 K (1,320°C);<br>2. Single crystal blades, vanes or tip shrouds;<br>3. Multiple domed combustors operating at average burner outlet temperatures exceeding 1,643 K (1,370°C), or combustors incorporating thermally decoupled combustion liners, non-metallic liners or non-metallic shells;<br>4. Components manufactured from organic "composite" materials designed to operate above 588 K (315°C), or from metal "matrix" "composite", ceramic "matrix", intermetallic or intermetallic reinforced materials specified in 1A002 or 1C007;<br>5. Uncooled turbine blades, vanes, tip-shrouds or other components designed to operate at gas path |

temperatures of 1,323 K (1,050°C) or more;

6. Cooled turbine blades, vanes or tip-shrouds, other than those described in 9E003.a.1. and 2., exposed to gas path temperatures of 1,643 K (1,370°C) or more;
7. Airfoil-to-disk blade combinations using solid state joining;
8. Gas turbine engine components using "diffusion bonding" "technology" specified in 2E003.b.;
9. Damage tolerant gas turbine engine rotating components using powder metallurgy materials specified in 1C002.b.;
10. FADEC for gas turbine and combined cycle engines and their related diagnostic components, sensors and specially designed components;
11. Adjustable flow path geometry and associated control systems for:
    a. Gas generator turbines;
    b. Fan or power turbines;
    c. Propelling nozzles;

        NOTES:
        1. Adjustable flow path geometry and associated control systems do not include inlet guide vanes, variable pitch fans, variable stators or bleed valves for compressors.
        2. 9E003.a.11. does not control "development" or "production" "technology" for adjustable flow path geometry for reverse thrust.
12. Rotor blade tip clearance control systems employing active compensating casing "technology" limited to a design and development data base;
13. Gas bearings for gas turbine engine rotor assemblies;
14. Wide chord hollow fan blades without part-span support;

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

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

   Technical Note: For the purposes of 9E003.c., incidence angle is measured from a plane tangential to the airfoil surface at the point where the hole axis enters the airfoil surface.

d. "Technology" "required" for the "development" or "production" of helicopter power transfer systems or tilt rotor or tilt wing "aircraft" power transfer systems:
   1. Capable of loss-of-lubrication operation for 30 minutes or more; or
   2. Having an input power-to-weight ratio equal to or more than 8.87 kW/kg;

e. 1. "Technology" for the "development" or "production" of reciprocating diesel engine ground vehicle propulsion systems having all of the following:
      a. A box volume of 1.2 $m^3$ or less;

b. An overall power output of more than 750 kW based on 80/1269/EEC, ISO 2534 or equivalents; and
c. A power density of more than 700 kW/$m^3$ of box volume;
Technical Note: Box volume is the product of three perpendicular dimensions measured in the following way:
Length: The length of the crankshaft from front flange to flywheel face;
Width: The widest of the following:
a. The outside dimension from valve cover to valve cover;
b. The dimensions of the outside edges of the cylinder heads; or
c. The diameter of the flywheel housing;
Height: The largest of the following:
a. The dimension of the crankshaft centre-line to the top plane of the valve cover (or cylinder head) plus twice the stroke; or
b. The diameter of the flywheel housing.
2. “Technology” “required” for the “production” of specially designed components, as follows, for high output diesel engines:
a. “Technology” “required” for the “production” of engine systems having all of the following components employing ceramics materials specified in 1C007:
1. Cylinder liners;
2. Pistons;
3. Cylinder heads; and
4. One or more other components (including exhaust ports, turbochargers, valve guides, valve assemblies

or insulated fuel injectors);

b. "Technology" "required" for the "production" of turbocharger systems, with single-stage compressors having all of the following:
   1. Operating at pressure ratios of 4:1 or higher;
   2. A mass flow in the range from 30 to 130 kg per minute; and
   3. Variable flow area capability within the compressor or turbine sections;

c. "Technology" "required" for the "production" of fuel injection systems with a specially designed multifuel (e.g., diesel or jet fuel) capability covering a viscosity range from diesel fuel (2.5 cSt at 310.8 K (37.8°C)) down to gasoline fuel (0.5 cSt at 310.8 K (37.8°C)), having both of the following:
   1. Injection amount in excess of 230 $mm^3$ per injection per cylinder; and
   2. Specially designed electronic control features for switching governor characteristics automatically depending on fuel property to provide the same torque characteristics by using the appropriate sensors;

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

Technical Note: High output diesel engines: Diesel engines with a

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| | 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. |
| **9E101** | "Technology" according to the General Technology Note for the "development" or "production" of goods specified in 9A101, 9A104 to 9A111 or 9A115 to 9A119. |
| **9E102** | "Technology" according to the General Technology Note for the "use" of goods specified in 9A004 to 9A011, 9A101, 9A104 to 9A111, 9A115 to 9A119, 9B105, 9B106, 9B115, 9B116, 9B117, 9D101 or 9D103. |