CATEGORY 2—MATERIALS PROCESSING

2A SYSTEMS, EQUIPMENT AND COMPONENTS
(For quiet running bearings, see the Munitions List)

2A001 Anti-friction bearings and bearing systems, as follows, and components for such bearings and systems: (L.N. 42 of 2017) 
N.B.: See also 2A101. (L.N. 42 of 2017) 
Note: 2A001 does not apply to balls with tolerances specified by the manufacturer in accordance with ISO 3290 as grade 5 or worse. (L.N. 161 of 2011) 
(a) Ball bearings and solid roller bearings having all tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 4 (or national equivalents), or better, and having both rings and rolling elements (ISO 5593) made from monel or beryllium; (L.N. 132 of 2001; L.N. 65 of 2004; L.N. 161 of 2011) 
Note: 2A001(a) does not apply to tapered roller bearings. (L.N. 161 of 2011) 
(b) (Repealed L.N. 161 of 2011) 
(c) Active magnetic bearing systems using any of the following: 
(1) Materials with flux densities of 2.0 T or greater and yield strengths greater than 414 MPa; 
(2) All-electromagnetic 3D homopolar bias designs for actuators; or 
(3) High temperature (450 K (177°C) and above) position sensors; 

2A101 Radial ball bearings, other than those specified in 2A001, having all tolerances specified in accordance with ISO 492 Tolerance Class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or other national equivalents), or better, and having all the following characteristics: 
(a) An inner ring bore diameter between 12 mm and 50 mm; 
(b) An outer ring outside diameter between 25 mm and 100 mm; (L.N. 42 of 2017)
(c) A width between 10 mm and 20 mm;

(L.N. 89 of 2013)

2A225 Crucibles made of materials resistant to liquid actinide metals, as follows:

(a) Crucibles having both of the following characteristics:
   (1) A volume of between 150 cm$^3$ and 8 000 cm$^3$; and
   (2) Made of or coated with any of the following materials, or a combination of the following materials, having an overall impurity level of 2% or less by weight: (L.N. 42 of 2017)
      (a) Calcium fluoride (CaF$_2$);
      (b) Calcium zirconate (metazirconate) (CaZrO$_3$);
      (c) Cerium sulphide (Ce$_2$S$_3$);
      (d) Erbium oxide (erbia) (Er$_2$O$_3$);
      (e) Hafnium oxide (hafnia) (HfO$_2$);
      (f) Magnesium oxide (MgO);
      (g)Nitrided niobium-titanium-tungsten alloy (approximately 50% Nb, 30% Ti, 20% W);
      (h) Yttrium oxide (yttria) (Y$_2$O$_3$); or
      (i) Zirconium oxide (zirconia) (ZrO$_2$);

(b) Crucibles having both of the following characteristics:
   (1) A volume of between 50 cm$^3$ and 2 000 cm$^3$; and
   (2) Made of or lined with tantalum, having a purity of 99.9% or greater by weight;

(c) Crucibles having all of the following characteristics:
   (1) A volume of between 50 cm$^3$ and 2 000 cm$^3$;
   (2) Made of or lined with tantalum, having a purity of 98% or greater by weight; and
   (3) Coated with tantalum carbide, nitride, boride, or any combination thereof;

(L.N. 65 of 2004)

2A226 Valves having all of the following characteristics:

(a) A ‘nominal size’ of 5 mm or greater;

(b) Having a bellows seal; and

(c) Wholly made of or lined with aluminium, aluminium alloy, nickel, or nickel alloy containing more than 60% nickel by
weight;

Technical Note:

For valves with different inlet and outlet diameters, the ‘nominal size’ in 2A226 refers to the smallest diameter.

(L.N. 65 of 2004)

2B TEST, INSPECTION AND PRODUCTION EQUIPMENT

Technical Notes:

1. Secondary parallel contouring axes, (e.g. the w-axis on horizontal boring mills or a secondary rotary axis the centre line of which is parallel to the primary rotary axis) are not counted in the total number of contouring axes. Rotary axes need not rotate over 360°. A rotary axis can be driven by a linear device (e.g. a screw or a rack-and-pinion).

2. For the purposes of 2B, the number of axes which can be coordinated simultaneously for “contouring control” is the number of axes along or around which, during processing of a workpiece, simultaneous and interrelated motions are performed between the workpiece and a tool. This does not include any additional axes along or around which other relative motions within the machine are performed, such as:
   (a) Wheel-dressing systems in grinding machines;
   (b) Parallel rotary axes designed for mounting of separate workpieces;
   (c) Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends. (L.N. 95 of 2006)

3. Axis nomenclature shall be in accordance with International Standard ISO 841 (2001), Industrial automation systems and integration—Numerical Control—of machines coordinate system and Motion Nomenclature. (L.N. 42 of 2017)

4. For the purposes of 2B001 to 2B009, a “tilting spindle” is counted as a rotary axis.

5. ‘Stated’ “unidirectional positioning repeatability” may be used for each machine tool model as an alternative to individual machine tests and is determined as follows:
   (a) Select 5 machines of a model to be evaluated;
(b) Measure the linear axis repeatability ($R_{↑}$, $R_{↓}$) according to ISO 230/2 (2014) and evaluate the “unidirectional positioning repeatability” for each axis of each machine;

(c) Determine the arithmetic mean value of the “unidirectional positioning repeatability”-values for each axis of all the 5 machines together. These arithmetic mean values of “unidirectional positioning repeatability” ($UPR$) become the stated value of each axis for the model ($UPR_{1}$, $UPR_{2}$, ...);

(d) Since the Category 2 list refers to each linear axis, there will be as many ‘stated’ “unidirectional positioning repeatability” values as there are linear axes;

(e) If any axis of a machine model not controlled by 2B001(a), 2B001(b) and 2B001(c) has a ‘stated’ “unidirectional positioning repeatability” equal to or less than the specified “unidirectional positioning repeatability” of each machine tool model plus 0.7 μm, the builder is to be required to reaffirm the accuracy level once every 18 months. (L.N. 42 of 2017)

6. For the purposes of 2B001(a), 2B001(b) and 2B001(c), measurement uncertainty for the “unidirectional positioning repeatability” of machine tools, as defined in ISO 230/2 (2014) or national equivalents, must not be considered. (L.N. 89 of 2013; L.N. 42 of 2017)

7. For the purposes of 2B001(a), 2B001(b) and 2B001(c), the measurement of axes is to be made according to the test procedures in paragraph 5.3.2 of ISO 230/2 (2014). Tests for axes longer than 2 m are to be made over 2 m segments. Axes longer than 4 m require multiple tests (for example, 2 tests for axes longer than 4 m and up to 8 m, 3 tests for axes longer than 8 m and up to 12 m), each over 2 m segments that are distributed in equal intervals over the axis length. Tests segments are equally spaced along the full axis length, with any excess length equally divided at the beginning, in between, and at the end of the test segments. The smallest “unidirectional positioning repeatability”-value of all test
Machine tools and any combination of machine tools, for removing or cutting metals, ceramics or “composites”, which, according to the manufacturer’s technical specification, can be equipped with electronic devices for “numerical control”, as follows: *(L.N. 42 of 2017)*

**Notes:**

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

2. 2B001 does not control special purpose machine tools limited to the manufacture of any of the following parts:
   (a) Crank shafts or cam shafts;
   (b) Tools or cutters;
   (c) Extruder worms;
   (d) Engraved or facetted jewellery parts; *(L.N. 132 of 2001; L.N. 42 of 2017)*
   (e) Dental prostheses. *(L.N. 42 of 2017)*

3. A machine tool having at least two of the three turning, milling or grinding capabilities (e.g., a turning machine with milling capability), must be evaluated against each applicable entry 2B001(a), (b) or (c). *(L.N. 65 of 2004)*

**N.B.:**

See also 2B201. For optical finishing machines, see 2B002. *(L.N. 254 of 2008)*

(a) Machine tools for turning, having all of the following characteristics:
   (1) “Unidirectional positioning repeatability” equal to or less (better) than 1.1 μm along one or more linear axis; *(L.N. 89 of 2013; L.N. 42 of 2017)*
   (2) Two or more axes which can be coordinated simultaneously for “contouring control”;

**Note:**

2B001(a) does not include turning machines specially designed for producing contact lenses, having all of the following characteristics:

(a) Machine controller limited to using ophthalmic based
software for part programming data input;

(b) No vacuum chucking. (*L.N. 254 of 2008*)

(b) Machine tools for milling, having any of the following characteristics:

(1) Having all of the following:

(a) “Unidirectional positioning repeatability” equal to or less (better) than 1.1 μm along one or more linear axis; (*L.N. 89 of 2013; L.N. 42 of 2017*)

(b) Three linear axes plus one rotary axis which can be coordinated simultaneously for “contouring control”; (*L.N. 132 of 2001*)

(2) Five or more axes which can be coordinated simultaneously for “contouring control” and that meet any of the following descriptions: (*L.N. 132 of 2001; L.N. 42 of 2017*)

_N.B._: ‘Parallel mechanism machine tools’ are specified in 2B001(b)(2)(d).

(a) “Unidirectional positioning repeatability” equal to or less (better) than 1.1 μm along one or more linear axes with a travel length less than 1 m;

(b) “Unidirectional positioning repeatability” equal to or less (better) than 1.4 μm along one or more linear axes with a travel length equal to or greater than 1 m and less than 4 m;

(c) “Unidirectional positioning repeatability” equal to or less (better) than 6.0 μm along one or more linear axes with a travel length equal to or greater than 4 m;

(d) Being a ‘parallel mechanism machine tool’; (*L.N. 42 of 2017*)

_Technical Note:_

A ‘parallel mechanism machine tool’ is a machine tool having multiple rods that are linked with a platform and actuators; each of the actuators operates the
respective rod simultaneously and independently. *(L.N. 42 of 2017)*

(3) A “unidirectional positioning repeatability” for jig boring machines, equal to or less (better) than 1.1 μm along one or more linear axes; *(L.N. 42 of 2017)*

(4) Fly cutting machines, having all of the following characteristics:
   
   a. Spindle “run out” and “camming” less (better) than 0.0004 mm TIR; *and*
   
   b. Angular deviation of slide movement (yaw, pitch and roll) less (better) than 2 seconds of arc, TIR, over 300 mm of travel; *(L.N. 132 of 2001)*

(c) Machine tools for grinding, having any of the following characteristics:

1. Having all of the following:
   
   a. “Unidirectional positioning repeatability” equal to or less (better) than 1.1 μm along one or more linear axes; *(L.N. 42 of 2017)*
   
   b. Three or more axes which can be coordinated simultaneously for “contouring control”; or *(L.N. 132 of 2001)*

2. Five or more axes which can be coordinated simultaneously for “contouring control” and that meet any of the following descriptions: *(L.N. 42 of 2017)*
   
   a. “Unidirectional positioning repeatability” equal to or less (better) than 1.1 μm along one or more linear axes with a travel length less than 1 m;
   
   b. “Unidirectional positioning repeatability” equal to or less (better) than 1.4 μm along one or more linear axes with a travel length equal to or greater than 1 m and less than 4 m;
   
   c. “Unidirectional positioning repeatability” equal to or less (better) than 6.0 μm along one or more linear axes with a travel length equal to or greater than 4 m; *(L.N. 42 of 2017)*
Note:
2B001(c) does not control grinding machines, as follows:

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

2. Machines designed specifically as jig grinders that do not have a z-axis or a w-axis, with a “unidirectional positioning repeatability” less (better) than 1.1 μm. (L.N. 95 of 2006; L.N. 89 of 2013; L.N. 42 of 2017)


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

   (e) Machine tools for removing metals, ceramics or “composites”, having all of the following characteristics:
      (1) Removing material by means of any of the following:
         (a) Water or other liquid jets, including those employing abrasive additives;
         (b) Electron beam; or
         (c) “Laser” beam; and
      (2) At least two rotary axes having all of the following: (L.N. 161 of 2011)
         (a) Can be coordinated simultaneously for “contouring control”; and
         (b) A positioning “accuracy” of less (better) than 0.0030; (L.N. 132 of 2001; L.N. 42 of 2017)

   (f) Deep-hole-drilling machines and turning machines modified for deep-hole-drilling, having a maximum depth-of-bore capability exceeding 5 m; (L.N. 42 of 2017)

2B002 Numerically controlled optical finishing machine tools equipped for selective material removal to produce non-spherical optical surfaces having all of the following characteristics:
   (a) Finishing the form to less (better) than 1.0 μm;
(b) Finishing to a roughness less (better) than 100 nm rms;
(c) Four or more axes which can be coordinated simultaneously for “contouring control”;
(d) Using any of the following processes:
   (1) ‘Magnetorheological finishing (MRF)’;
   (2) ‘Electrorheological finishing (ERF)’;
   (3) ‘Energetic particle beam finishing’;
   (4) ‘Inflatable membrane tool finishing’;
   (5) ‘Fluid jet finishing’;

Technical Note:
For the purposes of 2B002:
(a) ‘MRF’ is a material removal process using an abrasive magnetic fluid whose viscosity is controlled by a magnetic field;
(b) ‘ERF’ is a removal process using an abrasive fluid whose viscosity is controlled by an electric field;
(c) ‘Energetic particle beam finishing’ uses Reactive Atom Plasmas (RAP) or ion-beams to selectively remove material;
(d) ‘Inflatable membrane tool finishing’ is a process that uses a pressurized membrane that deforms to contact the workpiece over a small area;
(e) ‘Fluid jet finishing’ makes use of a fluid stream for material removal.

(L.N. 254 of 2008)

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

2B004 Hot “isostatic presses”, having all of the following, and specially designed components and accessories therefor: (L.N. 132 of 2001) N.B.:
See also 2B104 and 2B204.
(a) A controlled thermal environment within the closed cavity
and a chamber cavity with an inside diameter of 406 mm or more; and (L.N. 183 of 1999)

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

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

*N.B.:*
For specially designed dies, moulds and tooling see 1B003, 9B009 and ML18 of the Munitions List. (L.N. 132 of 2001)

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

(a) Chemical vapour deposition (CVD) production equipment having all of the following:
   (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) Any of the following:
      (a) Incorporating high vacuum (equal to or less than 0.01 Pa) rotating seals; or
      (b) Incorporating *in situ* coating thickness control;
   (b) Ion implantation production equipment having beam
currents of 5 mA or more;

(c) Electron beam physical vapour deposition (EB-PVD) production equipment incorporating power systems rated for over 80 kW, having any of the following:

(1) A liquid pool level “laser” control system which regulates precisely the ingots feed rate; or

(2) A computer controlled rate monitor operating on the principle of photo-luminescence of the ionized atoms in the evaporant stream to control the deposition rate of a coating containing two or more elements; *(L.N. 132 of 2001)*

(d) Plasma spraying production equipment having any of the following characteristics:

(1) Operating at reduced pressure controlled atmosphere (equal to or less than 10 kPa measured above and within 300 mm of the gun nozzle exit) in a vacuum chamber capable of evacuation down to 0.01 Pa prior to the spraying process; or

(2) Incorporating *in situ* coating thickness control;

(e) Sputter deposition production equipment capable of current densities of 0.1 mA/mm² or higher at a deposition rate of 15 μm/h or more;

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

(g) Ion plating production equipment capable of in situ measurement of any of the following: *(L.N. 161 of 2011)*

(1) Coating thickness on the substrate and rate control; or

(2) Optical characteristics;

Note:

2B005(a), 2B005(b), 2B005(e), 2B005(f) and 2B005(g) do not control chemical vapour deposition, cathodic arc, sputter deposition, ion plating or ion implantation equipment specially designed for cutting or machining tools. *(L.N. 95 of 2006)*

2B006 Dimensional inspection or measuring systems, equipment and
“electronic assemblies”, as follows: (L.N. 95 of 2006)

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

*N.B.*: See also 2B206.

*Technical Note:*

The $E_{0,\text{MPE}}$ of the most accurate configuration of the CMM specified by the manufacturer (e.g. best of the following: probe, stylus length, motion parameters, environment) and with “all compensations available” is to be compared to the $1.7 + L/1\,000$ μm threshold. (L.N. 161 of 2011)

(b) Linear and angular displacement measuring instruments, as follows:

(1) ‘Linear displacement’ measuring instruments having any of the following: (L.N. 65 of 2004; L.N. 42 of 2017)

*Note:*

Displacement measuring “laser” interferometers are only controlled in 2B006(b)(1)(c). (L.N. 42 of 2017)

*Technical Note:*

For the purpose of 2B006(b)(1), ‘linear displacement’ means the change of distance between the measuring probe and the measured object. (L.N. 65 of 2004)

(a) Non-contact type measuring systems with a “resolution” equal to or less (better) than 0.2 μm within a measuring range up to 0.2 mm;

(b) Linear Variable Differential Transformer (LVDT) systems that meet all of the following descriptions: (L.N. 42 of 2017)

(1) Having any of the following:

(a) “Linearity” equal to or less (better) than 0.1% measured from 0 to the ‘full operating
range’, for LVDTs with a ‘full operating range’ up to and including ±5 mm;

(b) “Linearity” equal to or less (better) than 0.1% measured from 0 to 5 mm, for LVDTs with a ‘full operating range’ greater than ±5 mm; (L.N. 42 of 2017)

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

Technical Note:
For the purposes of 2B006(b)(1)(b), ‘full operating range’ is half of the total possible linear displacement of the LVDT. For example, LVDTs with a ‘full operating range’ up to and including ±5 mm can measure a total possible linear displacement of 10 mm. (L.N. 42 of 2017)

(c) Measuring systems having all of the following:
(1) Containing a “laser”; and
(2) Maintaining, for at least 12 hours, at a temperature of 20±1°C, all of the following: (L.N. 42 of 2017)

(a) A “resolution” over their full scale of 0.1 μm or less (better);

(b) Capable of achieving a “measurement uncertainty” equal to or less (better) than (0.2 + L/2 000) μm (L is the measured length in mm) at any point within a measuring range, when compensated for the refractive index of air; (L.N. 254 of 2008; L.N. 42 of 2017)
(d) “Electronic assemblies” specially designed to provide feedback capability in systems specified in 2B006(b)(1)(c); (L.N. 95 of 2006; L.N. 161 of 2011; L.N. 42 of 2017)

Note:
2B006(b)(1) does not control measuring interferometer systems, with an automatic control system that is designed to use no feedback techniques, containing a “laser” to measure slide movement errors of machine-tools, dimensional inspection machines or similar equipment. (L.N. 95 of 2006; L.N. 254 of 2008; L.N. 42 of 2017)

(2) Angular displacement measuring instruments having an angular position “accuracy” equal to or less (better) than 0.00025\(^\circ\); (L.N. 65 of 2004; L.N. 42 of 2017)

Note:
2B006(b)(2) does not control optical instruments, such as autocollimators, using collimated light (e.g., laser light) to detect angular displacement of a mirror. (L.N. 65 of 2004; L.N. 161 of 2011; L.N. 42 of 2017)

(c) Equipment for measuring surface roughness (including surface defects), by measuring optical scatter, with a sensitivity of 0.5 nm or less (better); (L.N. 42 of 2017)

Note:
2B006 includes machine tools, other than those specified by 2B001, that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function. (L.N. 161 of 2011)

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

N.B.:
See also 2B207.

(a) Capable in real time of full three-dimensional image processing or full three-dimensional scene analysis to generate or modify “programmes” or to generate or modify numerical programme data;

Technical Note: (L.N. 132 of 2001)
The scene analysis limitation does not include approximation of the third dimension by viewing at a given angle, or limited grey scale interpretation for the perception of depth or texture for the approved tasks (2 1/2 D).

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

*Note:* 2B007(b) does not include “robots” specially designed for paint-spraying booths. *(L.N. 254 of 2008)*

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

(d) Specially designed to operate at altitudes exceeding 30 000 m;

**2B008** Assemblies or units, specially designed for machine tools, or dimensional inspection or measuring systems and equipment, as follows: *(L.N. 132 of 2001)*

(a) Linear position feedback units having an overall “accuracy” less (better) than (800 + (600 x L/1 000)) nm (L equals the effective length in mm); 

*N.B.:* For “laser” systems, see also 2B006(b)(1)(c) and (d).

(b) Rotary position feedback units having an “accuracy” less (better) than 0.00025°; 

*N.B.:* For “laser” systems, see also 2B006(b)(2).

*Note:* 2B008(a) and 2B008(b) apply to units, that are designed to determine the positioning information for feedback control, such as inductive type devices, graduated scales, infrared systems or “laser” systems.

(c) “Compound rotary tables” and “tilting spindles”, capable of upgrading, according to the manufacturer’s specifications, machine tools to or above the levels controlled by 2B; 

*(L.N. 254 of 2008; L.N. 89 of 2013)*
2B009  Spin-forming machines and flow-forming machines, which, according to the manufacturer’s technical specification, can be equipped with “numerical control” units or a computer control and having all of the following:

*N.B.:

See also 2B109 and 2B209.

(a) 3 or more axes that can be coordinated simultaneously for “contouring control”; *(L.N. 89 of 2013)*

(b) A roller force more than 60 kN;

*Technical Note:*

Machines combining the function of spin-forming and flow-forming are for the purpose of 2B009 regarded as flow-forming machines.

2B104  “Isostatic presses”, other than those controlled by 2B004, having all of the following: *(L.N. 95 of 2006)*

*N.B.:

See also 2B204.

(a) Maximum working pressure equal to or greater than 69 MPa; *(L.N. 95 of 2006)*

(b) Designed to achieve and maintain a controlled thermal environment of 873 K (600°C) or greater; and

(c) Possessing a chamber cavity with an inside diameter of 254 mm or greater; *(L.N. 132 of 2001)*

2B105  CVD furnaces, other than those controlled by 2B005(a), designed or modified for the densification of carbon-carbon composites; *(L.N. 132 of 2001; L.N. 95 of 2006)*

2B109  Flow-forming machines, other than those controlled by 2B009, and specially designed components as follows: *(L.N. 95 of 2006)*

*N.B.:

See also 2B209.

(a) Flow-forming machines having all of the following:

(1) According to the manufacturer’s technical specification, can be equipped with “numerical control” units or a computer control, even when not equipped with such units; and

(2) With more than two axes which can be coordinated
simultaneously for “contouring control”;
(b) Specially designed components for flow-forming machines controlled by 2B009 or 2B109(a); (L.N. 95 of 2006)

Note:
2B109 does not control machines that are not usable in the production of propulsion components and equipment (e.g. motor cases) for systems controlled by 9A005, 9A007(a) or 9A105(a). (L.N. 95 of 2006)

Technical Note:
Machines combining the function of spin-forming and flow-forming are for the purpose of 2B109 regarded as flow-forming machines. (L.N. 132 of 2001)

2B116 Vibration test systems, equipment and components therefor, as follows:
(a) Vibration test systems employing feedback or closed loop techniques and incorporating a digital controller, capable of vibrating a system at an acceleration equal to or greater than 10 g rms between 20 Hz to 2 kHz while imparting forces equal to or greater than 50 kN, measured ‘bare table’; (L.N. 95 of 2006; L.N. 254 of 2008)

(b) Digital controllers, combined with specially designed vibration test software, with a ‘real time control bandwidth’ greater than 5 kHz designed for use with vibration test systems controlled by 2B116(a); (L.N. 226 of 2009; L.N. 161 of 2011)

Technical Note:
In 2B116(b), the term ‘real time control bandwidth’ means the maximum rate at which a controller can execute complete cycles of sampling, processing data and transmitting control signals. (L.N. 226 of 2009; L.N. 161 of 2011)

(c) Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force equal to or greater than 50 kN, measured ‘bare table’ and usable in vibration test systems controlled by 2B116(a); (L.N. 95 of 2006)

(d) Test piece support structures and electronic units designed to combine multiple shaker units in a system capable of
providing an effective combined force equal to or greater than 50 kN, measured ‘bare table’, and usable in vibration systems controlled by 2B116(a); *(L.N. 95 of 2006)*

**Note:**

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

**2B117** Equipment and process controls, other than those controlled by 2B004, 2B005(a), 2B104 or 2B105, designed or modified for densification and pyrolysis of structural composite rocket nozzles and reentry vehicle nose tips;

*(L.N. 132 of 2001; L.N. 95 of 2006)*

**2B119** Balancing machines and related equipment, as follows:

*N.B.*:

See also 2B219.

(a) Balancing machines having all of the following characteristics:

1. Not capable of balancing rotors/assemblies having a mass greater than 3 kg;
2. Capable of balancing rotors/assemblies at speeds greater than 12 500 rpm;
3. Capable of correcting unbalance in two planes or more; and
4. Capable of balancing to a residual specific unbalance of 0.2 g mm per kg of rotor mass;

Note:

2B119(a) does not control balancing machines designed or modified for dental or other medical equipment.

(b) Indicator heads designed or modified for use with machines controlled by 2B119(a); *(L.N. 95 of 2006)*

*Technical Note*:

Indicator heads are sometimes known as balancing instrumentation.

*(L.N. 65 of 2004)*

**2B120** Motion simulators or rate tables having all of the following characteristics:
(a) Two axes or more;
(b) Designed or modified to incorporate slip rings or integrated 
non-contact devices capable of transferring electrical power 
or signal information, or both; \(\text{L.N. 226 of 2009}\)
(c) Having any of the following characteristics:
   (1) For any single axis having both of the following 
characteristics:
      (a) Capable of rates of 400 degrees/s or more, or 
30 degrees/s or less; \textit{and}
      (b) A rate resolution equal to or less than 6 
degrees/s and an accuracy equal to or less 
than 0.6 degrees/s;
   (2) Having a worst-case rate stability equal to or better 
(less) than plus or minus 0.05\% averaged over 10 
degrees or more; \textit{or}
   (3) A positioning accuracy equal to or less (better) than 5 
arcs second; \(\text{L.N. 254 of 2008}\)

\textit{Notes:}
1. 2B120 does not include rotary tables designed or 
modified for machine tools or for medical equipment. 
For machine tool rotary tables, see 2B008.
2. Motion simulators or rate tables specified in 2B120 
remain so specified whether or not slip rings or 
integrated non-contact devices are fitted at time of 
export. \(\text{L.N. 226 of 2009}\) \(\text{(L.N. 65 of 2004)}\)

\textbf{2B121} Positioning tables (equipment capable of precise rotary positioning 
in any axes), other than those controlled by 2B120, having all of the 
following characteristics: \(\text{L.N. 95 of 2006}\)
(a) Two axes or more; \textit{and}
(b) A positioning accuracy equal to or less (better) than 5 arc 
second; \(\text{L.N. 254 of 2008}\)

\textit{Note:}
2B121 does not control rotary tables designed or modified for 
machine tools or for medical equipment. For controls on machine 
tool rotary tables, see 2B008. \(\text{L.N. 65 of 2004}\)
2B122 Centrifuges capable of imparting accelerations above 100 g and
designed or modified to incorporate slip rings or integrated non-
contact devices capable of transferring electrical power or signal
information, or both;

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

*(L.N. 226 of 2009)*

2B201 Machine tools and any combination of machine tools, other than
those controlled by 2B001, as follows, for removing or cutting metals,
ceramics or "composites", which, according to the manufacturer’s
technical specification, can be equipped with electronic devices for
simultaneous "contouring control" in two or more axes: *(L.N. 254 of
2008; L.N. 42 of 2017)*

*Technical Note:*

Stated ‘positioning accuracy’ levels derived under the following
procedures from measurements made according to ISO 230/2 (1988)
or national equivalents (if provided to and accepted by national
authorities), instead of those derived from individual machine tests,
may be used for each machine tool model. Manufacturers calculating
‘positioning accuracy’ in accordance with ISO 230/2 (1997) or (2006)
are to consult the competent authorities of the Member State in
which they are established. Stated ‘positioning accuracy’ is
determined as follows:

(a) Select 5 machines of a model to be evaluated;
(b) Measure the linear axis accuracies according to ISO 230/2
(1988);
(c) Determine the accuracy value (A) for each axis of each
machine. The method of calculating the accuracy value is
described in ISO 230/2 (1988) standard;
(d) Determine the average accuracy value for each axis. This
average value becomes the stated ‘positioning accuracy’ of
each axis for the model (\(\bar{A}_x, \bar{A}_y, \ldots\));
(e) Since 2B201 refers to each linear axis, there will be as many
stated ‘positioning accuracy’ values as there are linear axes;
(f) If any axis of a machine tool not controlled by 2B201(a),
2B201(b) or 2B201(c) has the following stated ‘positioning accuracy’ according to ISO 230/2 (1988), then the builder is to be required to reaffirm the accuracy level once every 18 months—

(1) for grinding machines—equal to or less (better) than 6 \( \mu \text{m} \); or

(2) for milling and turning machines—equal to or less (better) than 8 \( \mu \text{m} \).

(L.N. 42 of 2017)

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

(1) ‘Positioning accuracies’ with “all compensations available” equal to or less (better) than 6 \( \mu \text{m} \) according to ISO 230/2 (1988) or national equivalents along any linear axis; (L.N. 65 of 2004; L.N. 42 of 2017)

(2) Two or more contouring rotary axes;

(3) Five or more axes which can be coordinated simultaneously for “contouring control”; (L.N. 254 of 2008; L.N. 42 of 2017)

Note:

2B201(a) does not control milling machines having the following characteristics:

(a) X-axis travel greater than 2 m; and

(b) Overall ‘positioning accuracy’ on the x-axis more (worse) than 30 \( \mu \text{m} \). (L.N. 65 of 2004; L.N. 95 of 2006; L.N. 42 of 2017)

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

(1) ‘Positioning accuracies’ with “all compensations available” equal to or less (better) than 4 \( \mu \text{m} \) according to ISO 230/2 (1988) or national equivalents along any linear axis; (L.N. 65 of 2004; L.N. 42 of 2017)

(2) Two or more contouring rotary axes; (L.N. 65 of 2004)

(3) Five or more axes, which can be coordinated simultaneously for “contouring control”; (L.N. 254 of 2008)
Note:

2B201(b) does not control the following grinding machines:  
(*L.N. 42 of 2017*)

1. Cylindrical external, internal, and external-internal grinding machines having all of the following characteristics:  
   (a) Limited to a maximum workpiece capacity of 150 mm outside diameter or length;  
   (b) Axes limited to x, z and c; *and*  
2. Jig grinders that do not have a z-axis or a w-axis with an overall ‘positioning accuracy’ less (better) than 4 μm according to ISO 230/2 (1988) or national equivalents. (*L.N. 254 of 2008; L.N. 42 of 2017*)  
   (c) Machine tools for turning, having ‘positioning accuracies’ with “all compensations available” better (less) than 6 μm according to ISO 230/2 (1988) along any linear axis (overall positioning) for machines capable of machining parts with diameters greater than 35 mm;  
   *Note:*  
   2B201(c) does not control bar machines (Swissturn) having the following characteristics:  
   (a) Only for machining bar feed thru;  
   (b) The maximum bar diameter is equal to or less than 42 mm; *and*  
   (c) No capability of mounting chucks, though such machines described above may have drilling or milling capabilities, or both, for machining parts with diameters less than 42 mm. (*L.N. 42 of 2017*)

*Notes:*  
1. 2B201 does not control special purpose machine tools limited to the manufacture of any of the following parts:  
   (a) Gears;  
   (b) Crankshafts or camshafts;  
   (c) Tools or cutters;  
   (d) Extruder worms. (*L.N. 42 of 2017*)  
2. A machine tool having at least two of the three turning, milling or grinding capabilities (e.g., a turning machine with milling capability), must be evaluated against each
applicable entry of 2B201(a), 2B201(b) or 2B201(c). (L.N. 254 of 2008; L.N. 42 of 2017)

(L.N. 254 of 2008; L.N. 42 of 2017)

2B204 “Isostatic presses”, other than those controlled by 2B004 or 2B104, and related equipment, as follows: (L.N. 95 of 2006)
(a) “Isostatic presses” having both of the following characteristics:
(1) Capable of achieving a maximum working pressure of 69 MPa or greater; and
(2) A chamber cavity with an inside diameter in excess of 152 mm;
(b) Dies, moulds and controls, specially designed for “isostatic presses” controlled by 2B204(a); (L.N. 95 of 2006)

Technical Note:
In 2B204, the inside chamber dimension is that of the chamber in which both the working temperature and the working pressure are achieved and does not include fixtures. That dimension will be the smaller of either the inside diameter of the pressure chamber or the inside diameter of the insulated furnace chamber, depending on which of the two chambers is located inside the other. (L.N. 132 of 2001)

2B206 Dimensional inspection machines, instruments or systems, other than those specified in 2B006, as follows: (L.N. 95 of 2006; L.N. 161 of 2011)
(a) Computer controlled or numerically controlled coordinate measuring machines (CMM) meeting either of the following descriptions: (L.N. 42 of 2017)
(1) Having only 2 axes and having a maximum permissible error of length measurement along any axis (1-dimensional), identified as any combination of $E_{0x,MPE}$, $E_{0y,MPE}$, or $E_{0z,MPE}$, equal to or less (better) than $(1.25 + L/1000) \mu$m (where L is the measured length in mm) at any point within the operating range of the machine (i.e. within the length of the axis), according to ISO 10360/2 (2009);
(2) Having 3 or more axes and having a 3-dimensional
(volumetric) maximum permissible error of length measurement ($E_{0,MPE}$) equal to or less (better) than $(1.7 + L/800) \mu m$ (where L is the measured length in mm) at any point within the operating range of the machine (i.e. within the length of the axis), according to ISO 10360/2 (2009); (L.N. 42 of 2017)

Technical Note:
The $E_{0,MPE}$ of the most accurate configuration of the CMM specified according to ISO 10360/2 (2009) by the manufacturer (e.g. best of the following: probe, stylus, length, motion parameters, environments) and with "all compensations available" is to be compared to the $1.7 + L/800 \mu m$ threshold. (L.N. 42 of 2017)

(b) Systems for simultaneously linear-angular inspection of hemishells, having both of the following characteristics:

1. “Measurement uncertainty” along any linear axis equal to or less (better) than $3.5 \mu m$ per 5 mm; and
2. “Angular position deviation” equal to or less than $0.02^\circ$;

Notes:
1. Machine tools that can be used as measuring machines are controlled if they meet or exceed the criteria specified for the machine tool function or the measuring machine function.
2. A machine specified in 2B206 is controlled if it exceeds the control threshold anywhere within its operating range.

Technical Note:
All parameters of measurement values in 2B206 represent plus/minus i.e. not total band. (L.N. 161 of 2011)

(L.N. 65 of 2004)

2B207 “Robots”, “end-effectors” and control units, other than those controlled by 2B007, as follows: (L.N. 95 of 2006)

(a) “Robots” or “end-effectors” specially designed to comply with national safety standards applicable to handling high explosives (for example, meeting electrical code ratings for high explosives);

(b) Control units specially designed for any of the “robots” or “end-effectors” controlled by 2B207(a); (L.N. 132 of 2001;
Flow forming machines, spin forming machines capable of flow forming functions, other than those controlled by 2B009 or 2B109, and mandrels, as follows: (L.N. 95 of 2006)

(a) Machines having both of the following characteristics:
   (1) Three or more rollers (active or guiding); and
   (2) Which, according to the manufacturer’s technical specification, can be equipped with “numerical control” units or a computer control; (L.N. 65 of 2004)

(b) Rotor-forming mandrels designed to form cylindrical rotors of inside diameter between 75 mm and 400 mm;

Note:
2B209(a) includes machines which have only a single roller designed to deform metal plus two auxiliary rollers which support the mandrel, but do not participate directly in the deformation process. (L.N. 65 of 2004)

Centrifugal multiplane balancing machines, fixed or portable, horizontal or vertical, as follows:

(a) Centrifugal balancing machines designed for balancing flexible rotors having a length of 600 mm or more and having all of the following characteristics:
   (1) Swing or journal diameter greater than 75 mm; (L.N. 65 of 2004)
   (2) Mass capability of from 0.9 to 23 kg; and
   (3) Capable of balancing speed of revolution more than 5 000 rpm;

(b) Centrifugal balancing machines designed for balancing hollow cylindrical rotor components and having all of the following characteristics:
   (1) Journal diameter greater than 75 mm; (L.N. 65 of 2004)
   (2) Mass capability of from 0.9 to 23 kg;
   (3) Capable of balancing to a residual imbalance equal to or less than 0.01 kg × mm/kg per plane; and (L.N. 65 of 2004)
   (4) Belt drive type; (L.N. 132 of 2001)
2B225 Remote manipulators that can be used to provide remote actions in radiochemical separation operations and hot cells, as follows:
(a) Having a capability of penetrating 0.6 m or more of hot cell wall (through-the-wall operation); or
(b) Having a capability of bridging over the top of a hot cell wall with a thickness of 0.6 m or more (over-the-wall operation);  
*Technical Note: (L.N. 65 of 2004)*
Remote manipulators provide translation of human operator actions to a remote operating arm and terminal fixture. They may be of master/slave type or operated by joystick or keypad.

2B226 Controlled atmosphere (vacuum or inert gas) induction furnaces, and power supplies therefor, as follows:
*N.B.:*
See also 3B.
(a) Furnaces having all of the following characteristics:
(1) Capable of operation above 1 123 K (850°C);  
(2) Induction coils 600 mm or less in diameter; and
(3) Designed for power inputs of 5 kW or more;
(b) Power supplies, with a specified power output of 5 kW or more, specially designed for furnaces controlled by 2B226(a); *(L.N. 95 of 2006)*

*Note:*
2B226(a) does not control furnaces designed for the processing of semiconductor wafers. *(L.N. 65 of 2004)*

2B227 Vacuum or other controlled atmosphere metallurgical melting and casting furnaces and related equipment as follows:
(a) Arc remelt and casting furnaces having both of the following characteristics:
(1) Consumable electrode capacities between 1 000 cm³ and 20 000 cm³; and
(2) Capable of operating with melting temperatures above 1 973 K (1 700°C);
(b) Electron beam melting furnaces and “plasma atomization” and melting furnaces, having both of the following
characteristics: \((L.N.\ 42\ of\ 2017)\)

(1) A power of 50 kW or greater; and

(2) Capable of operating with melting temperatures above 1 473 K \((1 200^\circ\text{C})\);

(c) Computer control and monitoring systems specially configured for any of the furnaces controlled by 2B227(a) or 2B227(b); \((L.N.\ 95\ of\ 2006)\)

\((L.N.\ 65\ of\ 2004)\)

2B228 Rotor fabrication or assembly equipment, rotor straightening equipment, bellows-forming mandrels and dies, as follows:

(a) Rotor assembly equipment for assembly of gas centrifuge rotor tube sections, baffles, and end caps;

Note:
2B228(a) includes precision mandrels, clamps, and shrink fit machines.

(b) Rotor straightening equipment for alignment of gas centrifuge rotor tube sections to a common axis;

Technical Note:
In 2B228(b), such equipment normally consists of precision measuring probes linked to a computer that subsequently controls the action of, for example, pneumatic rams used for aligning the rotor tube sections.

(c) Bellows-forming mandrels and dies for producing single-convolution bellows;

Technical Note:
In 2B228(c), the bellows have all of the following characteristics:

1. Inside diameter between 75 mm and 400 mm;
2. Length equal to or greater than 12.7 mm;
3. Single convolution depth greater than 2 mm; and
4. Made of high-strength aluminium alloys, maraging steel or high strength “fibrous or filamentary materials”.

\((L.N.\ 65\ of\ 2004)\)

2B230 All types of ‘pressure transducers’ capable of measuring absolute pressures that meet all of the following descriptions: \((L.N.\ 42\ of\ 2017)\)
(a) Pressure sensing elements made of or protected by aluminium, aluminium alloy, aluminium oxide (alumina or sapphire), nickel or nickel alloy with more than 60% nickel by weight, or fully fluorinated hydrocarbon polymers; (L.N. 42 of 2017)

(b) Seals, if any, essential for sealing the pressure sensing element, and in direct contact with the process medium, made of or protected by aluminium, aluminium alloy, aluminium oxide (alumina or sapphire), nickel or nickel alloy with more than 60% nickel by weight, or fully fluorinated hydrocarbon polymers; (L.N. 42 of 2017)

(c) Having either of the following characteristics:
   (1) A full scale of less than 13 kPa and an ‘accuracy’ of better than ±1% of full-scale;
   (2) A full scale of 13 kPa or greater and an ‘accuracy’ of better than ±130 Pa when measured at 13 kPa; (L.N. 42 of 2017)

Technical Notes:
1. In 2B230, ‘pressure transducer’ means a device that converts a pressure measurement into a signal.
2. For the purposes of 2B230, ‘accuracy’ includes non-linearity, hysteresis and repeatability at ambient temperature. (L.N. 42 of 2017)

2B231 Vacuum pumps having all of the following characteristics:
(a) Input throat size equal to or greater than 380 mm;
(b) Pumping speed equal to or greater than 15 m³/s; and
(c) Capable of producing an ultimate vacuum better than 13 mPa;

Technical Notes:
1. The pumping speed is determined at the measurement point with nitrogen gas or air.
2. The ultimate vacuum is determined at the input of the pump with the input of the pump blocked off.
   (L.N. 65 of 2004)

2B232 High-velocity gun systems (propellant, gas, coil, electromagnetic, and electrothermal types, and other advanced systems) capable of
accelerating projectiles to 1.5 km/s or greater;

N.B.: See also the Munitions List.

(L.N. 42 of 2017)

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

N.B.: See also 2B350(i).

(a) Capable of an inlet volume flow rate of 50 m$^3$/h or greater;
(b) Capable of a pressure ratio of 2:1 or greater;
(c) Having all surfaces that come in contact with the process gas made from any of the following materials:
   (1) Aluminium or aluminium alloy;
   (2) Aluminium oxide;
   (3) Stainless steel;
   (4) Nickel or nickel alloy;
   (5) Phosphor bronze;
   (6) Fluoropolymers;

(L.N. 42 of 2017)

2B350 Chemical manufacturing facilities, equipment and components, as follows: (L.N. 65 of 2004)

(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:
   (1) ‘Alloys’ with more than 25% nickel and 20% chromium by weight;
   (2) Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight); (L.N. 42 of 2017)
   (3) Glass (including vitrified or enamelled coating or glass lining);
   (4) Nickel or ‘alloys’ with more than 40% nickel by weight;
   (5) Tantalum or tantalum ‘alloys’;
(6) Titanium or titanium ‘alloys’;
(7) Zirconium or zirconium ‘alloys’;
(8) Niobium (columbium) or niobium ‘alloys’; (L.N. 254 of 2008)

(b) Agitators designed for use in reaction vessels or reactors specified in 2B350(a); and impellers, blades or shafts designed for such agitators, where all surfaces of the agitator that come in direct contact with the chemical(s) being processed or contained are made from any of the following materials: (L.N. 65 of 2004; L.N. 95 of 2006; L.N. 42 of 2017)

(1) ‘Alloys’ with more than 25% nickel and 20% chromium by weight;
(2) Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight); (L.N. 42 of 2017)
(3) Glass (including vitrified or enamelled coatings or glass lining);
(4) Nickel or ‘alloys’ with more than 40% nickel by weight;
(5) Tantalum or tantalum ‘alloys’;
(6) Titanium or titanium ‘alloys’;
(7) Zirconium or zirconium ‘alloys’;
(8) Niobium (columbium) or niobium ‘alloys’; (L.N. 254 of 2008)

(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 (polymeric or elastomeric materials with more than 35% fluorine by weight); (L.N. 42 of 2017)
(3) Glass (including vitrified or enamelled coatings or glass lining);
(4) Nickel or ‘alloys’ with more than 40% nickel by weight;
(5) Tantalum or tantalum ‘alloys’;
(6) Titanium or titanium ‘alloys’;
(7) Zirconium or zirconium ‘alloys’;
(8) Niobium (columbium) or niobium ‘alloys’; *(L.N. 254 of 2008)*

(d) Heat exchangers or condensers with a heat transfer surface area greater than 0.15 m\(^2\), and less than 20 m\(^2\); and tubes, plates, coils or blocks (cores) designed for such heat exchangers or condensers, where all surfaces that come in direct contact with the chemical(s) being processed are made from any of the following materials: *(L.N. 65 of 2004)*

1. ‘Alloys’ with more than 25% nickel and 20% chromium by weight;
2. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight); *(L.N. 42 of 2017)*
3. Glass (including vitrified or enamelled coatings or glass lining);
4. Graphite or ‘carbon graphite’; *(L.N. 65 of 2004)*
5. Nickel or ‘alloys’ with more than 40% nickel by weight;
6. Tantalum or tantalum ‘alloys’;
7. Titanium or titanium ‘alloys’; *(L.N. 132 of 2001)*
8. Zirconium or zirconium ‘alloys’;
9. Silicon carbide; *(L.N. 132 of 2001)*
10. Titanium carbide; *(L.N. 132 of 2001)*
11. Niobium (columbium) or niobium ‘alloys’; *(L.N. 254 of 2008)*

(e) Distillation or absorption columns of internal diameter greater than 0.1 m; and liquid distributors, vapour distributors or liquid collectors designed for such distillation or absorption columns, where all surfaces that come in direct contact with the chemical(s) being processed are made from any of the following materials: *(L.N. 65 of 2004)*

1. ‘Alloys’ with more than 25% nickel and 20% chromium by weight;
2. Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight); *(L.N. 42 of 2017)*
3. Glass (including vitrified or enamelled coatings or
glass lining);

(4) Graphite or ‘carbon graphite’; *(L.N. 65 of 2004)*

(5) Nickel or ‘alloys’ with more than 40% nickel by weight;

(6) Tantalum or tantalum ‘alloys’;

(7) Titanium or titanium ‘alloys’;

(8) Zirconium or zirconium ‘alloys’;

(9) Niobium (columbium) or niobium ‘alloys’; *(L.N. 254 of 2008)*

(f) Remotely operated filling equipment in which all surfaces that come in direct contact with the chemical(s) being processed are made from any of the following materials:

1. ‘Alloys’ with more than 25% nickel and 20% chromium by weight; or
2. Nickel or ‘alloys’ with more than 40% nickel by weight;

(g) Valves and components, as follows:

1. Valves that meet all of the following descriptions:
   (a) A ‘nominal size’ greater than 10 mm (3/8”);
   (b) All surfaces that come in direct contact with the chemical(s) being produced, processed, or contained are made from ‘corrosion resistant materials’;

2. Valves, other than those specified in 2B350(g)(1), that meet all of the following descriptions:
   (a) A ‘nominal size’ equal to or greater than 25.4 mm (1”) and equal to or less than 101.6 mm (4”);
   (b) Casings (valve bodies) or preformed casing liners;
   (c) A closure element designed to be interchangeable;
   (d) All surfaces of the casing (valve body) or preformed casing liner that come in direct contact with the chemical(s) being produced, processed, or contained are made from ‘corrosion resistant materials’;

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

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

**Technical Notes:**

1. For the purposes of 2B350(g), ‘corrosion resistant materials’ mean any of the following materials:
   (a) Nickel or ‘alloys’ with more than 40% nickel by weight;
   (b) ‘Alloys’ with more than 25% nickel and 20% chromium by weight;
   (c) Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight);
   (d) Glass or glass-lined (including vitrified or enamelled coating);
   (e) Tantalum or tantalum ‘alloys’;
   (f) Titanium or titanium ‘alloys’;
   (g) Zirconium or zirconium ‘alloys’;
   (h) Niobium (columbium) or niobium ‘alloys’;
   (i) Ceramic materials as follows:
      (1) Silicon carbide with a purity of 80% or more by weight;
      (2) Aluminium oxide (alumina) with a purity of 99.9% or more by weight;
      (3) Zirconium oxide (zirconia).

2. ‘Nominal size’ is defined as the smaller of the inlet and outlet diameters. *(L.N. 42 of 2017)*

   (h) Multi-walled piping incorporating a leak detection port, in which all surfaces that come in direct contact with the chemical(s) being processed or contained are made from any of the following materials:
   (1) ‘Alloys’ with more than 25% nickel and 20% chromium by weight;
   (2) Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight); *(L.N. 42 of 2017)*
   (3) Glass (including vitrified or enamelled coatings or
(4) Graphite or ‘carbon graphite’; \((L.N. \text{ 65 of 2004})\)

(5) Nickel or ‘alloys’ with more than 40% nickel by weight;

(6) Tantalum or tantalum ‘alloys’;

(7) Titanium or titanium ‘alloys’;

(8) Zirconium or zirconium ‘alloys’;

(9) Niobium (columbium) or niobium ‘alloys’; \((L.N. \text{ 254 of 2008})\)

(i) Multiple-seal and seal-less pumps, with manufacturer’s specified maximum flow-rate greater than 0.6 \(\text{m}^3/\text{hour}\), or vacuum pumps with manufacturer’s specified maximum flow-rate greater than 5 \(\text{m}^3/\text{hour}\) (under standard temperature \((273 \text{ K } (0^\circ\text{C}))\) and pressure \((101.3 \text{ kPa})\) conditions, other than those specified in 2B233); and casings (pump bodies), preformed casing liners, impellers, rotors or jet pump nozzles designed for such pumps), in which all surfaces that come in direct contact with the chemical(s) being processed are made from any of the following materials: \((L.N. \text{ 65 of 2004}; L.N. \text{ 95 of 2006}; L.N. \text{ 42 of 2017})\)

(1) ‘Alloys’ with more than 25% nickel and 20% chromium by weight;

(2) Ceramics;

(3) Ferrosilicon (high silicon iron ‘alloys’); \((L.N. \text{ 42 of 2017})\)

(4) Fluoropolymers (polymeric or elastomeric materials with more than 35% fluorine by weight); \((L.N. \text{ 42 of 2017})\)

(5) Glass (including vitrified or enamelled coatings or glass lining);

(6) Graphite or ‘carbon graphite’; \((L.N. \text{ 65 of 2004})\)

(7) Nickel or ‘alloys’ with more than 40% nickel by weight;

(8) Tantalum or tantalum ‘alloys’;

(9) Titanium or titanium ‘alloys’;

(10) Zirconium or zirconium ‘alloys’;

(11) Niobium (columbium) or niobium ‘alloys’; \((L.N. \text{ 254 of 2008})\)

\textit{Technical Note:}
In 2B350(i), the term seal refers to only those seals that come into direct contact with the chemical(s) being processed (or is designed to), and provide a sealing function where a rotary or reciprocating drive shaft passes through a pump body. (L.N. 42 of 2017)

(j) Incinerators designed to destroy chemicals controlled by 1C350, having specially designed waste supply systems, special handling facilities and an average combustion chamber temperature greater than 1 273 K (1 000°C), in which all surfaces in the waste supply system that come into direct contact with the waste products are made from or lined with any of the following materials:

1. ‘Alloys’ with more than 25% nickel and 20% chromium by weight;
2. Ceramics; or
3. Nickel or ‘alloys’ with more than 40% nickel by weight;

Note:
For the purposes of 2B350, the materials used for gaskets, packing, seals, screws, washers or other materials performing a sealing function do not determine the status of control, provided that such components are designed to be interchangeable. (L.N. 42 of 2017)

Technical Notes:
1. ‘Carbon graphite’ is a composition consisting of amorphous carbon and graphite, in which the graphite content is eight percent or more by weight.
2. For the listed materials in the above entries, the term ‘alloy’ when not accompanied by a specific elemental concentration is understood as identifying those alloys where the identified metal is present in a higher percentage by weight than any other element. (L.N. 161 of 2011)

(L.N. 254 of 2008; L.N. 161 of 2011)

2B351 Toxic gas monitoring systems and their dedicated detecting components, other than those specified in 1A004, as follows; and detectors; sensor devices; and replaceable sensor cartridges: (L.N. 161 of 2011)

(a) Designed for continuous operation and usable for the detection of chemical warfare agents or chemicals controlled
by 1C350, at concentrations of less than 0.3 mg/m$^3$; or (L.N. 65 of 2004; L.N. 95 of 2006)

(b) Designed for the detection of cholinesterase-inhibiting activity;

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

(a) Complete biological containment facilities at P3, P4 containment level;

*Technical Note:*

P3 or P4 (BL3, BL4, L3, L4) containment levels are as specified in the WHO Laboratory Biosafety manual (3rd edition, Geneva, 2004). (L.N. 254 of 2008)

(b) Fermenters and components as follows:

(1) ‘Fermenters’ capable of cultivation of pathogenic “microorganisms” or of live cells for the production of pathogenic viruses or toxins, without the propagation of aerosols, and having a total capacity of 20 litres or more;

(2) Components designed for ‘fermenters’ in 2B352(b)(1) as follows:

(a) Cultivation chambers designed to be sterilized or disinfected in situ;

(b) Cultivation chamber holding devices;

(c) Process control units capable of simultaneously monitoring and controlling 2 or more fermentation system parameters (e.g. temperature, pH, nutrients, agitation, dissolved oxygen, air flow, foam control);

*Technical Note:*

For the purposes of 2B352(b), ‘fermenters’ include bioreactors, single-use (disposable) bioreactors, chemostats and continuous-flow systems. (L.N. 42 of 2017)

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

(1) Flow rate exceeding 100 litres per hour;

(2) Components of polished stainless steel or titanium;

(3) One or more sealing joints within the steam
(4) Capable of in-situ steam sterilisation in a closed state;

Technical Note:
Centrifugal separators include decanters.

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

(1) Cross (tangential) flow filtration equipment capable of separation of pathogenic “microorganisms”, viruses, “toxins” or cell cultures, that meets all of the following descriptions: 

(a) A total filtration area equal to or greater than 1 m\(^2\); *(L.N. 42 of 2017)*

(b) Meeting any of the following descriptions:

(1) Capable of being ‘sterilized’ or ‘disinfected’ in situ;

(2) Using disposable or single-use filtration components; *(L.N. 42 of 2017)*

Technical Note:
In 2B352(d)(1)(b), ‘sterilized’ denotes the elimination of all viable microbes from the equipment through the use of either physical (e.g. steam) or chemical agents. ‘Disinfected’ denotes the destruction of potential microbial infectivity in the equipment through the use of chemical agents with a germicidal effect. Disinfection and sterilization are distinct from sanitization, the latter referring to cleaning procedures designed to lower the microbial content of equipment without necessarily achieving elimination of all microbial infectivity or viability. *(L.N. 42 of 2017)*

(2) Cross (tangential) flow filtration components (e.g. modules, elements, cassettes, cartridges, units or plates) with filtration area equal to or greater than 0.2 m\(^2\) for each component and designed for use in cross (tangential) flow filtration equipment controlled by 2B352(d);
Note:
2B352(d) does not control reverse osmosis equipment, as specified by the manufacturer. *(L.N. 95 of 2006)*

(e) Steam sterilisable freeze drying equipment with a condenser capacity exceeding 10 kg of ice in 24 hours and less than 1 000 kg of ice in 24 hours;

(f) Protective and containment equipment, as follows:
   (1) Protective full or half suits, or hoods dependent upon a tethered external air supply and operating under positive pressure;
       *Note:*
       2B352(f)(1) does not control suits designed to be worn with self-contained breathing apparatus.
   (2) Class III biological safety cabinets or isolators with similar performance standards;
       *Note:*
       In 2B352(f)(2), isolators include flexible isolators, dry boxes, anaerobic chambers, glove boxes and laminar flow hoods (closed with vertical flow). *(L.N. 65 of 2004)*

(g) Chambers designed for aerosol challenge testing with “microorganisms”, viruses or “toxins” and having a capacity of 1 m³ or greater;

(h) Spray-drying equipment capable of drying “toxins” or pathogenic “microorganisms”, that meets all of the following descriptions:
   (1) Having a water evaporation capacity of ≥ 0.4 kg/h and ≤ 400 kg/h;
   (2) Having the ability to generate a typical mean product particle size of ≤ 10 μm with existing fittings or by minimal modification of the spray-dryer with atomization nozzles enabling generation of the required particle size;
   (3) Capable of being ‘sterilized’ or ‘disinfected’ in situ; *(L.N. 42 of 2017)* *(L.N. 65 of 2004)*

2C MATERIALS
None.
2D SOFTWARE

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

(a) “Software” specially designed or modified for the “development” or “production” of equipment specified in 2A001 or 2B001;

(b) “Software” specially designed or modified for the “use” of equipment specified in 2A001(c), 2B001 or 2B003 to 2B009;

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

(L.N. 42 of 2017)

2D002 “Software” for electronic devices, even when residing in an electronic device or system, enabling such devices or systems to function as a “numerical control” unit, capable of coordinating simultaneously more than 4 axes for “contouring control”;

Notes: (L.N. 65 of 2004)
1. 2D002 does not control “software” specially designed or modified for the operation of items not specified in Category 2. (L.N. 132 of 2001; L.N. 65 of 2004; L.N. 42 of 2017)
2. 2D002 does not control "software" for items specified in 2B002. See 2D001 and 2D003 for “software” for items specified in 2B002. (L.N. 65 of 2004; L.N. 42 of 2017)
3. 2D002 does not control "software" that is exported with, and the minimum necessary for the operation of, items not specified in Category 2. (L.N. 42 of 2017)

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

(L.N. 42 of 2017)

2D101 “Software” specially designed or modified for the “use” of equipment controlled by 2B104, 2B105, 2B109, 2B116, 2B117 or 2B119 to 2B122; (L.N. 95 of 2006)
N.B.:  
See also 9D004.  

(L.N. 65 of 2004)

2D201 “Software” specially designed for the “use” of equipment controlled by 2B204, 2B206, 2B207, 2B209, 2B219 or 2B227;  

(L.N. 132 of 2001)

2D202 “Software” specially designed or modified for the “development”, “production” or “use” of equipment specified in 2B201;  
Note:  
2D202 does not control part programming “software” that generates “numerical control” command codes but does not allow direct use of equipment for machining various parts. (L.N. 42 of 2017)  

(L.N. 42 of 2017)

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

(L.N. 161 of 2011)

2E TECHNOLOGY

2E001 “Technology” according to the General Technology Note for the “development” of equipment or “software” controlled by 2A, 2B or 2D;  
Note:  
2E001 includes “technology” for the integration of probe systems into coordinate measurement machines (CMM) specified in 2B006(a). (L.N. 89 of 2013; L.N. 42 of 2017)

2E002 “Technology” according to the General Technology Note for the “production” of equipment controlled by 2A or 2B;

2E003 Other “technology”, as follows:  
(a) “Technology” for the “development” of interactive graphics as an integrated part in “numerical control” units for preparation or modification of part programmes;  
(b) “Technology” for metal-working manufacturing processes, as follows:
(1) “Technology” for the design of tools, dies or fixtures specially designed for any of the following processes:
   (a) “Superplastic forming”;
   (b) “Diffusion bonding”; or
   (c) “Direct-acting hydraulic pressing”;

(2) Technical data consisting of process methods or parameters as listed below used to control:
   (a) “Superplastic forming” of aluminium alloys, titanium alloys or “superalloys”:
       (1) Surface preparation;
       (2) Strain rate;
       (3) Temperature;
       (4) Pressure;
   (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;
   (e) “Technology” for the “development” or “production” of hydraulic stretch-forming machines and dies therefor, for the manufacture of airframe structures;
   (d) “Technology” for the “development” of generators of machine tool instructions (e.g., part programmes) from design data residing inside “numerical control” units;
   (e) “Technology for the development” of integration “software” for incorporation of expert systems for advanced decision support of shop floor operations into “numerical control” units;
   (f) “Technology” for the application of inorganic overlay
coatings or inorganic surface modification coatings (specified in column 3 of the following table) to non-electronic substrates (specified in column 2 of the following table), by processes specified in column 1 of the following table and defined in the Technical Note;

N.B.:
This Table should be read to control the technology of a particular ‘Coating Process’ only when the ‘Resultant Coating’ in column 3 is in a paragraph directly across from the relevant ‘Substrate’ under column 2. For example, Chemical Vapour Deposition (CVD) coating process technical data are controlled for the application of ‘Silicides’ to ‘Carbon-carbon, Ceramic and Metal “matrix” “composites”’ substrates, but are not controlled for the application of ‘Silicides’ to ‘Cemented tungsten carbide\(^{16}\)’, Silicon carbide\(^{18}\)’ substrates. In the second case, the ‘Resultant Coating’ is not listed in the paragraph under column 3 directly across from the paragraph under column 2 listing ‘Cemented tungsten carbide\(^{16}\)’, Silicon carbide\(^{18}\)’. (L.N. 132 of 2001)

### TABLE-DEPOSITION TECHNIQUES

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B. Thermal Evaporation—
Physical Vapour Deposition (TE-PVD)

1. Physical Vapour Deposition (PVD):
   “Superalloys”
   Alloyed silicides
   Alloyed aluminides
   MCrA1X
   Modified zirconia
   Silicides
   Aluminides
   Mixtures thereof
   Dielectric layers
   Ceramics
   Low-expansion glasses
   Corrosion resistant steel
   Carbon-carbon, Ceramic and Metal “matrix” “composites”
   Silicides
   Carbides
   Refractory metals
   Mixtures thereof
   Dielectric layers
   Boron nitride
   Cemented tungsten Carbides

Boron nitride
Carbides
Tungsten
Mixtures thereof
Dielectric layers
Dielectric layers
Diamond
Diamond-like carbon
Dielectric layers
Diamond
Diamond-like carbon

Cemented tungsten carbide
Silicon carbide
Carbides
Tungsten
Mixtures thereof
Dielectric layers
Boron nitride
Cemented tungsten carbide
Silicon carbide
Carbides
Tungsten
Mixtures thereof
Dielectric layers
Boron nitride
Cemented tungsten carbide
Silicon carbide
Carbides
Tungsten
Mixtures thereof
Dielectric layers
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Mixtures thereof
Dielectric layers
Boron nitride
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<td>Dielectric layers</td>
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<td>Diamond-like carbon</td>
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3. Physical Vapour Deposition (PVD):

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<td>Low-expansion</td>
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<tr>
<td>Carbon-carbon, Ceramic and Metal “matrix” “composites” &amp; Dielectric layers^{15}</td>
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<td>Beryllium and</td>
<td>Borides</td>
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<td>Beryllium alloys</td>
<td>Dielectric layers</td>
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<td>Beryllium</td>
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<td>Sensor window materials</td>
<td>Dielectric layers</td>
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<td>Diamond-like carbon</td>
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<td>Refractory metals and</td>
<td>Aluminides</td>
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<td>alloys</td>
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<td>G. Ion Implantation</td>
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<td>High temperature</td>
<td>Additions of Chromium,</td>
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<td>bearing steels</td>
<td>Tantalum or Niobium</td>
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<td>(Columbium)</td>
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<td>Titanium alloys</td>
<td>Borides</td>
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<td>Nitrides</td>
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<td>Beryllium and</td>
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Cap 60G - IMPORT AND EXPORT (STRATEGIC COMMODITIES) REGULATIONS
Beryllium alloys
Cemented tungsten Carbides
Carbide\(^{(16)}\) Nitrides

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

\((L.N. 132 \text{ of } 2001)\)

**TABLE-DEPOSITION TECHNIQUES-NOTES**

1. The term ‘coating process’ includes coating repair and refurbishing as well as original coating.

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

3. The term ‘noble metal modified aluminide’ coating includes multiple-step coatings in which the noble metal or noble metals are laid down by some other coating process prior to application of the aluminide coating.

4. The term ‘mixtures thereof’ includes infiltrated material, graded compositions, co-deposits and multilayer deposits and are obtained by one or more of the coating processes specified in the Table.

5. ‘MCrA1X’ 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) CoCrA1Y 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) CoCrA1Y 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) NiCrA1Y coatings which contain 21 to 23 weight percent of
chromium, 10 to 12 weight percent of aluminium and 0.9 to 1.1 weight percent of yttrium.

6. The term ‘aluminium alloys’ refers to alloys having an ultimate tensile strength of 190 MPa or more measured at 293 K (20°C).

7. The term ‘corrosion resistant steel’ refers to AISI (American Iron and Steel Institute) 300 series or equivalent national standard steels.

8. ‘Refractory metals and alloys’ include the following metals and their alloys: niobium (columbium), molybdenum, tungsten and tantalum.

9. ‘Sensor window materials’, as follows: alumina, silicon, germanium, zinc sulphide, zinc selenide, gallium arsenide, diamond, gallium phosphide, sapphire and the following metal halides: sensor window materials of more than 40 mm diameter for zirconium fluoride and hafnium fluoride.

10. “Technology” for single-step pack cementation of solid airfoils is not controlled by Category 2.

11. ‘Polymers’, as follows: polyimide, polyester, polysulphide, polycarbonates and polyurethanes.

12. ‘Modified zirconia’ refers to additions of other metal oxides (e.g. calcia, magnesia, yttria, hafnia, rare earth oxides) to zirconia in order to stabilise certain crystallographic phases and phase compositions. Thermal barrier coatings made of zirconia, modified with calcia or magnesia by mixing or fusion, are not controlled.

13. ‘Titanium alloys’ refers 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 x 10^-7 K^-1 or less measured at 293 K (20°C).

15. ‘Dielectric layers’ are coatings constructed of multi-layers of insulator
materials in which the interference properties of a design composed of materials of various refractive indices are used to reflect, transmit or absorb various wavelength bands. Dielectric layers refers to more than four dielectric layers or dielectric/metal “composite” layers.

16. ‘Cemented tungsten carbide’ does not include cutting and forming tool materials consisting of tungsten carbide/(cobalt, nickel), titanium carbide/(cobalt, nickel), chromium carbide/nickel-chromium and chromium carbide/nickel.

17. “Technology” specially designed to deposit diamond-like carbon on any of the following is not controlled: magnetic disk drives and heads, equipment for the manufacture of disposables, valves for faucets, acoustic diaphragms for speakers, engine parts for automobiles, cutting tools, punching-pressing dies, office automation equipment, microphones or medical devices; or moulds for casting or moulding of plastics, manufactured from alloys containing less than 5% beryllium. *(L.N. 65 of 2004)*

18. ‘Silicon carbide’ does not include cutting and forming tool materials.

19. Ceramic substrates, as used in this entry, does not include ceramic materials containing 5% by weight, or greater, clay or cement content, either as separate constituents or in combination. *(L.N. 132 of 2001)*

**TABLE-DEPOSITION TECHNIQUES-TECHNICAL NOTE**

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

(a) Chemical Vapour Deposition (CVD) is an overlay coating or surface modification coating process wherein a metal, alloy, “composite”, dielectric or ceramic is deposited upon a heated substrate. Gaseous reactants are decomposed or combined in the vicinity of a substrate resulting in the deposition of the desired elemental, alloy or compound material on the substrate. Energy for this decomposition or chemical reaction process may be provided by the heat of the substrate, a glow discharge plasma, or “laser” irradiation.
N.B.:  
1. CVD includes the following processes: directed gas flow out-of-pack deposition, pulsating CVD, controlled nucleation thermal deposition (CNTD), plasma enhanced or plasma assisted CVD processes.  
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) Ion Assisted Resistive Heating PVD employs electrically resistive heating sources in combination with impinging ion beam(s) to produce a controlled and uniform flux of evaporated coating species;  
(3) “Laser” Vaporization uses either pulsed or continuous wave “laser” beams to vaporize the material which forms the coating;  
(4) Cathodic Arc Deposition employs a consumable cathode of the material which forms the coating and has an arc discharge established on the surface by a momentary contact of a ground trigger. Controlled motion of arcing
erodes the cathode surface creating a highly ionized plasma. The anode can be either a cone attached to the periphery of the cathode, through an insulator, or the chamber. Substrate biasing is used for non line-of-sight deposition;

*NB*:
This definition does not include random cathodic arc deposition with non-biased substrates.

(5) Ion Plating is a special modification of a general TE-PVD process in which a plasma or an ion source is used to ionize the species to be deposited, and a negative bias is applied to the substrate in order to facilitate the extraction of the species from the plasma. The introduction of reactive species, evaporation of solids within the process chamber, and the use of monitors to provide in-process measurement of optical characteristics and thicknesses of coatings are ordinary modifications of the process.

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

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

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

(d) Plasma Spraying is an overlay coating process wherein a gun (spray torch) which produces and controls a plasma accepts powder or wire coating materials, melts them and propels them towards a substrate, whereon an integrally bonded coating is formed. Plasma spraying constitutes either low pressure plasma spraying or high velocity plasma spraying.

*NB*:
1. 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.

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

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

_N.B._:
1. The Table refers only to triode, magnetron or reactive sputter deposition which is used to increase adhesion of the coating and rate of deposition and to radio frequency (RF) augmented sputter deposition used to permit vaporization of non-metallic coating materials.
2. Low-energy ion beams (less than 5 keV) can be used to activate the deposition.

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

_(L.N. 132 of 2001)_

**TABLE-DEPOSITION TECHNIQUES-STATEMENT OF UNDERSTANDING**

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

1. “Technology” for pretreatments of the substrates listed in the Table, as follows:
(a) Chemical stripping and cleaning bath cycle parameters, as follows:

(1) Bath composition:
   (a) For the removal of old or defective coatings, corrosion product or foreign deposits;
   (b) For preparation of virgin substrates;

(2) Time in bath;
(3) Temperature of bath;
(4) Number and sequences of wash cycles;

(b) Visual and macroscopic criteria for acceptance of the cleaned part;

(c) Heat treatment cycle parameters, as follows:

(1) Atmosphere parameters, as follows:
   (a) Composition of the atmosphere;
   (b) Pressure of the atmosphere;

(2) Temperature for heat treatment;
(3) Time of heat treatment;

(d) Substrate surface preparation parameters, as follows:

(1) Grit blasting parameters, as follows:
   (a) Grit composition;
   (b) Grit size and shape;
   (c) Grit velocity;

(2) Time and sequence of cleaning cycle after grit blast;
(3) Surface finish parameters;

(e) Masking technique parameters, as follows:

(1) Material of mask;
(2) Location of mask.

2. “Technology” for in situ quality assurance techniques for evaluation of the coating processes listed in the Table, as follows:

(a) Atmosphere parameters, as follows:

(1) Composition of the atmosphere;
(2) Pressure of the atmosphere;

(b) Time parameters;
(c) Temperature parameters;
(d) Thickness parameters;
(e) Index of refraction parameters;
(f) Control of composition.
3. “Technology” for post deposition treatments of the coated substrates listed in the Table, as follows:
   (a) Shot peening parameters, as follows:
       (1) Shot composition;
       (2) Shot size;
       (3) Shot velocity;
   (b) Post shot peening cleaning parameters;
   (c) Heat treatment cycle parameters, as follows:
       (1) Atmosphere parameters, as follows:
           (a) Composition of the atmosphere;
           (b) Pressure of the atmosphere;
       (2) Time-temperature cycles;
       (d) Post heat treatment visual and macroscopic criteria for acceptance of the coated substrates.

4. “Technology” for quality assurance techniques for the evaluation of the coated substrates listed in the Table, as follows:
   (a) Statistical sampling criteria;
   (b) Microscopic criteria for:
       (1) Magnification;
       (2) Coating thickness uniformity;
       (3) Coating integrity;
       (4) Coating composition;
       (5) Coating and substrates bonding;
       (6) Microstructural uniformity;
   (c) Criteria for optical properties assessment (measured as a function of wavelength):
       (1) Reflectance;
       (2) Transmission;
       (3) Absorption;
       (4) Scatter.

5. “Technology” and parameters related to specific coating and surface modification processes listed in the Table, as follows:
   (a) For Chemical Vapour Deposition:
       (1) Coating source composition and formulation;
       (2) Carrier gas composition;
(3) Substrate temperature;
(4) Time-temperature-pressure cycles;
(5) Gas control and part manipulation;

(b) For Thermal Evaporation-Physical Vapour Deposition:
   (1) Ingot or coating material source composition;
   (2) Substrate temperature;
   (3) Reactive gas composition;
   (4) Ingot feed rate or material vaporisation rate;
   (5) Time-temperature-pressure cycles;
   (6) Beam and part manipulation;
   (7) “Laser” parameters, as follows:
      (a) Wave length;
      (b) Power density;
      (c) Pulse length;
      (d) Repetition ratio;
      (e) Source;
      (f) Substrate orientation;

(c) For Pack Cementation:
   (1) Pack composition and formulation;
   (2) Carrier gas composition;
   (3) Time-temperature-pressure cycles;

(d) For Plasma Spraying:
   (1) Powder composition, preparation and size distributions;
   (2) Feed gas composition and parameters;
   (3) Substrate temperature;
   (4) Gun power parameters;
   (5) Spray distance;
   (6) Spray angle;
   (7) Cover gas composition, pressure and flow rates;
   (8) Gun control and part manipulation;

(e) For Sputter Deposition:
   (1) Target composition and fabrication;
   (2) Geometrical positioning of part and target;
   (3) Reactive gas composition;
   (4) Electrical bias;
   (5) Time-temperature-pressure cycles;
   (6) Triode power;
(7) Part manipulation;

(f) For Ion Implantation: *(L.N. 65 of 2004)*

(1) Beam control and part manipulation;
(2) Ion source design details;
(3) Control techniques for ion beam and deposition rate parameters;
(4) Time-temperature-pressure cycles;

(g) For Ion Plating:

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

*(L.N. 183 of 1999)*

**2E101** “Technology” according to the General Technology Note for the “use” of equipment or “software” controlled by 2B004, 2B009, 2B104, 2B109, 2B116, 2B119 to 2B122 or 2D101;

*(L.N. 65 of 2004; L.N. 95 of 2006)*

**2E201** “Technology” according to the General Technology Note for the “use” of equipment or “software” specified in 2A225, 2A226, 2B001, 2B006, 2B007(b), 2B007(c), 2B008, 2B009, 2B201, 2B204, 2B206, 2B207, 2B209, 2B225 to 2B228, 2B230 to 2B233, 2D201 or 2D202;

*(L.N. 132 of 2001; L.N. 42 of 2017)*

**2E301** “Technology” according to the General Technology Note for the “use” of goods controlled by 2B350 to 2B352;

*(L.N. 132 of 2001)*