GOODS REVIEW LIST

Section A	Chemical Section
Section B	Biological Section
Section C	Missile Section
Section D	Nuclear Section
Section E	Conventional Section

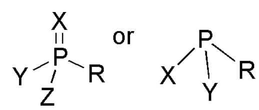
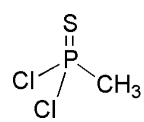
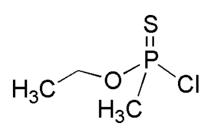
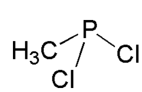
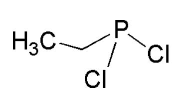
GOODS REVIEW LIST
SECTION A
CHEMICAL SECTION

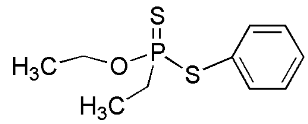
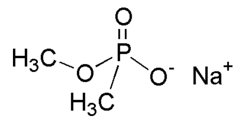
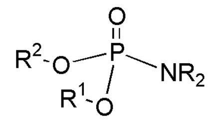
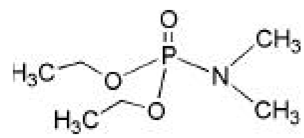
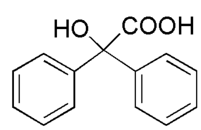
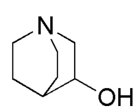
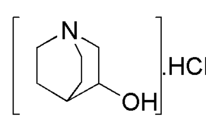
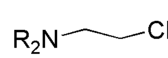
1. The following list (List A) contains chemicals capable of being used for the development, production or acquisition of chemical weapons, but which also are usable for purposes not prohibited by resolution 687 (1991) and, therefore, are subject to notification under the Export/Import monitoring mechanism for Iraq approved by Security Council resolution 1051 (1996). For the purposes of this annex the chemicals listed include their chemical forms and mixtures.

Note:
All mixtures which contain two or more chemicals from List A in any percentage, are subject to notification, but mixtures that contain less than 10% (weight/weight; on a solvent free basis) of only one chemical of List A are exempted.

The term chemical forms mean all stereoisomers, allotropes or isotopes of the chemical in any physical state (for example gaseous, liquid, solid, solvated, powdered etc).

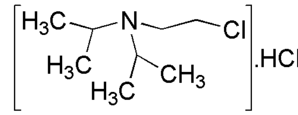
List A: Dual-Use Chemicals Requiring Review

ITEM	STRUCTURE
A.01 (Commodity Designator Code: CA000A01) Chemicals, except those specified in List B of this annex, containing a phosphorus atom to which is bonded one alkyl group but no further carbon atoms.	 where R = C_nH_{2n+1} $n \geq 1$ and X, Y, Z = any atom or group for which the atom directly bonded to the central phosphorus atom is not carbon
for example: Methylphosphonothioic dichloride [CAS No. 676-98-2]	
for example: O-Ethyl methylphosphonothioic chloride [CAS No. 2524-16-5]	
for example: Methylphosphonous dichloride [CAS No. 676-83-5]	
for example: Ethylphosphonous dichloride [CAS No. 1498-40-4]	

ITEM	STRUCTURE
for example: O-Ethyl S-phenyl ethylphosphonothiolothionate [CAS No. 944-22-9] (also known as: Fonofos)	
for example: Methylphosphonic acid, monomethyl ester, sodium salt. [CAS No. 73750-69-3]	
A.02 (Commodity Designator Code: CA000A02) Dialkyl (Me, Et, n-Pr or i-Pr) N,N-dialkyl (Me, Et, n-Pr or i-Pr)-phosphoramidates	 where R, R^1, R^2 = C_nH_{2n+1} n = 1-3
for example: Diethyl N,N-dimethylphosphoramidate [CAS No. 2404-03-7]	
A.03 (Commodity Designator Code: CA000A03) Arsenic trichloride [CAS No. 7784-34-1]	$AsCl_3$
A.04 (Commodity Designator Code: CA000A04) 2,2-Diphenyl-2-hydroxyacetic acid [CAS No. 76-93-7] (also known as: benzilic acid)	
A.05 (Commodity Designator Code: CA000A05) Quinuclidin-3-ol [CAS No. 1619-34-7] and corresponding protonated salts	
for example: Quinuclidin-3-ol hydrochloride [CAS No. 6238-13-7]	
A.06 (Commodity Designator Code: CA000A06) N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethyl-2-chloride and corresponding protonated salts	 where R = C_nH_{2n+1} n = 1-3

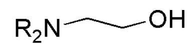
ITEM | **STRUCTURE**

for example:
2-(Diisopropylamino)ethyl chloride hydrochloride
[CAS No. 4261-68-1]



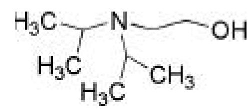
A.07 (Commodity Designator Code: CA000A07)

N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-ol and corresponding protonated salts



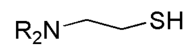
where R = C_nH_{2n+1} n = 1-3

for example:
2-(Diisopropylamino)ethanol
[CAS No. 96-80-0]



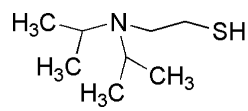
A.08 (Commodity Designator Code: CA000A08)

N,N-Dialkyl (Me, Et, n-Pr or i-Pr) aminoethane-2-thiol and corresponding protonated salts



where R = C_nH_{2n+1} n = 1-3

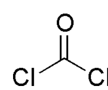
for example:
2-(Diisopropylamino)ethanethiol
[CAS No. 5842-07-9]



A.09 (Commodity Designator Code: CA000A09)

Phosgene
[CAS No. 75-44-5]

(also known as: carbonyl dichloride)



A.10 (Commodity Designator Code: CA000A10)

Cyanogen chloride
[CAS No. 506-77-4]

Cl—C≡N

A.11 (Commodity Designator Code: CA000A11)

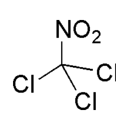
Hydrogen cyanide
[CAS No. 74-90-8]

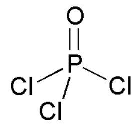
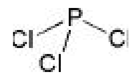
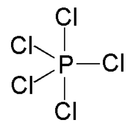
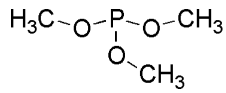
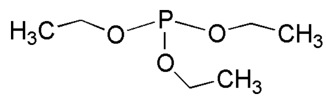
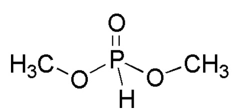
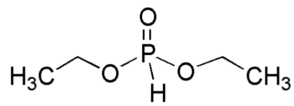
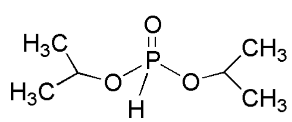
HCN

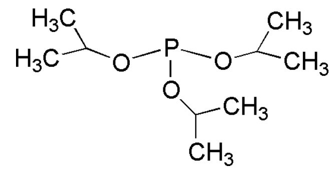
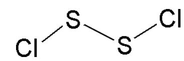
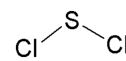
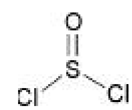
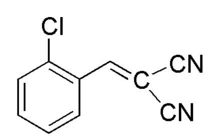
A.12 (Commodity Designator Code: CA000A12)

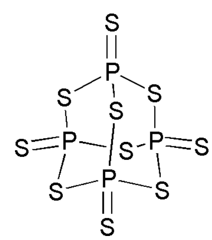
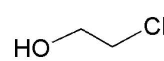
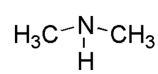
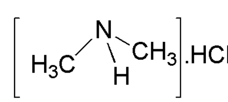
Trichloronitromethane
[CAS No. 76-06-2]

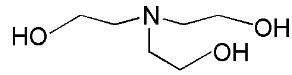
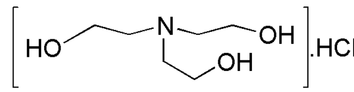
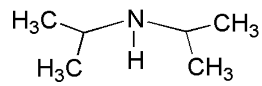
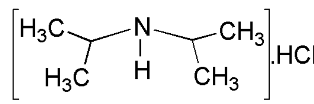
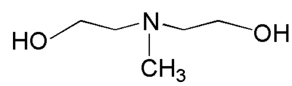
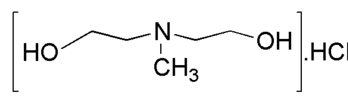
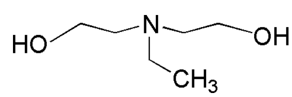
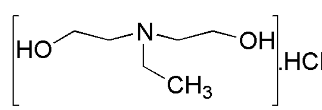
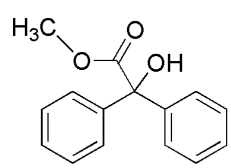
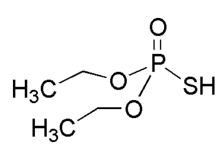
(also known as: chloropicrin)

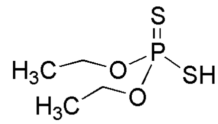
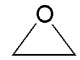
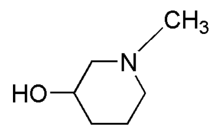
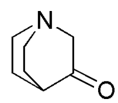
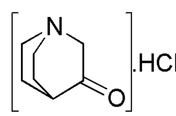
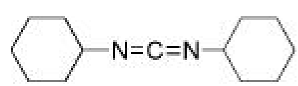
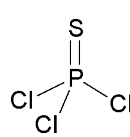


ITEM	STRUCTURE
A.13 (Commodity Designator Code: CA000A13) Phosphorus oxychloride [CAS No. 10025-87-3]	
A.14 (Commodity Designator Code: CA000A14) Phosphorus trichloride [CAS No. 7719-12-2]	
A.15 (Commodity Designator Code: CA000A15) Phosphorus pentachloride [CAS No. 10026-13-8]	
A.16 (Commodity Designator Code: CA000A16) Trimethyl phosphite [CAS No. 121-45-9]	
A.17 (Commodity Designator Code: CA000A17) Triethyl phosphite [CAS No. 122-52-1]	
A.18 (Commodity Designator Code: CA000A18) Dimethyl phosphite [CAS No. 868-85-9] (also known as: dimethyl phosphonate; dimethyl hydrogen phosphite)	
A.19 (Commodity Designator Code: CA000A19) Diethyl phosphite [CAS No. 762-04-9] (also known as: diethyl phosphonate) **A.20 (Commodity Designator Code: CA000A20)** Diisopropyl phosphite [CAS No. 1809-20-7] (also known as: diisopropyl phosphonate)	 

ITEM	STRUCTURE
A.21 (Commodity Designator Code: CA000A21) Triisopropyl phosphite [CAS No. 116-17-6]	
A.22 (Commodity Designator Code: CA000A22) Sulphur monochloride [CAS No. 10025-67-9]	
A.23 (Commodity Designator Code: CA000A23) Sulphur dichloride [CAS No. 10545-99-0]	
A.24 (Commodity Designator Code: CA000A24) Thionyl chloride [CAS No. 7719-09-7]	
A.25 (Commodity Designator Code: CA000A25) Hydrogen fluoride [CAS No. 7664-39-3]	HF
A.26 (Commodity Designator Code: CA000A26) ortho-Chlorobenzylidene malononitrile [CAS No. 2698-41-1] (also known as: CS)	
A.27 (Commodity Designator Code: CA000A27) Potassium fluoride [CAS No. 7789-23-3]	KF
A.28 (Commodity Designator Code: CA000A28) Ammonium bifluoride [CAS No. 1341-49-7]	$NH_4F.HF$
A.29 (Commodity Designator Code: CA000A29) Sodium bifluoride [CAS No. 1333-83-1]	$NaF.HF$

ITEM	STRUCTURE
A.30 (Commodity Designator Code: CA000A30) Sodium fluoride [CAS No. 7681-49-4]	NaF
A.31 (Commodity Designator Code: CA000A31) Potassium bifluoride [CAS No. 7789-29-9]	KF.HF
A.32 (Commodity Designator Code: CA000A32) Sodium sulphide [CAS No. 1313-82-2]	Na_2S
A.33 (Commodity Designator Code: CA000A33) Phosphorus pentasulphide [CAS No. 1314-80-3]	P_2S_5 exists as: 
A.34 (Commodity Designator Code: CA000A34) Chloroethanol [CAS No. 107-07-3]	
A.35 (Commodity Designator Code: CA000A35) Dimethylamine [CAS No. 124-40-3] and corresponding protonated salts	
for example: Dimethylamine hydrochloride [CAS No. 506-59-2]	
A.36 (Commodity Designator Code: CA000A36) Potassium cyanide [CAS No. 151-50-8]	KCN
A.37 (Commodity Designator Code: CA000A37) Sodium cyanide [CAS No. 143-33-9]	NaCN

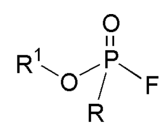
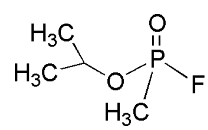
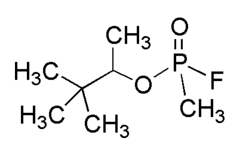
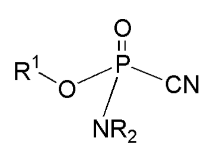
ITEM	STRUCTURE
A.38 (Commodity Designator Code: CA000A38) Triethanolamine [CAS No. 102-71-6] and corresponding protonated salts	
for example: Triethanolamine hydrochloride [CAS No. 637-39-8]	
A.39 (Commodity Designator Code: CA000A39) Diisopropylamine [CAS No. 108-18-9] and corresponding protonated salts	
for example: Diisopropylamine hydrochloride [CAS No. 819-79-4]	
A.40 (Commodity Designator Code: CA000A40) Methyl diethanolamine [CAS No. 105-59-9] and corresponding protonated salts	
for example: Methyl diethanolamine hydrochloride [CAS No. 54060-15-0]	
A.41 (Commodity Designator Code: CA000A41) Ethyl diethanolamine [CAS No. 139-87-7] and corresponding protonated salts	
for example: Ethyl diethanolamine hydrochloride [CAS No. 58901-15-8]	
A.42 (Commodity Designator Code: CA000A42) Methyl benzilate [CAS No. 76-89-1]	
A.43 (Commodity Designator Code: CA000A43) O,O-Diethyl phosphorothioate [CAS No. 2465-65-8]	

ITEM	STRUCTURE
A.44 (Commodity Designator Code: CA000A44) O,O-Diethyl phosphorodithioate [CAS No. 298-06-6]	
A.45 (Commodity Designator Code: CA000A45) Ethylene oxide [CAS No. 75-21-8]	
A.46 (Commodity Designator Code: CA000A46) 3-Hydroxy-1-methylpiperidine [CAS No. 3554-74-3] and corresponding protonated salts	
A.47 (Commodity Designator Code: CA000A47) 3-Quinuclidone [3731-38-2] and corresponding protonated salts	
for example: 3-Quinuclidone hydrochloride [CAS No. 1193-65-3]	
A.48 (Commodity Designator Code: CA000A48) Phosphorus [CAS No. 7723-14-0]	P
A.49 (Commodity Designator Code: CA000A49) Fluorine [CAS No. 7782-41-4]	F_2
A.50 (Commodity Designator Code: CA000A50) Dicyclohexylcarbodiimide [CAS No. 538-75-0]	
A.51 (Commodity Designator Code: CA000A51) Thiophosphoryl Chloride [CAS No. 3982-91-0] (also known as: Phosphorus sulphochloride)	

2. The following list (List B) contains chemicals that have little or no use except as chemical warfare agents or for the development, production or acquisition of chemical weapons, or which have been used by Iraq as essential precursors for chemical weapons and are, therefore, prohibited to Iraq, save under the procedure for special exceptions provided for in paragraph 32 of the Plan (S/22871/Rev.1).

> Note:
> For the purposes of this annex the chemicals listed include their chemical forms and mixtures in any percentage save under the procedure for special exceptions provided for in paragraph 32 of the Plan.
>
> The term chemical forms mean all stereoisomers or isotopes of the chemical in any physical state (for example gaseous, liquid, solid, solvated, powdered etc).

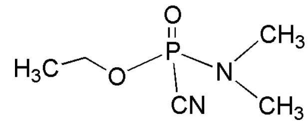
List B– Normally Prohibited Chemicals [except under paragraph 32 of the Plan (S/22871/Rev.1; 1991)]

ITEM	STRUCTURE
B.01 (Commodity Designator Code: CA000B01) O-Alkyl ($\leq C_{10}$, including cycloalkyl) alkyl (Me, Et, n-Pr or i-Pr) phosphonofluoridates	 where R = C_nH_{2n+1} n = 1-3 and R^1 = $\leq C_{10}$, including cycloalkyl
for example: O-Isopropyl methylphosphonofluoridate [CAS No. 107-44-8] (also known as: Sarin; GB)	
for example: O-Pinacolyl methylphosphonofluoridate [CAS No. 96-64-0] (also known as: Soman; GD)	
B.02 (Commodity Designator Code: CA000B02) O-Alkyl ($\leq C_{10}$- including cycloalkyl) N,N-dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidocyanidates	 where R = C_nH_{2n+1} n = 1-3 and R^1 = $\leq C_{10}$, including cycloalkyl

ITEM **STRUCTURE**

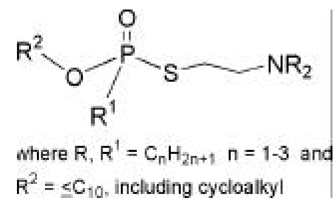
for example:
O-Ethyl N,N-dimethylphosphoramidocyanidate
[CAS No. 77-81-6]

(also known as: Tabun; GA)



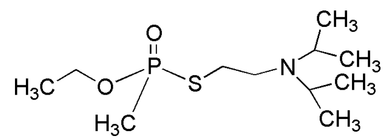
B.03 (Commodity Designator Code: CA000B03)

O-Alkyl (H or ≤C_{10}, including cycloalkyl) S-2-dialkyl (Me, Et, n-Pr or
i-Pr) aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonothiolates or corresponding alkylated and protonated salts



for example:
O-Ethyl S-[2-(diisopropylamino)ethyl] methylphosphonothiolate
[CAS No. 50782-69-9]

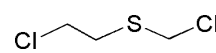
(also known as: VX)



B.04 (Commodity Designator Code: CA000B04)

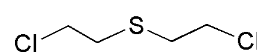
<u>Sulphur mustards</u>:

for example:
2-Chloroethylchloromethylsulphide
[CAS No. 2625-76-5]

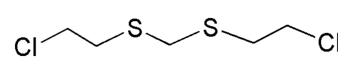


for example:
Bis(2-chloroethyl)sulphide
[CAS No. 505-60-2]

(also known as: Sulphur Mustard; H)

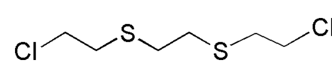


for example:
Bis(2-chloroethylthio)methane
[CAS No. 63869-13-6]

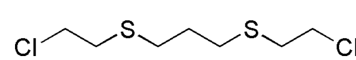


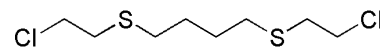
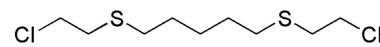
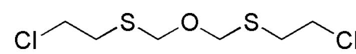
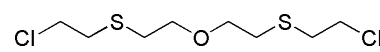
for example:
1,2-Bis(2-chloroethylthio)ethane
[CAS No. 3563-36-8]

(also known as: Sesquimustard; Q)



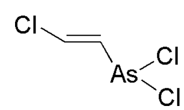
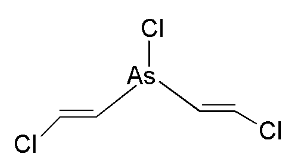
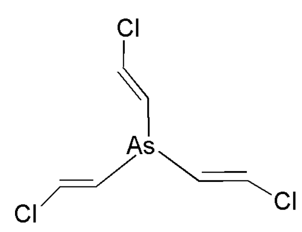
for example:
1,3-Bis(2-chloroethylthio)-n-propane
[CAS No. 63905-10-2]



ITEM	STRUCTURE
for example: 1,4-Bis(2-chloroethylthio)-n-butane [CAS No. 142868-93-7]	
for example: 1,5-Bis(2-chloroethylthio)-n-pentane [CAS No. 142868-94-8]	
for example: Bis(2-chloroethythiomethyl)ether [CAS No. 63918-90-1]	
for example: Bis(2-chloroethylthioethyl)ether [CAS No. 63918-89-8] (also known as: O-mustard; T)	

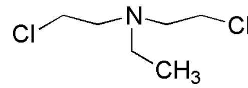
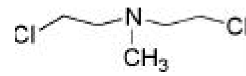
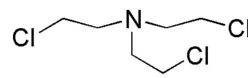
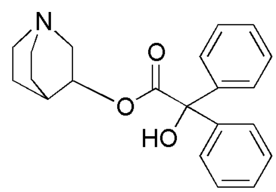
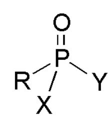
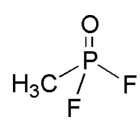
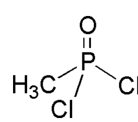
B.05 (Commodity Designator Code: CA000B05)

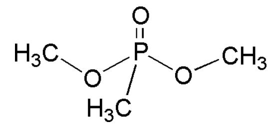
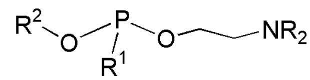
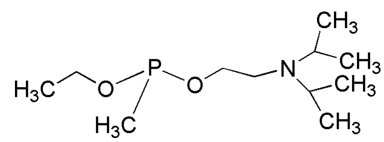
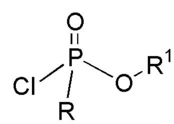
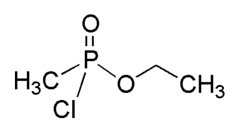
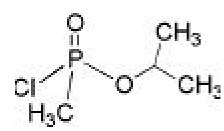
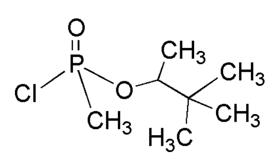
<u>Lewisites:</u>

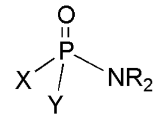
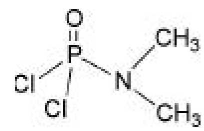
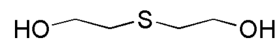
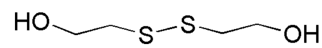
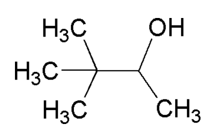
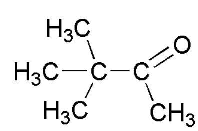
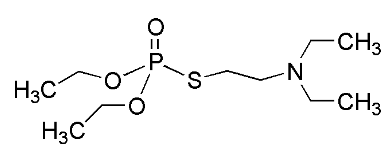
for example: 2-Chlorovinyldichloroarsine [CAS No. 541-25-3] (also known as: Lewisite 1)	
for example: Bis(2-chlorovinyl)chloroarsine [CAS No. 40334-69-8] (also known as: Lewisite 2)	
for example: Tris(2-chlorovinyl)arsine [CAS No. 40334-70-1] (also known as: Lewisite 3)	

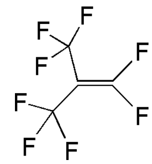
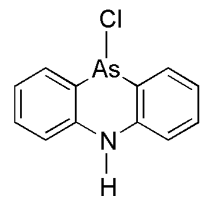
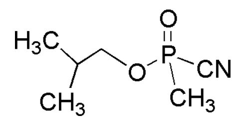
B.06 (Commodity Designator Code: CA000B06)

<u>Nitrogen mustards</u> and their protonated salts:

ITEM	STRUCTURE
for example: Bis(2-chloroethyl)ethylamine [CAS No. 538-07-8] (also known as: HN1)	
for example: Bis(2-chloroethyl)methylamine [CAS No. 51-75-2] (also known as: HN2)	
for example: Tris(2-chloroethyl)amine [CAS No. 555-77-1] (also known as: HN3)	
B.07 (Commodity Designator Code: CA000B07) 3-Quinuclidinyl benzilate [CAS No. 6581-06-2] (also known as: BZ)	
B.08 (Commodity Designator Code: CA000B08) Alkyl (Me, Et, n-Pr or I-Pr) phosphonyldihalides	 where R = C_nH_{2n+1} n = 1-3 and X, Y = halides
for example: Methylphosphonyl difluoride [CAS No. 676-99-3] (also known as: DF; MPF)	
for example: Methylphosphonyl dichloride [CAS No. 676-97-1] (also known as: DC; MPC)	

ITEM	STRUCTURE
B.09 (Commodity Designator Code: CA000B09) Dimethyl methylphosphonate [CAS No. 756-79-6] (also known as: DMMP)	
B.10 (Commodity Designator Code: CA000B10) O-Alkyl (H or $\leq C_{10}$, including cycloalkyl) O-2-Dialkyl (Me, Et, n-Pr or i-Pr)-aminoethyl alkyl (Me, Et, n-Pr or i-Pr) phosphonites and corresponding alkylated salts and protonated salts	 where R, $R^1 = C_nH_{2n+1}$ n = 1-3 and $R^2 = \leq C_{10}$, including cycloalkyl
O-Ethyl O-2-diisopropylaminoethyl methylphosphonite [CAS No. 57856-11-8] (also known as: QL)	
B.11 (Commodity Designator Code: CA000B11) O-Alkyl ($\leq C_{10}$, including cycloalkyl) alkyl (Me, Et, n-Pr or i-Pr) phosphonochloridates	 where $R = C_nH_{2n+1}$ n = 1-3 and $R^1 = \leq C_{10}$, including cycloalkyl
for example: O-Ethyl methylphosphonchloridate [CAS No. 5284-09-3]	
for example: O-Isopropyl methylphosphonochloridate [CAS No. 1445-76-7] (also known as: Chlorosarin)	
for example: O-Pinacolyl methylphosphonochloridate [CAS No. 7040-57-5] (also known as: Chlorosoman)	

ITEM	STRUCTURE
B.12 (Commodity Designator Code: CA000B12) N,N-Dialkyl (Me, Et, n-Pr or i-Pr) phosphoramidic dihalides	 where R = C_nH_{2n+1} n = 1-3 and X, Y = halides
for example: N,N-dimethylphosphoramidic dichloride [CAS No. 677-43-0]	
B.13 (Commodity Designator Code: CA000B13) Bis(2-hydroxyethyl)sulphide [CAS No. 111-48-8] (also known as: Thiodiglycol)	
B.14 (Commodity Designator Code: CA000B14) Bis(2-hydroxyethyl)disulphide [CAS No. 1892-29-1] (also known as: Dithiodiglycol)	
B.15 (Commodity Designator Code: CA000B15) 3,3-Dimethylbutan-2-ol [CAS No. 464-07-3] (also known as: Pinacolyl alcohol)	
B.16 (Commodity Designator Code: CA000B16) 3,3-Dimethylbutan-2-one [CAS No. 75-97-8] (also known as: Pinacolone)	
B.17 (Commodity Designator Code: CA000B17) O,O-Diethyl S-[2-(diethylamino)ethyl] phosphorothiolate [CAS No. 78-53-5] and corresponding alkylated and protonated salts (also known as: Amiton)	

ITEM	STRUCTURE
B.18 (Commodity Designator Code: CA000B18) 1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene [CAS No. 382-21-8] (also known as: PFIB)	
B.19 (Commodity Designator Code: CA000B19) Diphenylaminechloroarsine [CAS No. 578-94-9] (also known as: Adamsite)	
B.20 (Commodity Designator Code: CA000B20) O-Isobutyl methylphosphonocyanidate	

C.10.4.1.1 (Commodity Designator Code: CA010411)

Corrosion resistant[1] reactor vessels or reactors with an internal volume of 0.05 m^3 or greater but less than 20 m^3.

Corrosion resistant[1] agitators for use in reactor vessels.

C.10.4.1.2 (Commodity Designator Code: CA010412)

Corrosion resistant[1] condensers and corrosion resistant[1] heat exchangers with a heat transfer surface area of 0.03 m^2 or greater.

C.10.4.1.3 (Commodity Designator Code: CA010413)

Corrosion resistant[1] distillation and corrosion resistant[1] absorption columns with an internal diameter of 0.05 m or greater.

C.10.4.1.4 (Commodity Designator Code: CA010414)

Corrosion resistant[1] scrubbers and corrosion resistant[1] separators for use in scrubbers.

C.10.4.1.5 (Commodity Designator Code: CA010415)

Corrosion resistant[1] tanks and other corrosion resistant[1] storage vessels with an internal volume of 0.05 m^3 or more.

C.10.4.1.6 (Commodity Designator Code: CA010416)

Sheets made of fluoropolymer or corrosion resistant[1] metal or alloy with a surface area of more than 1 m^2 and a thickness of 4 mm or more.

C.10.4.2 (Commodity Designator Code: CA010420)

Corrosion resistant[1] multiple-seal, canned drive, magnetic drive, bellows or diaphragm pumps, or progressive cavity tubing pumps (including peristaltic or roller pumps in which only the elastometric tubing is corrosion resistant[1]) with manufacturer’s specified maximum flow-rate of 0.01 m^3/minute or greater, under standard temperature (293 K) and standard pressure (101.30 kPa) conditions.

Corrosion resistant[1] vacuum pumps with manufacture’s specified maximum flow-rate greater than 0.08 m^3/minute under standard temperature (293 K) and pressure (101.3 kPa) conditions.

C.10.4.3 (Commodity Designator Code: CA010430)

Corrosion resistant[1] conduits (including single and double-walled pipes, towers, columns and tubes) with an inner diameter of 0.05 m or more.

C.10.4.4 (Commodity Designator Code: CA010440)

Corrosion resistant[1] valves with a smallest inner diameter of 12.5 mm or more.

C.10.4.5 (Commodity Designator Code: CA010450)

Corrosion resistant[1] remote-controlled filling equipment.

C.10.4.6 (Commodity Designator Code: CA010460)

Incineration equipment designed for the disposal of toxic chemicals with an average combustion chamber temperature of over 1273 K (1000^0 C) or with catalytic incineration over 623 K (350^0 C).

C.10.4.7 (Commodity Designator Code: CA010470)

Equipment and instruments designed for detecting, measuring or recording directly and near real time (within one minute),
(a) the air concentration of the Goods Review List, Chemical Section, List A dual-use chemicals or toxic organic substances/organic compounds containing the elements chlorine, fluorine, phosphorus or sulphur, with a detection threshold from 0.3 mg/m^3 ; or
(b) levels of cholinesterase-inhibitors in the air, including specially designed equipment for the detection or identification of chemical warfare agents.

Note: The above entry excludes smoke detectors for household protection.

C.10.4.8 (Commodity Designator Code: CA010480)

Chemical protection equipment designed for protection against toxic chemicals (as given in the Goods Review List, Chemical Section, Lists A & B) as follows:
(a) external ventilated semi- or full-protection personal suits;
(b) autonomous respirators; and
(c) air filtration equipment using liquid or solid adsorption agent.

Note: The above entry excludes equipment specially designed for fire fighting use and specially designed equipment for use by personnel in emergency evacuation procedures.

C.10.4.9 (Commodity Designator Code: CA010490)

Chemical spraying equipment made from corrosion resistant[1] materials with an operating pressure of 1 bar or more forming droplets of 300 microns or smaller.

Materials encompassed by the term "Corrosion Resistant"

[1/] For the purposes of this annex, "corrosion resistant" means where all surfaces that come in direct contact with the chemical(s) being processed are made from the following:

(i) glass (including vitrified or enamelled coatings or glass lining);
(ii) ceramics;
(iii) ferrosilicons;
(iv) titanium or titanium alloys - (some examples: Monel 10, Monel 11, titanium 20, titanium nitride 70, titanium nitride 90);
(v) tantalum or tantalum alloys;
(vi) zirconium or zirconium alloys;
(vii) nickel or alloys with more than 40 per cent nickel by weight - (some examples: Alloy 400, AMS 4675, ASME SB164-B, ASTM B127, DIN2.4375, EN60, FM60, IN60, Hastelloy, Monel, K500, UNS NO4400, Inconel 600, Colmonoy Nr.6);
(viii) alloys with more than 25 per cent nickel and 20 per cent chromium and/or copper by weight - (some examples: Alloy 825, Cunifer 30Cr, EniCu-7, IN 732 X, Inconel 800, Monel 67, Monel WE 187, Nicrofer 3033, UNS C71900);
(ix) graphite or carbon/graphite (a composite consisting of amorphous carbon and graphite in which the graphite content is 8 per cent or more by weight);
(x) fluoropolymers - (some examples: Aclar, Aflex COP, Aflon COP 88, F 40, Flurorex, Ftorlon, Ftoroplast, Neoflon, ETFE, Teflon, Tetzel, PVDF, PVF_2, PFA, PTFE, PE TFE 500 LZ, Halar; Viton A);
(xi) silver.

NOTE: Documents, information, software or technology for the design, development, use, storage, manufacture, maintenance or support of entries in Lists A-C, excluding that in the public domain, published basic scientific research or the minimum necessary for the use of the goods detailed in Lists A and C, require review. “Document” means blueprints, plans, diagrams, models, formulae, tables, engineering designs or specifications, manuals or instructions.

GOODS REVIEW LIST
SECTION B
BIOLOGICAL SECTION

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1. Microorganisms, other organisms, toxins or genetically modified organisms or material, as specified in List 1 (Explanatory Note, see attached).

Microorganisms means bacteria (including mycoplasma, and rickettsiae), viruses, or fungi, whether natural, enhanced or modified, either in the form of isolated live cultures, including live cultures in dormant form or in dried preparations, or as material including living material which has been deliberately inoculated or contaminated with such cultures.

Toxins include purified or crude material.

2.1 (Commodity Designator Code: BA002100)

Facilities, rooms or other enclosures that meet the physical containment criteria for P3 or P4 (BL3, BL4, L3, L4) biological containment as specified in the <u>WHO Laboratory Biosafety Manual</u> (Geneva, 1993).

2.2 (Commodity Designator Code: BA002200)

Biological safety cabinets, which allow manual operations to be performed within, whilst providing an equivalent to Class I, II or III biological protection, as specified in the <u>WHO Laboratory Biosafety Manual</u> (Geneva, 1993) as follows:

<u>Class I cabinet:</u> an open-fronted, ventilated cabinet for personal protection with an unrecirculated inward air flow away from the operator. It is fitted with a HEPA filter to protect the environment from a discharge of microorganisms;

<u>Class II cabinet</u>: an open-fronted, ventilated cabinet for personal, product and environmental protection, which provides an inward air flow and HEPA-filtered supply and exhaust air. There are two main variations: the Class IIA type recirculates 70 percent of the air; the Class IIB type recirculates 30 percent of the air; and

Class III cabinet: a totally enclosed ventilated cabinet, which is gas-tight and is maintained under negative air pressure. The supply air is HEPA-filtered and the exhaust air is passed through two HEPA filters in series. Work is performed with attached long-sleeved gloves.

Kits to upgrade Class I biosafety cabinets to Class II or III.

Specially designed long sleeved gloves for Class III biosafety cabinet.

2.3 (Commodity Designator Code: BA002300)

Flexible film isolators, glove boxes, anaerobic chambers, dry boxes and secondary containment systems using HEPA air filtration, and having access ports for control, manipulation and decontamination.

2.4 (Commodity Designator Code: BA002400)

HEPA filters of a frame area of 0.0625 m^2 or greater and which have a DOP rating of 99.997 % (at 0.3 micron) or higher.

2.5 (Commodity Designator Code: BA002500)

Autoclaves designed to sterilize infectious material, with an internal volume equal to 1.0 m^3 or greater.

2.6 (Commodity Designator Code: BA002600)

Positive pressure air-fed suits, half suits, helmets and respirators designed for biological use.

3.1 (Commodity Designator Code: BA003100)

Fermenters, bioreactors, chemostats, and continuous flow fermentation systems with a vessel capacity of 50 litres or more and the following specially designed components:

Top plates;
Vessels;
PH probes; and
PO_2 probes.

3.2 (Commodity Designator Code: BA003200)

Specially designed tissue culture cultivation vessels in which each vessel has an effective growth surface area of 450cm^2 or greater.

3.3 (Commodity Designator Code: BA003300)

Orbital or reciprocal shakers with a total flask capacity greater than 250 litres, designed for use with biological material.

Shaking incubators with a total flask capacity greater than 250 litres, designed for use with biological material.

4.1 (Commodity Designator Code: BA004100)

Centrifugal separators (or decanters) designed for use with biological material capable of continuous operation at a flow rate of 50 litres per hour or greater and specially designed rotors therefor.

4.2 (Commodity Designator Code: BA004200)

Batch centrifuges with a rotor capacity of 25 litres or greater, designed for use with biological material.

4.3 (Commodity Designator Code: BA004300)

Cross-flow and tangential filtration equipment designed for use with biological material with a filter area equal to or greater than $2m^2$ and component filter cartridges therefor.

4.4 (Commodity Designator Code: BA004400)

Spray drying equipment designed for use with biological material and the following specially designed components:

Spray/atomiser units;
Cyclones;
Classifiers; and
Electronic control units.

4.5 (Commodity Designator Code: BA004500)

Freeze-drying (lyophilisation) equipment with a condenser capacity greater than 5 kg of ice in 24 hours, and specially designed vacuum chambers therefor.

4.6 (Commodity Designator Code: BA004600)

Size reduction equipment (including milling and grinding equipment) capable of producing powders with a mean particle size of 15 microns or less, and the following specially designed components:

Grinding heads;
Milling heads;
Milling bodies;
Grinders; and
Classifiers.

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5. (Commodity Designator Code: BA005000)

Formulated powdered complex growth media or cell culture media prepackaged in a container size of 5 kg or greater.

Formulated concentrated liquid complex growth media or cell culture media prepackaged in a container size of 5 liters or greater.

Microbiological grade yeast extract when prepackaged in a container size of 5 kg or greater.

Cell culture grade fetal bovine serum when prepackaged in containers of 1 liter or greater.

6.1 (Commodity Designator Code: BA006100)

Immunological assay systems for microorganisms, toxins, or genetic material in List 1, with specially designed reagents.

6.2 (Commodity Designator Code: BA006200)

Gene probe assay systems for microorganisms, toxins, or genetic material in List 1, with specially designed reagents.

6.3 (Commodity Designator Code: BA006300)

Biological agent detection systems for microorganisms, toxins, or genetic material in List 1, designed for biological defense or civil defense applications.

6.4 (Commodity Designator Code: BA006400)

Nucleic acid sequencing equipment.

6.5 (Commodity Designator Code: BA006500)

Nucleic acid synthesizers.

6.6 (Commodity Designator Code: BA006600)

Electroporation or biolistics equipment.

6.7 (Commodity Designator Code: BA006700)

Thermal cyclers designed for use in molecular biology.

7.1 (Commodity Designator Code: BA007100)

Aircraft sprayers capable of dispersing aerosols with an ultimate mean size of 15 microns or less at a flow rate exceeding 1 litre of liquid suspension per minute or 10 g of dry material per minute, and the following specially designed components:

Spray tanks;
Certified pumps; and
Spray nozzles.

7.2 (Commodity Designator Code: BA007200)

Aerosol disseminators (other than aircraft sprayers and foggers), capable of dispersing aerosols with an ultimate mean size of 15 microns or less at a flow rate exceeding 1 litre of liquid suspension per minute or 10 g of dry material per minute.

Note: This entry excludes dry powder fire extinguishers.

7.3 (Commodity Designator Code: BA007300)

Foggers including pulse jet disseminators capable of dispersing aerosols with an ultimate mean size of 15 microns or less at a flow rate exceeding 1 litre of liquid suspension per minute or 10 g of dry material per minute, and the following specially designed components:

Head unit; and
Nozzle assembly.

8.1 (Commodity Designator Code: BA008100)

Aerosolization drums, cabinets, chambers, rooms or other enclosures usable in the study of aerosols.

8.2 (Commodity Designator Code: BA008200)

Nose–only aerosolisation equipment but excluding devices for personal prophylaxis or therapy for medical conditions.

8.3 (Commodity Designator Code: BA008300)

Aerodynamic particle-sizing equipment.

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9. (Commodity Designator Code: BA009000)

Vaccines to microorganisms or toxins described in List 1 (excluding subcategories 1.4, 1.5, and 1.6) for use with humans and animals except for the following entries:

Shigella dysenteriae;
Foot and mouth disease virus;
Lyssa virus;
Newcastle disease virus;
Peste des petits ruminants virus;
Rinderpest virus; and
Yellow fever virus.

Note: Vaccines containing viable microorganisms included in List 1 are notifiable under the List 1 entry.

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10. (Commodity Designator Code: BA010000)

Documents, information, software or technology for the design, development, use, storage, manufacture, maintenance or support of entries 1 to 9 above and item 11, excluding that in the public domain, published basic scientific research or the minimum necessary for the use of the goods detailed in entries 1 to 9 and 11.

Note: "Document" means blueprints, plans, diagrams, models, formulae, tables, engineering designs or specifications, manuals or instructions, pertaining to micro-organisms, toxins and genetic material except those containing information generally available to the public.

11. (Commodity Designator Code: BA011000)

Equipment for the microencapsulation of live microorganisms and toxins in the range of 1-15 micron particle size, to include interfacial polycondensors and phase separators.

Explanatory Note

LIST 1 - Microorganisms, Viruses, Toxins, Fungi, Other Organisms, and Genetically Modified Organisms Subject to Review

1.1 Microorganisms

Entry Number	Name	Other Names	Commodity Designator Code
1.1.1	Bacillus anthracis		BA001101
1.1.2	Bacillus cereus		BA001102
1.1.3	Bacillus licheniformis		BA001103
1.1.4	Bacillus megaterium		BA001104
1.1.5	Bacillus pumilis		BA001105
1.1.6	Bacillus subtilis		BA001106
1.1.7	Bacillus thuringensis		BA001107
1.1.8	Bartonella quintana,	Rochalimaea quintana, Rickettsia quintana	BA001108
1.1.9	Brucella abortus		BA001109
1.1.10	Brucella melitensis		BA001110
1.1.11	Brucella suis		BA001111
1.1.12	Burkholderia mallei	Pseudomonas mallei	BA001112
1.1.13	Burkholderia pseudomallei	Pseudomonas pseudomallei	BA001113
1.1.14	Chlamydia psittaci		BA001114
1.1.15	Clostridium botulinum		BA001115
1.1.16	Clostridium perfringens		BA001116
1.1.17	Coxiella burnetii		BA001117
1.1.18	Erwinia amylovora		BA001118
1.1.19	Escherichia coli O157:H7		BA001119
1.1.20	Francisella tularensis		BA001120
1.1.21	Mycoplasma mycoides		BA001121
1.1.22	Ralstonia solanacearum		BA001122
1.1.23	Rickettsia prowazekii		BA001123
1.1.24	Rickettsia rickettsii		BA001124
1.1.25	Salmonella typhi	Salmonella enterica var typhi	BA001125
1.1.26	Serratia marcescens		BA001126
1.1.27	Shigella dysenteriae		BA001127
1.1.28	Staphylococcus aureus		BA001128
1.1.29	Vibrio cholerae		BA001129
1.1.30	Xanthomonas albilineans		BA001130
1.1.31	Xanthomonas campestris pv. citri	Xanthomonas campestris pv. citri types A, B, C, D, E; Xanthomonas citri; Xanthomonas campestris pv. aurantifolia; Xanthomonas campestris pv. Citrumelo	BA001131
1.1.32	Yersinia pestis	Yersinia pseudotuberculosis var pestis	BA001132

1.2 Viruses

Entry Number	Name	Other Names	Commodity Designator Code
1.2.1	African horse sickness virus		BA001201
1.2.2	African swine fever virus		BA001202
1.2.3	Avian influenza virus	Fowl plague virus	BA001203
1.2.4	Blue tongue virus		BA001204
1.2.5	Camel pox virus		BA001205
1.2.6	Chikungunya virus		BA001206
1.2.7	Congo-Crimean haemorrhagic fever virus		BA001207
1.2.8	Dengue fever virus		BA001208
1.2.9	Eastern equine encephalitis virus		BA001209
1.2.10	Ebola virus		BA001210
1.2.11	Enterovirus 70		BA001211
1.2.12	Foot and mouth disease virus		BA001212
1.2.13	Goat pox virus		BA001213
1.2.14	Hantaan virus		BA001214
1.2.15	Human influenza virus		BA001215
1.2.16	Infectious haemorrhagic conjunctivitis virus		BA001216
1.2.17	Japanese encephalitis virus		BA001217
1.2.18	Junin virus		BA001218
1.2.19	Kyasanus Forest virus		BA001219
1.2.20	Lassa fever virus		BA001220
1.2.21	Louping ill virus		BA001221
1.2.22	Lymphocytic choriomeningitis virus		BA001222
1.2.23	Lyssa virus	Rabies virus	BA001223
1.2.24	Machupo virus		BA001224
1.2.25	Marburg virus		BA001225
1.2.26	Monkey pox virus		BA001226
1.2.27	Murray Valley encephalitis virus		BA001227
1.2.28	Newcastle disease virus		BA001228
1.2.29	Nipah virus		BA001229
1.2.30	Oropouche virus		BA001230
1.2.31	Peste des petits ruminants virus		BA001231
1.2.32	Porcine herpes virus	Aujeszky's disease virus	BA001232
1.2.33	Powarsan virus		BA001233
1.2.34	Rift Valley fever virus		BA001234
1.2.35	Rinderpest virus		BA001235
1.2.36	Rocia virus		BA001236
1.2.37	Rotaviruses		BA001237
1.2.38	Sheep pox virus		BA001238
1.2.39	Sin Nombre virus		BA001239
1.2.40	St. Louis encephalitis virus		BA001240
1.2.41	Sugar cane Fiji disease virus		BA001241
1.2.42	Swine fever virus	Hog cholera virus	BA001242
1.2.43	Swine influenza virus		BA001243
1.2.44	Swine vesicular disease	Porcine enterovirus type 9	BA001244
1.2.45	Teschen disease virus		BA001245
1.2.46	Tick-borne encephalitis virus	Russian Spring-Summer encephalitis virus	BA001246
1.2.47	Variola virus(es)	Smallpox virus	BA001247
1.2.48	Venezuelan equine encephalitis virus		BA001248
1.2.49	Vesicular stomatitis virus		BA001249
1.2.50	Western equine encephalitis virus		BA001250
1.2.51	White pox virus		BA001251
1.2.52	Yellow fever virus		BA001252

1.3 Toxins

Entry Number	Name	Other Names	Commodity Designator Code
1.3.1	Abrin(s)		BA001301
1.3.2	Aflatoxin(s)		BA001302
1.3.3	Botulinum toxin(s)		BA001303
1.3.4	Bungarotoxin(s)		BA001304
1.3.5	Ciguatoxin(s)		BA001305
1.3.6	Clostridium perfringens toxin(s)		BA001306
1.3.7	Conotoxin(s)		BA001307
1.3.8	Microcystin(s)	Yanoginosins; Cyanginosin	BA001308
1.3.9	Modeccin(s)		BA001309
1.3.10	Pseudomonas exotoxin(s)		BA001310
1.3.11	Ricin(s) [CAS No.9009-86-3]	Ricins, Ricine	BA001311
1.3.12	Saxitoxin(s) [CAS No. 35523-89-8]	1H,10H-Pyrrolo[1,2-c]purine-10,10-diol, 2,6-diamino-4-[[(aminocarbonyl)oxy]methyl]-3a,4,8,9-tetrahydro-,[3aS-(3a.a,4a,10aR*)]-, Saxitoxin hydrate, Mussel poison, Clam poison, Paralytic shellfish poison, Gonyaulax toxin, STX.	BA001312
1.3.13	Shiga toxin(s)		BA001313
1.3.14	Staphylococcal enterotoxin(s)	Staphylococcus aureus entertoxin Staphylococcus aureus toxin	BA001314
1.3.15	Tetrodotoxin(s)		BA001315
1.3.16	Trichothecene toxin(s)		BA001316
1.3.17	Verotoxin(s)		BA001317
1.3.18	Volkensin(s)		BA001318

1.4 Fungi

Entry Number	Name	Other Names	Commodity Designator Code
1.4.1	Aspergillus flavus		BA001401
1.4.2	Aspergillus nidans		BA001402
1.4.3	Cochliobolus miyabeanus	Helminthosporium oryzae	BA001403
1.4.4	Colletotrichum coffeanum var. virulans		BA001404
1.4.5	Dothistroma pini	Scirrhia pini	BA001405
1.4.6	Fusarium oxysporum		BA001406
1.4.7	Magnaporthe grisea	Pyricularia grisea, Pyricularia oryzae	BA001407
1.4.8	Microcyclus ulei	Dothidella ulei	BA001408
1.4.9	Peronospora hyoscyami de Bary f.sp. tabacina skalicky	Peronospora hyoscyami de Bary f.sp. Adam skalicky	BA001409
1.4.10	Puccinia graminis	Puccinia graminis f. sp. Tritici	BA001410
1.4.11	Puccinia striiformis	Puccinia glumarum	BA001411
1.4.12	Tilletia carnis		BA001412
1.4.13	Tilletia foetida		BA001413
1.4.14	Tilletia indica		BA001414

1.5 Other Organisms

Entry Number	Name	Other Names	Commodity Designator Code
1.5.1	Eukaryotic (non-microbial) organism which produce any listed toxins		BA001501

1.6 Genetically Modified Organisms

Entry Number	Name	Other Names	Commodity Designator Code
1.6.1	Genetically modified microorganisms listed above.		BA001601
1.6.2	Genetically modified microorganisms or genetic material containing nucleic acid sequences derived from any of the listed microorganisms, above or that contain nucleic acid sequences associated with pathogenicity determinants of any listed microorganism; or that contain nucleic acid sequences associated with any listed toxin.		BA001602
1.6.3	Genetically modified variants of eukaryotic (non-microbial) organisms which produce any listed toxin.		BA001603

GOODS REVIEW LIST
SECTION C
MISSILE SECTION

A. **Prohibited Items.**

The prohibitions under the Plan (S/22871 Rev. 1 of 20 Oct 1991) apply to any ballistic missiles or missile delivery systems (referred to as "missile systems") capable of a range greater than 150 kilometres regardless of payload, and to any related major parts, including surface-to-surface missiles, space launch vehicles, sounding rockets, cruise missiles, target drones, reconnaissance drones, and other unmanned air vehicle systems and such other items as are identified below as being prohibited.

B. **Dual Use Items.**

The following list contains equipment, other items and technologies capable of being used in the development, production, construction, modification or acquisition of missile systems capable of a range greater than 150 kilometers and shall therefore, in accordance with paragraph 40 of the Plan (S/22871 Rev. 1 20 Oct 1991), be subject to ongoing monitoring and verification, and notifiable under the Export/Import Mechanism approved by SCR 1051 (1996).

1. **(Commodity Designator code: MA010000)**

Complete subsystems designed or modified for missile systems, and technologies, production facilities, and production equipment therefore, as follows:

Note: Re-entry vehicles and equipment designed or modified therefor are prohibited.

1.1 **(Commodity Designator code: MA011000)**

Individual rocket stages.

1.1.1 **(Commodity Designator code: MA011100)**

Solid- or liquid-propellant rocket engines.

1.1.2 **(Commodity Designator code: MA011200)**

Ramjet/scramjet/pulse jet/combined cycle engines, including devices to regulate combustion, and components therefore.

1.1.3 **(Commodity Designator code: MA011300)**

Hybrid rocket motors and components therefore.

1.2 (Commodity Designator code: MA012000)

Guidance sets.

1.3 (Commodity Designator code: None)

Thrust vector controls, as follows;

1.3.1 (Commodity Designator code: MA013100)

Flexible nozzles.

1.3.2 (Commodity Designator code: MA013200)

Fluid or secondary gas injection systems.

1.3.3 (Commodity Designator code: MA013300)

Movable engines or nozzles.

1.3.4 (Commodity Designator code: None)

Deflection systems of the exhaust gas stream as follows:

1.3.4.1 (Commodity Designator code: MA013410)

Jet vanes.

1.3.4.2 (Commodity Designator code: MA013420)

Probes.

1.3.4.3 (Commodity Designator code: MA013430)

Jet-avator.

1.3.4.4 (Commodity Designator code: MA013440)

Thrust tabs.

1.4 (Commodity Designator code: MA014000)

Warhead or weapon safing, arming, fuzing and firing mechanisms.

2. (Commodity Designator code: MA020000)

Propulsion components and equipment, including components, equipment, propellant and constituent chemicals for propellants usable in missile systems and technology, production facilities and production equipment, as follows:

2.1 (Commodity Designator code: MA021000)

Rocket-motor cases and production equipment therefor including interior lining, insulation and nozzles, and the technology, the production facilities and production equipment therefor; engines, including devices to regulate combustion, and components therefor.

2.2 (Commodity Designator code: MA022000)

Lightweight turbojet, turbofan and turbocompound engines that are small and fuel efficient, as follows:

a. Engines with both of the following characteristics:
   (i) Maximum thrust greater than 400N (achieved un-installed) excluding civil certified engines with a maximum thrust greater than 8,890N (achieved un-installed), and
   (ii) Specific fuel consumption of 0.15kg/N/hr or less (at sea level static and standard conditions); or

b. Engines designed or modified for missile systems, regardless of thrust or specific fuel consumption.

2.3 (Commodity Designator code: MA023000)

Production equipment also covers shear forming, and flow-forming machines, including machines combining the function of spin-forming and flow-forming, including components and software therefore, as follows:

a. which, according to the manufacturer's technical specification, are capable of being equipped with numerical control units or a computer control, even when not equipped with such units at delivery, and

b. with more than two axes which are capable of being coordinated simultaneously for contouring control.

2.4 (Commodity Designator code: MA024000)

Staging, clustering, and separation mechanisms, and the technology, production facilities and production equipment therefore.

2.5 (Commodity Designator code: MA025000)

Liquid-propellant control systems and components therefore, including slurry propellant control systems, and components therefor, designed or modified to operate in vibration environments of more than 5 ***g*** RMS between 20 Hz and 2,000 Hz, and the technology, the production facilities and production equipment therefor and also including:

2.5.1 (Commodity Designator code: MA025100)

Servo valves designed for flow rates of 5 litres per minute or greater, at an absolute pressure of 4,000 kPa (600 psi) or greater, with an actuator response time of less than 100 ms;

Note: Servo valves designed for flow rates of 24 litres per minute or greater, at an absolute pressure of 7,000 kPa (1,000 psi) or greater, with an actuator response time of less than 100 ms are prohibited.

2.5.2 (Commodity Designator code: MA025200)

Pumps, for liquid propellants, with shaft speeds equal to or greater than 6,000 RPM or with discharge pressures equal to or greater than 4,000 kPa (600 psi) or with a flow rate of 200 litres per minute or greater at atmospheric pressure.

Note: Pumps, for liquid propellants, with shaft speeds equal to or greater than 8,000 RPM or with discharge pressures equal to or greater than 7,000 kPa (1,000 psi) or 450 litres per minute or greater at standard atmospheric pressure are prohibited.

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3. (Commodity Designator code: None)

Propellants and constituent chemicals for propellants, as follows:

3.1 (Commodity Designator code: None)

Propulsive substances:

3.1.1 (Commodity Designator code: MA031100)

Hydrazine with a concentration of more than 70 percent and its derivatives, as follows:

Monomethylhydrazine (MMH); hydrazine hydrate (also known as hydrazine monohydrate), diamine hydrate, and hydrazine aqueous);

3.1.2 (Commodity Designator code: MA031200)

Unsymmetric dimethylhydrazine (UDMH);

3.1.3 (Commodity Designator code: MA031300)

Organic azides: diazidodecane, diazidohexane.

3.2 (Commodity Designator code: MA032000)

Ammonium perchlorate and other solid oxidizers as follows:

Ammonium dinitramide (ADN), compounds of nitroform, dinitramides, nitramines, nitrocubanes.

3.3 (Commodity Designator code: MA033000)

Spherical aluminium powder with particles of uniform diameter less than 500 x 10^{-6} m (500 microns) and an aluminium content of 97 percent by weight or greater;

3.3.1 (Commodity Designator code: MA033100)

Metal fuels in particle sizes less than 500 x 10^{-6} m (500 microns), whether spherical, atomized, spheroidal, flaked or ground, consisting of 97 percent by weight or more of any of the following: zirconium*, beryllium, boron**, magnesium, and alloys of these.

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

** The threshold for boron is at 85 percent by weight or higher.

3.3.2 (Commodity Designator code: MA033200)

Nitramines, Cyclotetramethylenetetranitramine (HMX), Cyclotrimethylenetrinitramine (RDX).

3.3.3 (Commodity Designator code: MA033300)

Perchlorates, chlorates or chromates mixed with high energy fuel components such as powdered metals.

3.3.4 (Commodity Designator code: MA033400)

Carboranes, decaboranes, pentaboranes and derivatives thereof.

3.3.5 (Commodity Designator code: None)

Liquid oxidizers, as follows:

3.3.5.1 (Commodity Designator code: MA033510)

Dinitrogen Trioxide;

3.3.5.2 Commodity Designator code: MA033520)

Nitrogen dioxide/ dinitrogen tetroxide;

3.3.5.3 (Commodity Designator code: MA033530)

Dinitrogen pentoxide;

3.3.5.4 (Commodity Designator code: MA033540)

Inhibited Red Fuming Nitric Acid (IRFNA);

3.3.5.5 (Commodity Designator code: MA033550)

Hydrogen peroxide with a concentration greater than 70 percent;

3.3.5.6 (Commodity Designator code: MA033560)

Compounds composed of fluorine and one or more of other halogens, oxygen or nitrogen;

3.3.6 (Commodity Designator code: None)

Polymeric substances as follows:

3.3.6.1 (Commodity Designator code: MA033610)

Carboxyl-terminated polybutadiene (CTPB);

3.3.6.2 (Commodity Designator code: MA033620)

Hydroxyl-terminated polybutadiene (HTPB);

3.3.6.3 (Commodity Designator code: MA033630)

Glycidyl azide polymer (GAP);

3.3.6.4 (Commodity Designator code: MA033640)

Polybutadiene-Acrylic Acid (PBAA);

3.3.6.5 (Commodity Designator code: MA033650)

Polybutadiene-acrylic acid-acrylonitrile (PBAN);

3.3.6.6 (Commodity Designator code: MA033660)

Oxetanes as follows:

Polymers of Nitratomethyl Methyl Oxetane (NIMMO), 3, 3 Bis-(Azido Methyl Oxetane) (BAMO), Azido Methyl Methyl Oxetane (AMMO);

3.3.6.7 (Commodity Designator code: MA033670)

Composite propellants including case-bonded propellants and propellants with nitrated binders.

3.3.6.7.1 (Commodity Designator code: MA033671)

Noncomposite propellants including double-base propellants.

3.3.6.7.2 (Commodity Designator code: MA033672)

Other high-energy-density propellants, with an energy density of 40 x 10^6 joules/kg or greater, e.g. boron slurry.

3.4 (Commodity Designator code: None)

Other propellant additives and agents:

3.4.1 (Commodity Designator code: None)

Bonding and linking agents as follows:

3.4.1.1 (Commodity Designator code: MA034110)

Tris(1-(2-methyl) aziridinyl) phosphine oxide (MAPO).

3.4.1.2 (Commodity Designator code: MA034120)

Trimesol-1(2-ethyl) aziridine (HX-868, BITA).

3.4.1.3 (Commodity Designator code: MA034130)

Tepanol (HX-878), (reaction product of tetraethylenepentamine, acrylonitrile and glycidol).

3.4.1.4 (Commodity Designator code: MA034140)

Tepan (HX-879), (reaction product of tetraethylenepentamine with acrylonitrile).

3.4.1.5 (Commodity Designator code: MA034150)

Polyfunctional aziridene amides with isophthalic, trimesic, isocyanuric, or trimethyladipic backbone with a 2-methyl or 2-ethyl aziridine group (HX-752, H-874 and HX-877).

3.4.2 (Commodity Designator code: MA034200)

Cross linking agents and catalysts as follows:

isophorone diisocyanate, hexamethyl diisocyanide, dimeryl diisocyanate, trimethylol propane; toluene-2,4-diisocyanate; and,

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3.4.2.1 (Commodity Designator code: MA034210)

Triphenyl Bismuth (TPB);

3.4.3 (Commodity Designator code: None)

Burning rate modifiers as follows:

3.4.3.1 (Commodity Designator code: MA034310)

Catocene.

3.4.3.2 (Commodity Designator code: MA034320)

N-butyl-ferrocene.

3.4.3.3 (Commodity Designator code: MA034330)

Butacene.

3.4.3.4 (Commodity Designator code: MA034340)

Any other ferrocene derivatives.

3.4.4 (Commodity Designator code: None)

Nitrate esters and nitratoplasticizers as follows:

3.4.4.1 (Commodity Designator code: MA034410)

Triethylene glycol dinitrate (TEGDN).

3.4.4.2 (Commodity Designator code: MA034420)

Trimethylolethane trinitrate (TMETN).

3.4.4.3 (Commodity Designator code: MA034430)

1, 2, 4-butanetriol trinitrate (BTTN).

3.4.4.4 (Commodity Designator code: MA034440)

Diethylene glycol dinitrate (DEGDN).

3.4.5 (Commodity Designator code: None)

Stabilizers as follows:

3.4.5.1 (Commodity Designator code: MA034510)

2-nitrodiphenylamine (also known as 2-NDPA), phenylnaphthylamine.

3.4.5.2 (Commodity Designator code: MA034520)

N-methyl-p-nitroaniline (MNA; PNMA).

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4. (Commodity Designator code: None)

Production technology or production equipment for missile propellants and propellant constituents and specially designed components therefor, as follows:

4.1 (Commodity Designator code: MA041000)

Production technology and production equipment for the handling or acceptance testing of liquid propellants or propellant constituents described in item 3.

4.2 (Commodity Designator code: MA042000)

Production, handling, mixing, curing, casting, pressing, machining, extruding or acceptance testing of solid propellants or propellant constituents described in item 3, including:

4.2.1 (Commodity Designator code: MA042100)

Batch mixers, with all of the following characteristics:

a. Capable of mixing under vacuum in the range of zero to 13.326 kPa (1.933 psi); and
b. Capable of controlling the temperature of the mixing chamber;
c. With a total volumetric capacity of 110 litres or more;
d. With at least one mixing/kneading shaft mounted off-centre

Specially designed components for the above batch mixers as follows:
Planetary drive systems,
blades, and
bowls.

Note: Such batch mixers with a total volumetric capacity of more than 210 litres are prohibited.

Note: Continuous mixers with the same pressure and temperature characteristics as item 4.2.1 and with two or more mixing/kneading shafts and capacity to open the mixing chamber are also prohibited.

4.2.2 (Commodity Designator code: MA042200)

Equipment for the production of atomised or spherical metallic powder less than 500×10^{-6} m (500 microns) in a controlled environment as follows;

a. Plasma generators (high frequency arc-jet) usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;
b. Electroburst equipment usable for obtaining sputtered or spherical metallic powders with organization of the process in an argon-water environment;
c. Equipment usable for the "production" of spherical aluminum powders by powdering a melt in an inert medium (e.g. nitrogen).

4.2.3 (Commodity Designator code: MA042300)

Fluid energy mills usable for grinding or milling ammonium perchlorate, RDX or HMX and ammonium perchlorate hammer and pin mills.

4.2.4 (Commodity Designator code: MA042400)

Dryers designed for the drying of ammonium perchlorate or other energetic materials. This includes both batch and continuous drying systems.

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5. (Commodity Designator code: None)

Guidance and control equipment, flight control systems, and avionics equipment, as follows:

5.1 (Commodity Designator code: MA051000)

Gyroscopes, accelerometers and other inertial equipment, including instrumentation, navigation and direction finding equipment and systems, and production and test equipment therefor, as follows, and components and software therefor:

Note: Continuous output accelerometers or gyros of any type, designed to function at acceleration levels greater than 100 *g*, are prohibited.

5.1.1 (Commodity Designator code: MA051100)

Integrated flight instrument systems, including gyrostabilizers or automatic pilots and integration software therefor, usable in missile systems.

5.1.2 (Commodity Designator code: MA051200)

Gyro-astro compasses and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites.

5.2 (Commodity Designator code: MA052000)

Accelerometers with a threshold of 0.5 ***g*** or less, or a linearity error of less than 0.25 percent of full scale output, or both, designed for use in inertial navigation systems or in guidance systems of all types except those specially designed and developed as MWD (Measurement While Drilling) Sensors for use in downhole well service operations;

5.3 (Commodity Designator code: MA053000)

All types of gyros usable in missile systems, with a rated drift rate stability of less than 5 degrees (1 sigma or rms) per hour in a 1 ***g*** environment.

5.3.1 (Commodity Designator code: MA053100)

Inertial or other equipment using;

a. accelerometers with a threshold of 0.5 ***g*** or less, or a linearity error of less than 0.25 percent of full scale output, or both, designed for use in inertial navigation systems or in guidance systems of all types, except those specially designed and developed as MWD (Measurement While Drilling) Sensors for use in downhole well service operations; or
b. gyros with a rated drift rate stability of less than 5 degrees (1 sigma or rms) per hour in a 1 ***g*** environment; and systems incorporating such equipment, and integration software therefor.

5.4 (Commodity Designator code: MA054000)

Test, calibration, alignment, and production equipment as follows; for items specified in Integrated Flight Instrument systems, including gyrostabilizers or automatic pilots and integration software therefor, usable in missile systems; and inertial or other equipment using;

a. accelerometers with a threshold of 0.5 ***g*** or less, or a linearity error of less than 0.25 percent of full scale output, or both, designed for use in inertial navigation systems or in guidance systems of all types except those specially designed and developed as MWD (Measurement While Drilling) sensors for use in downhole well service operations; or

b. gyros described by a rated drift rate stability of less than 5 degrees (1 sigma or rms) per hour in a 1 ***g*** environment; and systems incorporating such equipment, and integration software.

5.4.1 (Commodity Designator code: MA054100)

For laser gyro equipment, the following equipment used to characterize mirrors, with the threshold accuracy shown or better.

5.4.2 (Commodity Designator code: MA054200)

Scatterometer (10 ppm).

5.4.3 (Commodity Designator code: MA054300)

Reflectometer (50 ppm).

5.4.4 (Commodity Designator code: MA054400)

Profilometer (5 Angstroms).

5.5 (Commodity Designator code: None)

Other inertial equipment;

5.5.1 (Commodity Designator code: MA055100)

Inertial Measurement Unit (IMU) Module Tester.

5.5.1.1 (Commodity Designator code: MA055110)

IMU Platform Tester.

5.5.1.2 (Commodity Designator code: MA055120)

IMU Stable Element Handling Fixture.

5.5.1.3 (Commodity Designator code: MA055130)

IMU Platform Balance fixture.

5.5.2 (Commodity Designator code: MA055200)

Gyro Tuning Test Station.

5.5.3 (Commodity Designator code: MA055300)

Gyro Dynamic Balance Station

5.5.4 (Commodity Designator code: MA055400)

Gyro Run-In/Motor Test station.

5.5.5 (Commodity Designator code: MA055500)

Gyro Evacuation and Filling Station.

5.5.6 (Commodity Designator code: MA055600)

Centrifuge Fixture for Gyro Bearings.

5.5.7 (Commodity Designator code: MA055700)

Accelerometer Axis Align Station.

5.5.8 (Commodity Designator code: MA055800)

Accelerometer Test Station.

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6. (Commodity Designator code: None)

Flight control systems and technology, as follows, designed or modified for use in missile systems and the test, calibration, and alignment equipment therefor:

6.1 (Commodity Designator code: MA061000)

Hydraulic, mechanical, electro-optical, or electro-mechanical flight control systems (including fly-by-wire systems);

6.2 (Commodity Designator code: MA062000)

Attitude control equipment;

6.2.1 (Commodity Designator code: MA062100)

Design technology for integration of air vehicle fuselage, propulsion system and lifting control surfaces to optimise aerodynamic performance throughout the flight regime of an unmanned air vehicle;

6.2.1.1 (Commodity Designator code: MA062110)

Design technology for integration of flight control, guidance, and propulsion data into a flight management system for optimisation of rocket system trajectory.

6.2.2 (Commodity Designator code: MA062200)

Avionics equipment (both active and passive), as follows:

1. Terrain contour mapping equipment;
2. Scene mapping and correlation (both digital and analog) equipment;
3. Doppler navigation radar equipment;
4. Passive interferometer equipment;
5. Imaging sensor equipment technology and components, as follows, designed or modified for use in missile systems, and software therefore.

6.2.2.1 (Commodity Designator code: MA062210)

Radar and laser radar systems, including altimeters;

6.2.2.2 (Commodity Designator code: MA062220)

Passive sensors for determining bearings to specific electromagnetic sources (direction finding equipment) or terrain characteristics;

6.2.2.3 (Commodity Designator code: MA062230)

Satellite navigation systems such as GPS, Magellan, GLONASS, or Galileo, capable of providing navigation information at speeds in excess of 515 m/s (1,000 nautical miles/hour) and at altitudes in excess of 18 km (60,000 feet); or

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6.2.2.4 (Commodity Designator code: MA062240)

Satellite navigation systems designed or modified for use with missile systems.

6.2.2.5 (Commodity Designator code: MA062250)

Electronic assemblies and components designed, modified, tested, certified, or screened for military use and operation at temperatures in excess of 125^{o} C.

6.2.3 (Commodity Designator code: MA062300)

Design technology for protection of avionics and electrical subsystems against electromagnetic pulse (EMP) and electromagnetic interference (EMI) hazards from external sources, as follows:

6.2.3.1 (Commodity Designator code: MA062310)

Design technology for shielding systems;

6.2.3.2 (Commodity Designator code: MA062320)

Design technology for the configuration of hardened electrical circuits and subsystems;

6.2.4 (Commodity Designator code: MA062400)

Determination of hardening criteria for; the shielding of avionics and electrical subsystems against electromagnetic pulse (EMP) and electromagnetic interference (EMI) hazards from external sources, the design criteria for shielding systems, and the configuration of hardened electrical circuits and subsystems.

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7. (Commodity Designator code: None)

Equipment and technology for the production of structural composites designed or modified for use in missile systems, as follows, and components, accessories and software therefor, and structural materials usable in missile systems as follows:

7.1 (Commodity Designator code: MA071000)

Filament winding machines for which the motions for positioning, wrapping and winding fibres are capable of being 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;

7.1.1 (Commodity Designator code: MA071100)

Tape-laying machines for which the motions for positioning and laying tape and sheets are capable of being coordinated and programmed in two or more axes;

7.1.2 (Commodity Designator code: MA071200)

Multi-directional, multi-dimensional 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;

7.1.3 (Commodity Designator code: None)

Equipment designed or modified for the production of fibrous or filamentary materials as follows:

7.1.3.1 (Commodity Designator code: MA071310)

Equipment for converting polymeric fibres (e.g. polyacrylonitrile, rayon or polycarbosilane) including special provision to strain the fibre during heating;

7.1.3.2 (Commodity Designator code: MA071320)

Equipment for the vapour deposition of elements or compounds on heated filament substrates; and

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7.1.3.3 (Commodity Designator code: MA071330)

Equipment for the wet-spinning of refractory ceramics (such as aluminium oxide).

7.1.3.4 (Commodity Designator code: MA071340)

Equipment designed or modified for special fibre surface treatment and equipment designed or modified for producing prepregs and preforms, including:

7.1.3.4.1 Rollers;
7.1.3.4.2 Tension stretchers;
7.1.3.4.3 Coating equipment;
7.1.3.4.4 Cutting equipment; and
7.1.3.4.5 Clicker dies.

7.1.3.5 (Commodity Designator code: MA071350)

Technical data (including processing conditions) and procedures for the regulation of temperature, pressures or atmosphere in autoclaves or hydroclaves in the production of composites or partially processed composites.

7.1.3.6 (Commodity Designator code: MA071360)

Components and accessories for the equipment to produce structural composites, fibres, prepregs or preforms, as follows: moulds, mandrels, dies, fixtures and tooling for the preform pressing, curing, casting, sintering or bonding of composite structures, laminates and manufactures thereof.

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8. (Commodity Designator code: None)

Structural materials designed for use in missile systems as follows:

8.1 (Commodity Designator code: MA081000)

Composite structures, laminates, and manufactures thereof, designed or modified for missile systems or the subsystems in item 2.1, and resin impregnated fibre prepregs using resins with a glass transition temperature (T_g), after cure, exceeding 145^o C as determined by ASTM D4065 or national equivalents, and metal-coated fibre preforms therefor, made either with organic matrix or metal matrix utilizing fibrous or filamentary reinforcements with a specific tensile strength greater than 7.62 x 10^4 m (3 x 10^6 inches) and a specific modulus greater than 3.18 x 10^6 m (1.25 x 10^8 inches);

8.1.1 (Commodity Designator code: MA081100)

Resaturated pyrolized (i.e., carbon-carbon) materials designed for missile systems;

8.1.2 (Commodity Designator code: MA081200)

Fine grain recrystallized bulk graphites (with a bulk density of at least 1.72 g/cm^3 measured at 15^o C and having a particle size of 100 x 10^{-6}m (100 microns) or less), pyrolytic, or fibrous reinforced graphites usable for rocket nozzles and reentry vehicle nose tips;

8.1.3 (Commodity Designator code: MA081300)

Ceramic composite materials (dielectric constant less than 6 at frequencies from 100 Hz to 10,000 MHz) for use in missile radomes, and bulk machinable silicon carbide reinforced unfired ceramic usable for nose tips;

8.1.4 (Commodity Designator code: MA081400)

Tungsten, molybdenum and alloys of these metals in the form of uniform spherical or atomized particles of 500 x 10^{-6} m (500 microns), or less with a purity of 97 percent by weight or greater;

8.1.5 (Commodity Designator code: MA081500)

Maraging steels (steels generally with high nickel, very low carbon content and using substitutional elements or precipitates to produce age-hardening) with an ultimate tensile strength of 1.5 x 10^9Pa or greater, measured at 20℃ in the form of sheet, plate or tubing with a wall or plate thickness equal to or less than 5.0 mm (0.2 inch).

8.1.6 (Commodity Designator code: MA081600)

Nitrogen stabilized duplex stainless steel (N-DSS) having all of the following characteristics:

1. containing at least 18 percent by weight chromium and 4.5 - 8.0 percent by weight nickel;
2. a ferritic-austenitic microstructure (also referred to as a two-phase microstructure) of which at least 10 percent is austenite by volume (according to ASTM E-1181-87 or national equivalents); <u>and</u>
3. having any of the following forms:
   a. ingots or bars having a size of 100 mm or more in each dimension;
   b. sheets having a width of 600 mm or more and a thickness of 3 mm or less; <u>or</u>
   c. tubes having an outer diameter of 600 mm or more and a wall thickness of 3 mm or less.

8.1.7 (Commodity Designator code: MA081700)

Titanium-stabilized duplex stainless steel (Ti-DSS) having all of the following characteristics:

1. containing 17.0 - 23.0 percent by weight chromium and 4.5 - 7.0 percent by weight nickel;
2 having a titanium content of greater than 0.10 percent by weight; <u>and</u>
3. a ferritic-austenitic microstructure (also referred to as a two-phase microstructure) of which at least 10 percent is austenite by volume (according to ASTM E-1181-87 or national equivalents); <u>and</u>
4. having any of the following forms:
   a. ingots or bars having a size of 100 mm or more in each dimension;
   b. sheets having a width of 600 mm or more and a thickness of 3 mm or less; <u>or</u>
   c. tubes having an outer diameter of 600 mm or more and a wall thickness of 3 mm or less.

8.2 (Commodity Designator code: None)

Pyrolytic deposition and densification equipment and technology as follows:

8.2.1 (Commodity Designator code: MA082100)

Technology for producing pyrolytically derived materials formed on a mould, mandrel or other substrate from precursor gases which decompose in the 1,300° C to 2,900° C temperature range at pressures of 130 Pa (1 mm Hg) to 20 kPa (150 mm Hg) including technology for the composition of precursor gases, flow-rates and process control schedules and parameters;

8.2.2 (Commodity Designator code: MA082200)

Nozzles for the above processes;

8.2.3 (Commodity Designator code: MA082300)

Equipment and process controls, and software therefor, designed or modified for densification and pyrolysis of structural composites, including:

8.2.3.1 (Commodity Designator code: MA082310)

Isostatic presses with a maximum working pressure of 69 MPa (10,000 psi) or greater and designed to achieve and maintain a controlled thermal environment of 600° C or greater, and possessing a chamber cavity with an inside diameter of 254 mm (10 inches) or greater.

8.2.3.2 (Commodity Designator code: MA082320)

Chemical vapour deposition furnaces designed or modified for the densification of carbon-carbon composites.

8.3 (Commodity Designator code: None)

Launch and ground support equipment, facilities and software designed or modified for missile systems, as follows:

8.3.1 (Commodity Designator code: MA083100)

Apparatus and devices designed or modified for the handling, control, activation and launching of missile systems;

8.3.1.1 (Commodity Designator code: MA083110)

Vehicles designed or modified for the transport, handling, control, activation and launching of missile systems;

8.3.2 (Commodity Designator code: MA083200)

Gravity meters (gravimeters), gravity gradiometers, and specially designed components therefor, designed or modified for airborne or marine use, and with a static or operational accuracy of 7×10^{-6} m/s^2 (0.7 milligal) or better, and a time to steady-state registration of two minutes or less;

8.3.3 (Commodity Designator code: MA083300)

Telemetering and telecontrol equipment usable for missile systems;

8.3.4 (Commodity Designator code: MA083400)

Precision tracking systems, as follows:

8.3.4.1 (Commodity Designator code: MA083410)

Tracking systems using a code translator or transponder installed on the missile systems and either surface or airborne references or aviation satellite navigation systems to provide real time measurements of in-flight position and velocity;

Note: Tracking systems specified in item 8.3.4.1 with a range greater than 150 km are prohibited.

8.3.4.2 (Commodity Designator code: MA083420)

Range instrumentation radars including associated optical/infrared trackers and the software therefor with an angular resolution better than 3 milli-radians (0.5 mils), and a range of 30 km or greater with a range resolution better than 10 m RMS, and a velocity resolution better than 3 m/s; and

Note: Range instrumentation radars specified above with a range greater than 150 km are prohibited.

8.3.4.3 (Commodity Designator code: MA083430)

Software with post-flight, recorded data, for the determination of vehicle position throughout its flight path.

8.4 (Commodity Designator code: None)

Analog computers, digital computers or digital differential analysers and analog-to-digital converters, as follows:

8.4.1 (Commodity Designator code: MA084100)

Analog computers, digital computers, or digital differential analysers designed for use in missile systems, having either of the following characteristics:

8.4.1.1 (Commodity Designator code: MA084110)

Analog computers, digital computers, or digital differential analysers rated for continuous operation at temperatures from below minus 45^{o} C to above plus 55^{o} C; or

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8.4.1.2 (Commodity Designator code: MA084120)

Analog computers, digital computers, or digital differential analysers designed as ruggedised or radiation hardened;

8.4.2 (Commodity Designator code: MA084200)

Analog-to-digital converters, designed for missile systems, with either of the following characteristics:

8.4.2.1 (Commodity Designator code: MA084210)

Designed to meet military specifications for ruggedised equipment; or,

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8.4.2.2 (Commodity Designator code: MA084220)

Designed, modified, tested, certified or screened for military use, and being one of the following types:

8.4.2.3 (Commodity Designator code: MA084230)

Analog-to-digital converter microcircuits, with a resolution of 8 bits or more or which are radiation-hardened; and are rated for operation in the temperature range from below minus 45° C to above plus 125° C; and are hermetically sealed;

8.4.2.4 (Commodity Designator code: MA084240)

Electrical input type analog-to-digital converter printed circuit boards or modules, having

a. a resolution of 8 bits or more, and
b. rated for operation from below minus 45° C to above plus 55° C, and
c. which incorporate analog-to-digital converter microcircuits, with
   1. a resolution of 8 bits or more or
   2. which are radiation-hardened; and
   3. are rated for operation in the temperature range from below minus 45° C to above plus 125° C; and
   4. are hermetically sealed.

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9. (Commodity Designator code: None)

Test facilities and equipment as follows, and software therefor:

9.1 (Commodity Designator code: None)

Vibration test systems and components therefor, as follows:

9.1.1 (Commodity Designator code: MA091100)

Vibration test systems using feedback or closed loop techniques and 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 25kN (5,625 lbs), measured "bare table", or greater;

9.1.1.1 (Commodity Designator code: MA091110)

Digital controllers, which use specially designed vibration test software, with a real-time bandwidth greater than 5 kHz and designed for use with vibration test systems using feedback or closed loop techniques and 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 25kN (5,625 lbs), measured "bare table", or greater;

9.1.1.2 (Commodity Designator code: MA091120)

Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force of 25 kN (5,625 lbs), measured “bare table”, or greater, and usable in vibration test systems using feedback or closed loop techniques and 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 25 kN (5,625 lbs), measured “bare table”, or greater;

9.1.1.3 (Commodity Designator code: MA091130)

Bump or shock test tables with or without their associated amplifiers, capable of imparting a force of at least 100 ***g***, or greater;

9.1.1.4 (Commodity Designator code: MA091140)

Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective total force of 25 kN (5,625 lbs), measured "bare table", or greater, and usable in vibration test systems using feedback or closed loop techniques and 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 25 kN (5,625 lbs), measured "bare table", or greater.

9.1.2 (Commodity Designator code: MA091200)

Wind-tunnels;

9.1.3 (Commodity Designator code: MA091300)

Test benches/stands capable of handling solid or liquid propellant rockets or rocket motors of more than 10 kN (2248 lbs) of thrust, or capable of simultaneously measuring the three axial thrust components;

9.1.4 (Commodity Designator code: MA091400)

Environmental chambers and anechoic chambers capable of;

a. simulating the flight conditions at altitudes of 15,000 meters or greater, or
b. simulating acoustic environments at an overall sound pressure level of 140 dB or greater (referenced to 2 x 10^{-5} N per square metre) or with a rated power output of 4 kiloWatts or greater, or,
c. capable of achieving temperatures of at least minus 50° C to plus 125° C, and
d. are capable of being equipped with vibration thrusters (shaker units) or acoustic generators capable of generating vibration environments of 10 ***g*** RMS or greater between 20 Hz and 2,000 Hz imparting forces of 5 kN (1124 lbs) or greater.

9.1.4.1 (Commodity Designator code: MA091410)

Accelerators, except those specially designed for medical purposes, capable of delivering electromagnetic radiation produced by "Bremsstrahlung" from accelerated electrons of 2 MeV or greater, and systems containing those accelerators.

9.2 (Commodity Designator code: MA092000)

Software, or software with related specially designed hybrid (combined analogue/digital) computers, for modelling (including in particular the aerodynamic and thermodynamic analysis of the systems), simulation, or design integration of missile systems or subsystems.

9.3 (Commodity Designator code: MA093000)

Materials, devices, and software for reduced observables (e.g. radar reflectivity, ultraviolet/infrared signatures and acoustic signatures, i.e. stealth technology), for applications designed for missile systems or subsystems including:

9.3.1 (Commodity Designator code: MA093100)

Structural materials and coatings specially designed for reducing radar reflectivity by 10 dB or more;

9.3.2 (Commodity Designator code: MA093200)

Coatings, including paints, specially designed for reducing or tailoring reflectivity or emissivity in infrared or ultraviolet spectra by 10 dB or more;

9.3.3 (Commodity Designator code: MA093300)

Software or databases for analysis of signature reduction;

9.3.4 (Commodity Designator code: MA093400)

Radar cross-section measurement systems.

9.4 (Commodity Designator code: None)

Material and devices for protecting missile systems against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), as follows:

9.4.1 (Commodity Designator code: MA094100)

Radiation Hardened microcircuits and detectors capable of withstanding:

a. a total irradiation dose of $1x10^5$ rad (Si); or
b. prompt dose rate of $5x10^8$ rad (Si) /s.

9.4.2 (Commodity Designator code: MA094200)

Radomes designed to withstand a combined thermal shock greater than 100 cal/cm^2 accompanied by a peak over pressure of greater than 50 kPa.

GOODS REVIEW LIST
SECTION D
NUCLEAR SECTION

• GENERAL PROVISIONS TO THE GOODS REVIEW LIST, NUCLEAR SECTION

Introduction

In paragraph 12 of resolution 687 (1991), the Security Council decided, inter alia, that Iraq shall unconditionally agree not to acquire or develop nuclear weapons or nuclear-weapon-usable material or any subsystems or components or any research, development, support or manufacturing facilities related thereto; to declare to the IAEA the locations, amounts and types of such items, and to accept the destruction, removal, or rendering harmless of all such items. In paragraph 13 of that resolution, the Security Council also asked the IAEA to develop a plan for the future ongoing monitoring and verification of Iraq's compliance with paragraph 12. An additional restriction, specified in paragraph 3. iv) of resolution 707 (1991), currently prohibits Iraq from carrying out nuclear activities of any kind, except for the use of isotopes for medical, agricultural or industrial purposes.

The IAEA's "Plan for Ongoing Monitoring and Verification (OMV) of Iraq's Compliance with Paragraph 12 of Part C of Security Council Resolution 687 (1991) and with the Requirements of Paragraphs 3 and 5 of Resolution 707 (1991)" (hereinafter referred to as the "OMV Plan") was approved by the Security Council in resolution 715 (1991). The Security Council approved the OMV Plan in resolution 715 (1991). Annex 3 of the IAEA's OMV Plan[1] sets out a list of nuclear and nuclear-related items which are either prohibited to Iraq or are subject to certain controls (including reporting to the IAEA by Iraq and reporting by any State exporting such items to Iraq).[2]

In resolution 715 (1991), the Security Council also requested the Committee established under resolution 661 (1990) (hereinafter referred to as the Sanctions Committee), the IAEA and the United Nations Special Commission (UNSCOM) to develop "a mechanism for monitoring any future sales or supplies by other countries to Iraq of items relevant to the implementation of section C of resolution 687 (1991) and other relevant resolutions". The provisions for the export/import monitoring mechanism developed by the Sanctions Committee, UNSCOM and the IAEA were transmitted to the Security Council in document S/1995/1017 (7 December 1995. They included the establishment of a Joint Unit to which relevant exports to, and imports by, Iraq must be reported. That mechanism (hereinafter referred to as the Export/Import Mechanism) was approved by the Security Council in resolution 1051 (1996).

As provided for in the Export/Import Mechanism, Annex 3 of the IAEA's OMV Plan (hereinafter referred to as Annex 3) serves as the list of those nuclear and nuclear-related items which are subject to reporting, under that mechanism, to the Joint Unit, by Iraq and by

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[1] The OMV Plan, including Annex 3 thereto, was originally published as S/22872/Rev.1 and Corr. 1 (20 September 1991 and 10 October 1991, respectively), and was approved by the United Nations Security Council on 11 October 1991 in Security Council resolution 715 (1991). A first update and revision was issued as S/24300 (16 July 1992). Annex 3 was subsequently revised and re-issued as S/1995/215 (23 March 1995), S/1995/215/Corr. 1 (7 April 1995) and S/1995/215/Corr. 2 (2 August 1995).

[2] See also, for example, paragraphs 22(c), 25, 26, 30(a) and 30(b) of the OMV Plan.

any State exporting such items to Iraq. Items related to the chemical, biological and missile aspects of the relevant Security Council resolutions are set out in Annexes II, III and IV to the OMV Plans of UNSCOM.[3]

In resolution 1284 (1999), the Security Council requested UNMOVIC (which replaced UNSCOM)[4] and the IAEA to resume the revision and updating of the lists of items and technology to which the Export/Import Mechanism applies. In paragraph 19 of resolution 1330 (2000), the Security Council established 5 June 2001 as the date by which this revision should be completed. This document reflects the results of the revision and updating of Annex 3 with respect to nuclear and nuclear-related items and technology.

Purpose

Annex 3 of the IAEA's OMV Plan lists nuclear material, equipment and technology and nuclear-related materials, equipment, software and related technology, which are subject to the OMV Plan as well to the Export/Import Mechanism. It is designed to assist all organizations, agencies and personnel responsible for ensuring compliance with the OMV and/or the Export/Import Mechanism. These include exporters, customs and other officials in exporting States and in Iraq, personnel in the Joint Unit responsible for the Export/Import Mechanism, and staff of the IAEA and UNMOVIC at Headquarters and in the field.

In addition to certain nuclear materials, the items listed in Annex 3 include those considered to be "especially designed or prepared for the processing, use or production of special fissionable material"[5] (i.e., items for use exclusively in nuclear activities, whether military or civilian). Such items are, for ease of reference, termed, "single-use". Furthermore, Annex 3 lists items considered to be "dual-use" items[6] (i.e., items that may have non-nuclear applications as well as nuclear applications).

Prohibitions and Restrictions

Items prohibited pursuant to resolution 687 (1991)

Those items which are prohibited to Iraq pursuant to resolution 687 (1991), i.e., those related to weapons development or use, are indicated in Annex 3 by shading and an asterisk. Iraq is required to declare the existence in Iraq of such items to the IAEA so that the IAEA can arrange to destroy, remove or render such items harmless.

Iraq is also prohibited from acquiring such items; thus, the transfer to Iraq of any item indicated by shading and an asterisk (including technology directly associated with or required for the development, production or use of such item) is prohibited. It bears noting that some of the items indicated as prohibited under resolution 687 (1991) are dual-use items.

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[3] See United Nations document S/22871/Rev.1, dated 2 October 1991.

[4] In resolution 1284 (1999), the Security Council established the United Nations Monitoring, Verification and Inspection Commission (UNMOVIC) as a subsidiary body of the Council to replace UNSCOM. UNMOVIC is to undertake the responsibilities mandated to UNSCOM under resolution 687 (1991) and other relevant resolutions of the Security Council.

[5] See IAEA document INFCIRC/254/Rev.4/ Part 1, dated 15 March 2000.

[6] See IAEA document INFCIRC/254/Rev.4/ Part 2, dated 9 March 2000.

Items restricted pursuant to resolution 707

As indicated above, paragraph 3. (iv) of resolution 707 (1991) demands that Iraq "halt all nuclear activities of any kind, except for the use of isotopes for medical, agricultural or industrial purposes until the Security Council determines that Iraq is in full compliance with that resolution and paragraphs 12 and 13 of resolution 687 (1991), and the IAEA determines that Iraq is in full compliance with its safeguards agreement with that Agency." Consequently, in addition to the items prohibited pursuant to resolution 687 (1991). Annex 3 lists items that are of use in peaceful nuclear activities, including research and development, which, although not prohibited under resolution 687 (1991), are prohibited under the additional strictures imposed by resolution 707 (1991). Furthermore, in paragraph 27 of the IAEA OMV plan approved under resolution 715 (1991) requires that, at such a time as the Security Council determines that Iraq may resume nuclear activities not prohibited under resolution 687 (1991), "Iraq shall submit a request to the Security Council specifying precisely the activity, the facility, installation or site where it is to be carried out, and the material or other items involved".

"The transfer to Iraq of those items indicated with an asterisk in the Annex 3 listing is prohibited."

Transfers of non-proscribed items for non-proscribed purposes

The transfer to Iraq of non-proscribed items for non-proscribed purposes is subject to the approval of the IAEA under the OMV Plan and is required to be reported under the Export/Import Mechanism. The list of non-proscribed applications of isotopes is found in Annex 4 of the OMV Plan and is reproduced as Appendix 3 of this Section for convenience.

In addition, and in accordance with paragraphs 3 and 4 of resolution 661 (1990) and paragraphs 3 and 11 of resolution 670 (1990), the transfer of any such items is regulated by the Sanctions Committee established under resolution 660 (1990). Resolution 661 prohibits, inter alia, the sale or supply of any commodities or products to Iraq, but not including "supplies intended strictly for medical purposes, and in humanitarian circumstances, foodstuffs to any person or body in Iraq." Resolution 670 (1990) calls upon all States "to carry out their obligations to ensure strict and complete compliance with resolution 661 (1990), and in particular paragraphs 3, 4 and 5 thereof."

Definitions

Annex 3 uses many terms with specific technical meanings. Definitions of these terms are found at appropriate locations in the body of Annex 3, and in Appendix 4 to this Section.

Abbreviations and Units

Annex 3 uses the International System of Units (SI). The abbreviations of such units used in Annex 3 are set out in Appendix 5 to this Section.

• NUCLEAR MATERIALS

NOTE:
See Appendix 4 for definitions of nuclear materials.

1. *Nuclear Materials

1. 1. Uranium and Thorium

Uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound or concentrate and any other goods containing one or more of the foregoing.

1. 2. Low Enriched Uranium (LEU), or plutonium

Uranium enriched to less than 20% of the isotopes 233, 235, or both; plutonium with an isotopic concentration of Pu-238 exceeding 80%; any of the foregoing in the form of metal, alloy, chemical compound or concentrate and any other goods containing one or more of the foregoing, other than irradiated nuclear fuel (*See item 1.4*).

1. 3. *Highly Enriched Uranium (HEU) or plutonium

Uranium enriched to 20% or more in isotopes 233, 235, or both; plutonium containing less than 80% plutonium 238; any of the foregoing in the form of metal, alloy, chemical compound or concentrate and any other goods containing one or more of the foregoing, other than irradiated nuclear fuel (*See item 1.4*).

NOTE:
The following items are not prohibited, but are required to be reported:

i) Sub-gram amounts of the special fissionable material specified in 1.3 above in the form of:

a) Certified reference material;

b) Instrument calibration source; or

c) Sensing component in instruments

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1. 4. *Irradiated nuclear fuel

EXPLANATORY NOTE:
The prohibition applies only to the transfer of irradiated nuclear fuel to Iraq.

1. 5. *Neptunium-237

Neptunium enriched to 20% or more in isotope 237; in the form of metal, alloy, chemical compound or concentrate and any other goods containing one or more of the foregoing.

• NON-NUCLEAR MATERIALS

NOTE 1
See item for 49.11 deuterium and heavy water.

NOTE 2
See item 49.12 for nuclear grade graphite.

2. Aluminium alloys

Aluminium alloys having both of the following characteristics:

(a) 'Capable of' an ultimate tensile strength of 460 MPa or more at 293 K (20 °C); and

(b) In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.

TECHNICAL NOTE
In item 2(a), the phrase 'capable of' encompasses aluminium alloys before or after heat treatment.

3. Beryllium

Beryllium metal, alloys containing more than 50% beryllium by weight, beryllium compounds, manufactures thereof, and waste or scrap of any of the foregoing.

NOTE:
Item 3 does not include the following:

i) Metal windows for X-ray machines or for bore-hole logging devices;

ii) Oxide shapes in fabricated or semi-fabricated forms especially designed for electronic component parts or as substrates for electronic circuits;

iii) Beryl (silicate of beryllium and aluminium) in the form of emeralds or aquamarine.

4. Bismuth

Bismuth having both of the following characteristics:

(a) A purity of 99.99% or greater by weight; and

(b) Containing less than 10 parts per million by weight of silver.

5. Boron

Boron enriched in the boron-10 (^{10}B) isotope to greater than its natural isotopic abundance, as follows: elemental boron, compounds, mixtures containing boron, manufactures thereof, waste or scrap of any of the foregoing.

NOTE:
In item 5 mixtures containing boron include boron-loaded materials.

TECHNICAL NOTE
The natural isotopic abundance of boron-10 is approximately 18.5 weight percent (20 atom percent).

6. Calcium

Calcium having <u>both</u> of the following characteristics:

(a) Containing less than 2000 parts per million by weight of metallic impurities other than magnesium; and

(b) Containing less than 20 parts per million by weight of boron.

7. Chlorine trifluoride

8. 'Fibrous or filamentary materials' and prepregs

NOTE
Items 8.1 - 8.3 refer to raw materials. Item 8.4 refers to finished products.

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

(a) A 'specific modulus' of 12.7 x 10^6 m or greater; <u>or</u>

(b) A 'specific tensile strength' of 23.5 x 10^4 m or greater;

NOTE:
Item 8.1 does not include aramid 'fibrous or filamentary materials' having 0.25% or more by weight of an ester based fibre surface modifier.

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

(a) A 'specific modulus' of 3.18 x 10^6 m or greater; <u>and</u>

(b) A 'specific tensile strength' of 7.62 x 10^4 m or greater;

8. 3. Thermoset resin impregnated continuous 'yarns', 'rovings', 'tows' or 'tapes' with a width of 15 mm or less (prepregs), made from carbon or glass 'fibrous or filamentary materials' specified in item 8.1 or item 8.2.

TECHNICAL NOTE
The resin forms the matrix of the composite.

8. 4. *Composite structures in the form of tubes having both of the following characteristics:

(a) An inside diameter of between 75 and 400 mm; and

(b) Made with any of the materials specified in item 8.1, item 8.2 and item 8.3.

TECHNICAL NOTE
The term 'fibrous or filamentary materials' includes continuous monofilaments, yarns, rovings, tows, and tapes.

'Filament' or 'monofilament' is the smallest increment of fibre, usually several µm in diameter.

'Roving' is a bundle (typically 12-120) of approximately parallel strands.

'Strand' is a bundle of filaments (typically over 200) arranged approximately parallel.

'Tape' is a material constructed of interlaced or unidirectional filaments, strands, rovings, tows, yarns, etc. usually pre-impregnated with resin.

'Tow' is a bundle of filaments, usually approximately parallel.

'Yarn' is a bundle of twisted strands.

'Specific modulus' is the Young's modulus in N/m^2 divided by the specific weight in N/m^3 when measured at a temperature of 23±2°C and a relative humidity of 50±5%.

'Specific tensile strength'' is the ultimate tensile strength in N/m^2 divided by the specific weight in N/m^3 when measured at a temperature of 23±2°C and a relative humidity of 50±5%.

9. Hafnium

Hafnium metal, alloys containing more than 60% hafnium by weight, and hafnium compounds containing more than 60% hafnium by weight, manufactures thereof and waste or scrap of any of the foregoing.

10. *Lithium

Lithium enriched in the lithium-6 (^6Li) isotope to greater than its natural isotopic abundance and products or devices containing enriched lithium, as follows: elemental lithium, alloys, compounds, mixtures containing lithium, manufactures thereof, waste or scrap of any of the foregoing.

NOTE
Item 10 does not include thermoluminescent dosimeters.

TECHNICAL NOTE
The natural isotopic abundance of lithium-6 is approximately 6.5 weight percent (7.5 atom percent).

11. Magnesium

Magnesium having both of the following characteristics:

(a) Containing less than 2000 parts per million by weight of metallic impurities other than calcium; and

(b) Containing less than 20 parts per million by weight of boron.

12. *Maraging steel

Maraging steel 'capable of' an ultimate tensile strength of 2050 MPa (2.050×10^9 N/m^2) or more at 293 K (20°C).

TECHNICAL NOTE
In item 12, the phrase 'capable of' encompasses maraging steel before or after heat treatment.

NOTE:
Item 12 does not include forms in which all linear dimensions are 75 mm or less.

13. Radium-226 (^{226}Ra)

Radium-226 (^{226}Ra), Radium-226 alloys, radium-226 compounds, mixtures containing radium-226, manufactures thereof, and products or devices containing any of the foregoing.

NOTE 1
See item 20 for other alpha-emitting radioisotopes.

NOTE 2
Item 13 does not include the following:

i) Medical applicators;

ii) A product or device containing less than 0.37 GBq of radium-226.

14. Titanium
Titanium alloys capable of having both of the following characteristics:

(a) Of an ultimate tensile strength of 900 MPa or more at 293 K (20 °C); and

(b) In the form of tubes or cylindrical solid forms (including forgings) with an outside diameter of more than 75 mm.

TECHNICAL NOTE
In item 14, the phrase 'capable of' encompasses titanium alloys before or after heat treatment.

15. Tungsten

Tungsten, tungsten carbide, and alloys containing more than 90% tungsten by weight, having both of the following characteristics:

(a) In forms with a hollow cylindrical symmetry (including cylinder segments) with an inside diameter between 100 and 300 mm; and

(b) A mass greater than 20 kg.

16. Zirconium

Zirconium with a hafnium content of less than 1 part hafnium to 500 parts zirconium by weight, as follows: metal, alloys containing more than 50% zirconium by weight, compounds, manufactures thereof, waste or scrap of any of the foregoing.

NOTE 1
Item 16 does not include zirconium in the form of foil having a thickness of 0.10 mm or less.

NOTE 2
See item 49.6 for additional zirconium controls.

17. Nickel

Nickel powder and porous nickel metal, as follows:

17. 1. Nickel powder having both of the following characteristics:

(a) A nickel purity content of 99.0% or greater by weight; and

(b) A mean particle size of less than 10 microns (µm) measured by the ASTM B 330 standard;

17. 2 Porous nickel metal produced from materials specified in item 17.1

NOTE 1
For nickel powders, which are especially prepared for the manufacture of gaseous diffusion barriers, see item 24.1.

NOTE 2
Item 17 does not include the following:

i) Filamentary nickel powders;

ii) Single porous nickel metal sheets with an area of 1000 cm^2 per sheet or less.

TECHNICAL NOTE
Item 17.2 refers to porous metal formed by compacting and sintering the material in item 17.1 to form a metal material with fine pores interconnected throughout the structure.

18. *Tritium

Tritium, tritium compounds, mixtures containing tritium in which the ratio of tritium to hydrogen by atoms exceeds 1 part in 1000, and products or devices containing any of the foregoing,

NOTE 1
The following are not prohibited but are required to be reported:

Tritium in luminescent devices (e.g. safety devices installed in aircraft, watches, runway lights) containing less than 40 Ci (4 mg) of tritium in any chemical or physical form. The *total amount of tritium imported in any twelve month period under this exception shall not exceed 2000 Ci (0.2 g);*

NOTE 2
Tritium labelled organic compounds are not prohibited and are not required to be reported.

NOTE 3
See also item 36.

19. *Helium-3

Helium-3 (^3He), mixtures containing helium-3, and products or devices containing any of the foregoing.

NOTE:
Item 19 does not prohibit a product or device containing less than 1 g of helium-3.

20. Alpha sources

Alpha-emitting radionuclides having an alpha half-life of 10 days or greater but less than 200 years, in the following forms:

(a) Elemental;

(b) Compounds having a specific alpha activity of 37 GBq per kg or greater;

(c) Mixtures having a specific alpha activity of 37 GBq per kg or greater;

(d) Products or devices containing any of the foregoing.

NOTE 1
Item 20 does not include a product or device containing less than 3.7 GBq of alpha activity.

NOTE 2
See item 13 for Ra^{226}.

NOTE 3
Item 20(a) above includes, but it is not limited to, the following:

Atomic Number	***Element***	***Half Life***	
		Years	***Days***
147	*Europium*		*24d*
148	*Europium*		*54.5d*
148	*Gadolinium*	*75y*	
151	*Gadolinium*		*120d*
188	*Platinum*		*10.2d*
208	*Polonium*	*2.898y*	
209	*Polonium*	*1.02y*	
210(RaD)	*Lead*	*22.3y*	

Atomic Number	***Element***	***Half Life***	
		Years	***Days***
210(RaF)	*Polonium*		*138.376d*
223(AcX)	*Radium*		*11.43d*
225	*Actinium*		*10.00d*
227(Ac)	*Actinium*	*21.77y*	
227(RaAc)	*Thorium*		*18.718d*
228(RaTh)	*Thorium*	*1.913y*	
230 *230*	*Protactinium* *Uranium*		*17.4d* *20.8d*
232	*Uranium*	*68.9y*	
235	*Neptunium*	*1.085y*	
236	*Plutonium*	*2.851y*	
237	*Plutonium*		*45.17d*
238	*Plutonium*	*87.74y*	
240	*Curium*		*27d*
241	*Curium*		*32.8d*
241	*Neptunium*	*14.4y*	
242m	*Americium*	*141y*	
242	*Curium*		*162.94d*
243	*Curium*	*28.5y*	
244 *248*	*Curium* *Californium*	*18.11y*	 *334d*
250	*Californium*	*13.08y*	
252	*Californium*	*2.645y*	
252	*Einsteinium*	*1.291y*	
253	*Einsteinium*		*20.4d*
254	*Californium*		*60.5d*
254	*Einsteinium*		*275.7d*
255	*Einsteinium*		*38.8d*
257	*Fermium*		*100.5d*
258	*Mendelevium*		*55d*

NOTE 4
Americium in industrial process equipment and petroleum equipment shall not exceed 20 Ci (6.16g) per device.

NOTE 5
The total amount of americium imported in any twelve month period shall not exceed 200 Ci (61.6 g).

NOTE 6
Item 20 does not apply to americium when used in smoke detectors.

21. Tantalum

Tantalum sheets with a thickness of 2.5 mm or greater from which a circle of 200 mm diameter can be obtained.

• *PLANTS FOR THE SEPARATION OF ISOTOPES OF URANIUM AND EQUIPMENT, OTHER THAN ANALYTICAL INSTRUMENTS, SPECIALLY DESIGNED OR PREPARED THEREFOR

Items of equipment that are considered to fall within the meaning of the phrase 'equipment other than analytical instruments, especially designed or prepared' for the separation of isotopes of uranium include:

22. *Gas centrifuges and assemblies and components specially designed or prepared for use in gas centrifuges

INTRODUCTORY NOTE:
The gas centrifuge normally consists of a thin-walled cylinder(s) of between 75 mm and 400 mm diameter contained in a vacuum environment and spun at high peripheral speed of the order of 300 m/s or more with its central axis vertical. In order to achieve high speed, the materials of construction for the rotating components have to be of a high strength to density ratio and the rotor assembly, and hence its individual components have to be manufactured to very close tolerances in order to minimize the imbalance. In contrast to other centrifuges, the gas centrifuge for uranium enrichment is characterized by having, within the rotor chamber, a rotating disc-shaped baffle(s) and a stationary tube arrangement for feeding and extracting the UF_6 *gas and featuring at least 3 separate channels, of which 2 are connected to scoops extending from the rotor axis towards the periphery of the rotor chamber. Also contained within the vacuum environment are a number of critical items which do not rotate and which, although they are especially designed, are not difficult to fabricate, nor are they fabricated out of unique materials. A centrifuge facility, however, requires a large number of these components, so that quantities can provide an important indication of end use.*

22. 1. *Rotating components

(a) Complete rotor assemblies:

Thin-walled cylinders (or a number of interconnected thin-walled cylinders) manufactured from one or more of the high strength to density ratio materials described in the *EXPLANATORY NOTE* to this section. If interconnected, the cylinders are joined together by flexible bellows or rings as described in section (c) below. The rotor is fitted with an internal baffle(s) and end caps, as described in section (d) and (e) below, if in final form. However, the complete assembly may be delivered only partly assembled;

(b) Rotor tubes:

Especially designed or prepared thin-walled cylinders with thickness of 12 mm or less, a diameter of between 75 mm and 400 mm and manufactured from one or more of the high strength to density ratio materials described in the *EXPLANATORY NOTE* to this section;

(c) Rings or bellows:

Components especially designed or prepared to give localized support to the rotor tube or to join together a number of rotor tubes. The bellows is a short cylinder of wall thickness 3 mm or less, a diameter of between 75 mm and 400 mm, having a convolute and manufactured from one or more of the high strength to density ratio materials described in the *EXPLANATORY NOTE* to this section;

(d) Baffles:

Disc-shaped components of between 75 mm and 400 mm in diameter especially designed or prepared to be mounted inside the centrifuge rotor tube, in order to isolate the take-off chamber from the main separation chamber and, in some cases, to assist the UF_6 gas circulation within the main separation chamber of the rotor tube, and manufactured from one or more of the high strength to density ratio materials described in the *EXPLANATORY NOTE* to this section;

(e) Top caps/Bottom caps:

Disc-shaped components of between 75 mm and 400 mm in diameter especially designed or prepared to fit to the ends of the rotor tube, and so contain the UF_6 within the rotor tube, and in some cases to support, retain, or contain as an integrated part an element of the upper bearing (top cap) or to carry the rotating elements of the motor and lower bearing (bottom cap), and manufactured from one of the high strength to density ratio materials described in the *EXPLANATORY NOTE* to this section.

EXPLANATORY NOTE:
The materials used for centrifuge rotating components are:

i) Maraging steel capable of an ultimate tensile strength of 2.05×10^9 N/m^2 or more;

ii) Aluminium alloys capable of an ultimate tensile strength of 0.46×10^9 N/m^2 or more; and

iii) Filamentary materials suitable for use in composite structures and having a specific modulus of 12.3×10^6 m or greater and a specific ultimate tensile strength of 0.3×10^6 m or greater ('Specific Modulus' is the Young modulus in N/m^2 divided by the specific weight in N/m^3; 'Specific Ultimate Tensile Strength' is the ultimate tensile strength in N/m^2 divided by the specific weight in N/m^3.)

22. 2. *Static components

(a) Magnetic suspension bearings:

Especially designed or prepared bearing assemblies consisting of an annular magnet suspended within a housing containing a damping medium. The housing is manufactured from an UF6-resistant material (see EXPLANATORY NOTE to Section 22 above). The magnet couples with a pole piece or a second magnet fitted to the top cap described in Section 22.1(e) above. The magnet may be ring-shaped with a relation between the outer and inner diameter smaller or equal to 1.6:1. The magnet may be in a form having an initial permeability of 0.15 H/m (120,000 in CGS units) or more, or a remanence of 98.5% or more, or an energy product of greater than 80 kJ/m^3 (107 gauss-oersteds). In addition to the usual material properties, it is a prerequisite that the deviation of the magnetic axes from the geometrical axes is limited to very small tolerances (lower than 0.1 mm) or that homogeneity of the material of the magnet is specially called for;

(b) Bearings/Dampers:

Especially designed or prepared bearings comprising a pivot/cup assembly mounted on a damper. The pivot is normally a hardened steel shaft with a hemisphere at one end with a means of attachment to the bottom cap described in Section 22.1(e) at the other. The shaft may, however, have a hydrodynamic bearing attached. The cup is pellet-shaped with a hemispherical indentation in one surface. These components are often supplied separately to the damper;

(c) Molecular pumps:

Especially designed or prepared cylinders having internally machined or extruded helical grooves and internally machined bores. Typical dimensions are as follows: 75 mm to 400 mm internal diameter, 10 mm or more wall thickness, with the length equal to or greater than the diameter. The grooves are typically rectangular in cross-section and 2 mm or more in depth;

(d) Motor stators:

Especially designed or prepared ring-shaped stators for high-speed multiphase AC hysteresis (or reluctance) motors for synchronous operation within a vacuum in the frequency range of 600-2000 Hz and a power range of 50-1000 VA. The stators consist of multiphase windings on a laminated low loss iron core comprised of thin layers typically 2.0 mm thick or less;

(e) Centrifuge housings/recipients:

Components especially designed or prepared to contain the rotor tube assembly of a gas centrifuge. The housing consists of a rigid cylinder of wall thickness up to 30 mm with precision-machined ends to locate the bearings and with one or more flanges for mounting. The machined ends are parallel to each other and perpendicular to the cylinder's longitudinal axis to within 0.05 degrees or less. The housing may also be a honeycomb type structure to accommodate several rotor tubes. The housings are made of, or protected by, materials resistant to corrosion by UF_6;

(f) Scoops:

Especially designed or prepared tubes of up to 12 mm internal diameter for the extraction of UF_6 gas from within the rotor tube by a Pitot tube action (that is, with an aperture facing into the circumferential gas flow within the rotor tube, for example by bending the end of a radially disposed tube) and capable of being fixed to the central gas extraction system. The tubes are made of, or protected by, materials resistant to corrosion by UF_6.

23. *Specially designed or prepared auxiliary systems, equipment and components for gas centrifuge enrichment plants

INTRODUCTORY NOTE

The auxiliary systems, equipment, and components for a gas centrifuge enrichment plant are the systems of the plant needed to feed UF_6 to the centrifuges, to link the individual centrifuge to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the 'product' and 'tails' UF_6 from the centrifuge together with the equipment required to drive the centrifuges or to control the plant.

Normally, UF_6 is evaporated from the solid using heated autoclaves and is distributed in gaseous form to the centrifuge by way of cascade header pipework. The 'product' and 'tails' UF_6 gaseous streams flowing from the centrifuge are also passed by way of cascade header pipework to cold traps (operating at about 203 K (-70°C)) where they are condensed prior to onward transfer into suitable containers for transportation or storage. Because an enrichment plant consists of many thousands of centrifuges arranged in cascades there are many kilometres of cascade header pipework, incorporating thousands of welds with a substantial amount of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.

23. 1. *Feed systems/'product' and 'tails' withdrawal systems

Especially designed or prepared process systems including:

(a) Feed autoclaves (or stations) used for passing UF_6 to the centrifuge cascades at up to 100 kPa and at a rate of 1 kg/h or more;

(b) Desublimers (or cold traps) used to remove UF_6 from the cascades at up to 3 kPa pressure. The desublimers are capable of being chilled to 203 K (-70°C) and heated to 343 K (70°C); and

(c) Product' and 'tails' stations used for trapping UF_6 into containers.

This plant, equipment, and pipework is wholly made of or lined with UF_6-resistant materials (see *EXPLANATORY NOTE* at the end of this section) and is fabricated to very high vacuum and cleanliness standards.

23. 2. *Machine header piping systems

Especially designed or prepared piping systems and header systems for handling UF_6 within the centrifuge cascades.

The piping network is normally of the 'triple' header system with each centrifuge connected to each of the headers. There is, thus, a substantial amount of repetition in its form. It is wholly made of UF_6-resistant materials (see *EXPLANATORY NOTE* at the end of this section) and is fabricated to very high vacuum and cleanliness standards.

23. 3. *UF_6 mass spectrometers/ion sources

Especially designed or prepared magnetic or quadrupole mass spectrometers, capable of taking 'on-line' samples of feed, 'product' or 'tails', from UF_6 gas streams and having all of the following characteristics:

(a) Unit resolution for atomic mass unit greater than 320;

(b) Ion sources constructed of or lined with nichrome or Monel or nickel plated;

(c) Electron bombardment ionization sources; and

(d) A collector system suitable for isotopic analysis.

23. 4. *Frequency changers

Frequency changers (also known as converters or inverters) especially designed or prepared to supply motor stators as defined under 22.2(d), or parts, components, and sub-assemblies of such frequency changers having all of the following characteristics:

(a) A multiphase output of 600 to 2000 Hz;

(b) High stability (with frequency control better than 0.1%); and

(c) Total harmonic distortion less than 2%.

NOTE:
See also item 84.

EXPLANATORY NOTE:
The items listed in section 23 either come into direct contact with the UF_6 process gas or directly control the centrifuges and the passage of the gas from centrifuge to centrifuge and cascade to cascade.

Materials resistant to corrosion by UF_6 include stainless steel, aluminium, aluminium alloys, nickel, or alloys containing 60% or more nickel.

24. *Specially designed or prepared assemblies or components for use in gaseous diffusion enrichment

INTRODUCTORY NOTE:
In the gaseous diffusion method of uranium isotope separation, the main technological assembly is a special porous gaseous diffusion barrier, heat exchanger for cooling the gas (which is heated by the process of compression), seal valves and control valves, and pipelines. In as much as gaseous diffusion technology uses uranium hexafluoride (UF_6), all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that remain stable in contact with UF_6. A gaseous diffusion facility requires a number of these assemblies, so that quantities can provide an important indication of end use.

24. 1. *Gaseous diffusion barriers

(a) Especially designed or prepared thin, porous filters, with a pore size of 100 - l000 Å (ångstroms), a thickness of 5 mm or less, and for tubular forms, a diameter of 25 mm or less, made of metallic, polymer or ceramic materials resistant to corrosion by UF_6; and

(b) Specially prepared compounds or powders for the manufacture of such filters. Such compounds and powders include nickel or alloys containing 60% or more nickel, aluminium oxide, or UF_6-resistant fully fluorinated hydrocarbon polymers having a purity of 99.9% or more, a particle size less than 10 microns, and a high degree of particle size uniformity, which are specially prepared for the manufacture of gaseous diffusion barriers.

24. 2. *Diffuser housings

Especially designed or prepared hermetically sealed cylindrical vessels greater than 300 mm in diameter and greater than 900 mm in length, or rectangular vessels of comparable dimensions, which have an inlet connection and two outlet connections all of which are greater than 50 mm in diameter, for containing the gaseous diffusion barrier, made of or lined with UF_6-resistant materials and designed for horizontal or vertical installation.

24. 3. *Compressors and gas blowers

Especially designed or prepared axial, centrifugal, or positive displacement compressors, or gas blowers with a suction volume capacity of 1 m^3/min or more of UF_6, and with a discharge pressure of up to several hundred kPa, designed for long-term operation in the UF_6 environment with or without an electrical motor of appropriate power, as well as separate assemblies of such compressors and gas blowers. These compressors and gas blowers have a pressure ratio between 2:1 and 6:1 and are made of, or lined with, materials resistant to UF_6.

24. 4. *Rotary shaft seals

Especially designed or prepared vacuum seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor or the gas blower rotor with the driver motor, so as to ensure a reliable seal against in-leaking of air into the inner chamber of the compressor or gas blower which is filled with UF_6. Such seals are normally designed for a buffer gas in-leakage rate of less than 1000 cm^3/min (60 in^3/min).

24. 5. *Heat exchangers for cooling UF_6

Especially designed or prepared heat exchangers made of or lined with UF_6-resistant materials (except stainless steel) or with copper or any combination of those metals, and intended for a leakage pressure change rate of less than 10 Pa per hour under a pressure difference of 100 kPa.

24. 6. *Porous membranes

Porous membranes, other than those specified in item 24.1, having both of the following characteristics:

(a) Mean pore diameter between 1 nm and 100 nm;

(b) Surfaces that come in contact with the process fluid made from any of the following materials: aluminium, aluminium alloy, aluminium oxide, nickel, nickel alloy, stainless steel, or fully fluorinated hydrocarbon polymers.

NOTE:
This entry does not prohibit porous membranes that are component parts of devices or finished products specially designed for water purification or medical uses, and that are being supplied as part of such devices or finished products.

25. *Specially designed or prepared auxiliary systems, equipment and components for use in gaseous diffusion enrichment

INTRODUCTORY NOTE:
The auxiliary systems, equipment and components for gaseous diffusion enrichment plants are the systems of plant needed to feed UF_6 to the gaseous diffusion assembly, to link the individual assemblies to each other to form cascades (or stages) to allow for progressively higher enrichments and to extract the 'product' and 'tails' UF_6 from the diffusion cascades.

Because of the high inertial properties of diffusion cascades, any interruption in their operation, and specially their shut-down, leads to serious consequences. Therefore, a strict and constant maintenance of vacuum in all technological systems, automatic protection from accidents and the precise automated regulation of the gas flow is of importance in a gaseous diffusion plant. All this leads to a need to equip the plant with a large number of special measuring, regulating and controlling systems.

Normally, UF_6 is evaporated from cylinders placed within autoclaves and is distributed in gaseous form to the entry point by way of cascade header pipework. The 'product' and 'tails' UF_6 gaseous streams flowing from exit points are passed by way of cascade header pipework to either cold traps or to compression stations where the UF_6 gas is liquefied prior to onward transfer into suitable containers for transportation or storage. Because a gaseous diffusion enrichment plant consists of a large number of gaseous diffusion assemblies arranged in cascades, there are many kilometres of cascade header pipework, incorporating thousands of welds with substantial amounts of repetition of layout. The equipment, components and piping systems are fabricated to very high vacuum and cleanliness standards.

25. 1. *Feed systems/'product' and 'tails' withdrawal systems

Especially designed or prepared process systems, capable of operating at pressures of 300 kPa or less, including:

(a) Feed autoclaves, or systems used for passing UF_6 to the gaseous diffusion cascade;

(b) Desublimers (or cold traps) used to remove UF_6 from diffusion cascades;

(c) Liquefaction stations where UF_6 gas from the cascade is compressed and cooled to form liquid UF_6; and

(d) 'Product' or 'tails' stations used for transferring UF_6 into containers.

25. 2. *Header piping systems

Especially designed or prepared piping systems and header systems for handling UF_6 within the gaseous diffusion cascade.

This piping network is normally of the 'double' header system with each stage or group of stages connected to each of the headers.

25. 3. *Vacuum systems

(a) Especially designed or prepared large vacuum manifolds, vacuum headers and vacuum pumps having a suction capacity of 5 m^3/min or more; and

(b) Vacuum pumps especially designed for service in UF_6-bearing atmospheres made of, or lined with, aluminium, nickel, or alloys bearing more than 60% nickel. These pumps may be either rotary or positive, may have displacement and fluorocarbon seals, and may have special working fluids present.

25. 4. *Special shut-off and control valves

Especially designed or prepared manual or automated shut-off and control bellows valves made of UF_6-resistant materials with a diameter of 40 to 1500 mm for installation in main and auxiliary systems of gaseous diffusion enrichment plants.

25. 5 *UF_6 mass spectrometers/ion sources

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking 'on-line' samples of feed, 'product' or 'tails', from UF_6 gas streams and having all of the following characteristics:

(a) Unit resolution for atomic mass unit greater than 320;

(b) Ion sources constructed of or lined with nichrome or monel or nickel plated;

(c) Electron bombardment ionization sources; and

(d) Collector system suitable for isotopic analysis.

EXPLANATORY NOTE:
The items listed in section 25 above either come into direct contact with the UF_6 process gas or directly control the flow within the cascade. All surfaces that come into contact with the process gas are wholly made of, or lined with, UF_6-resistant materials. For the purposes of the sections relating to gaseous diffusion items, the materials resistant to corrosion by UF_6 include stainless steel, aluminium, aluminium alloys, aluminium oxide, nickel or alloys containing 60% or more nickel and UF_6-resistant fully fluorinated hydrocarbon polymers.

26. *Specially designed or prepared systems, equipment and components for aerodynamic enrichment plants

INTRODUCTORY NOTE:
In aerodynamic enrichment processes, a mixture of gaseous UF_6 and light gas (hydrogen or helium) is compressed and then passed through separating elements wherein isotopic separation is accomplished by the generation of high centrifugal forces over a curved-wall geometry. Two processes of this type have been successfully developed: the separation nozzle process and the vortex tube process. For both processes, the main components of a separation stage include cylindrical vessels housing the special separation elements (nozzle or vortex tubes), gas compressors, and heat exchangers to remove the heat of compression. An aerodynamic plant requires a number of these stages, so that quantities can provide an important indication of end use. Since aerodynamic processes use $UF_{6,}$ all equipment, pipeline and instrumentation surfaces (that come in contact with the gas) must be made of materials that are stable in contact with UF_6.

EXPLANATORY NOTE:
The items listed in this section either come into direct contact with the UF_6 process gas or directly control the flow within the cascade. All surfaces that come into contact with the process gas are wholly made of, or protected by, UF_6-resistant materials. For the purposes of the section relating to aerodynamic enrichment items, the materials resistant to corrosion by UF_6 include copper, stainless steel, aluminium, aluminium alloys, nickel or alloys containing 60% or more nickel and UF_6-resistant fully fluorinated hydrocarbon polymers.

26. 1. *Separation nozzles

Especially designed or prepared separation nozzles and assemblies thereof. The separation nozzles consist of slit-shaped, curved channels having a radius of curvature less than 1 mm (typically 0.1 to 0.05 mm), resistant to corrosion by UF6 and having a knife-edge within the nozzle that separates the gas flowing through the nozzle into two fractions.

26. 2. *Vortex tubes

Especially designed or prepared vortex tubes and assemblies thereof. The vortex tubes are cylindrical or tapered, made of, or protected by, materials resistant to corrosion by UF_6, having a diameter of between 0.5 cm and 4 cm, a length to diameter ratio of 20:1 or less and with one or more tangential inlets. The tubes may be equipped with nozzle-type appendages at either or both ends.

EXPLANATORY NOTE:
The feed gas enters the vortex tube tangentially at one end or through swirl vanes or at numerous tangential positions along the periphery of the tube.

26. 3. *Compressors and gas blowers

Especially designed or prepared axial, centrifugal or positive displacement compressors or gas blowers made of, or protected by, materials resistant to corrosion by UF_6 and with a suction volume capacity of 2 m^3/min or more of UF_6/carrier gas (hydrogen or helium) mixture.

EXPLANATORY NOTE:
These compressors and gas blowers typically have a pressure ratio between 1.2:1 and 6:1.

26. 4. *Rotary shaft seals

Especially designed or prepared rotary shaft seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor rotor or the gas blower rotor with the driver motor so as to ensure a reliable seal against out-leakage of process gas or in-leakage of air or seal gas into the inner chamber of the compressor or gas blower which is filled with a UF_6/carrier gas mixture.

26. 5. *Heat exchangers for gas cooling

Especially designed or prepared heat exchangers made of, or protected by, materials resistant to corrosion by UF_6.

26. 6. *Separation element housings

Especially designed or prepared separation element housings, made of, or protected by, materials resistant to corrosion by UF_6, for containing vortex tubes or separation nozzles.

EXPLANATORY NOTE:
These housings may be cylindrical vessels greater than 300 mm in diameter and greater than 900 mm in length or may be rectangular vessels of comparable dimensions, and may be designed for horizontal or vertical installation.

26. 7. *Feed systems/'product' and 'tails' withdrawal systems

Especially designed or prepared process systems or equipment for enrichment plants made of, or protected by, materials resistant to corrosion by UF_6, including:

(a) Feed autoclaves, ovens, or systems used for passing UF_6 to the enrichment process;

(b) Desublimers (or cold traps) used to remove UF_6 from the enrichment process for subsequent transfer upon heating;

(c) Solidification or liquefaction stations used to remove UF_6 from the enrichment process by compressing and converting UF_6 to a liquid or solid form; and

(d) 'Product' or 'tails' stations used for transferring UF_6 into containers

26. 8. *Header piping systems

Especially designed or prepared header piping systems, made of, or protected by, materials resistant to corrosion by UF_6, for handling UF_6 within the aerodynamic cascades. This piping network is normally of the 'double' header design with each stage or group of stages connected to each of the headers.

26. 9. *Vacuum systems and pumps

(a) Especially designed or prepared vacuum systems having a suction capacity of 5 m^3/min or more, consisting of vacuum manifolds, vacuum headers and vacuum pumps, and designed for service in UF_6-bearing atmospheres; and

(b) Vacuum pumps especially designed or prepared for service in UF_6-bearing atmospheres and made of, or protected by, materials resistant to corrosion by UF_6. These pumps may use fluorocarbon seals and special working fluids.

26. 10. *Special shut-off and control valves

Especially designed or prepared manual or automated shut-off and control bellows valves made of, or protected by, materials resistant to corrosion by UF_6 with a diameter of 40 to 1500 mm for installation in main and auxiliary systems of aerodynamic enrichment plants.

26. 11. *UF_6 mass spectrometers/ion sources

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking 'on-line' samples of feed, 'product' or 'tails', from UF_6 gas streams and having all of the following characteristics:

(a) Unit resolution for mass greater than 320;

(b) Ion sources constructed of or lined with nichrome or monel or nickel plated;

(c) Electron bombardment ionization sources; and

(d) Collector system suitable for isotopic analysis.

26. 12. *UF_6/carrier gas separation systems

Especially designed or prepared process systems for separating UF_6 from carrier gas (hydrogen or helium).

EXPLANATORY NOTE:
These systems are designed to reduce the UF_6 content in the carrier gas to 1 ppm or less, and may incorporate equipment such as:

i) Cryogenic heat exchangers and cryoseparators capable of temperatures of -120°C or less, or

ii) Cryogenic refrigeration units capable of temperatures of -120°C or less, or

iii) Separation nozzle or vortex tube units for the separation of UF_6 from carrier gas, or

iv) UF_6 cold traps capable of temperatures of -20°C or less.

27. *Specially designed or prepared systems, equipment and components for chemical exchange or ion exchange enrichment plants

INTRODUCTORY NOTE:
The slight difference in mass between the isotopes of uranium causes small changes in chemical reaction equilibria that can be used as a basis for separation of the isotopes. Two processes have been successfully developed: liquid-liquid chemical exchange and solid-liquid ion exchange.

In the liquid-liquid chemical exchange process, immiscible liquid phases (aqueous and organic) are counter currently contacted to give the cascading effect of thousands of separation stages. The aqueous phase consists of uranium chloride in hydrochloric acid solution. The organic phase consists of an extractant containing uranium chloride in an organic solvent. The contactors employed in the separation cascade can be liquid-liquid exchange columns (such as pulsed columns with sieve plates) or liquid centrifugal contactors. Chemical conversions (oxidation and reduction) are required at both ends of the separation cascade in order to provide for the reflux requirement at each end. A major design concern is to avoid contamination of the process streams with certain metal ions. Plastic, plastic-lined (including use of fluorocarbon polymers) and/or glass-lined columns and piping are therefore used.

In the solid-liquid ion-exchange process, enrichment is accomplished by uranium adsorption/desorption on a special very fast-acting, ion-exchange resin or adsorbent. A solution of uranium in hydrochloric acid and other chemical agents is passed through cylindrical enrichment columns containing packed beds of the adsorbent. For a continuous process, a reflux system is necessary to release the uranium from the adsorbent back into the liquid flow so that 'products' and 'tails' can be collected. This is accomplished with the use of suitable reduction/oxidation chemical agents that are fully regenerated in separate external circuits and that may be partly regenerated within the isotopic separation columns themselves.. The presence of hot concentrated hydrochloric acid solutions in the process requires that the equipment be made of, or protected by, special corrosion-resistant materials.

27. 1. *Liquid-liquid exchange columns (Chemical exchange)

Countercurrent liquid-liquid exchange columns having mechanical power input (i.e., pulsed columns with sieve plates, reciprocating plate columns, and columns

with internal turbine mixers), especially designed or prepared for uranium enrichment using the chemical exchange process. For corrosion resistance to concentrated hydrochloric acid solutions, these columns and their internals are made of, or protected by, suitable plastic materials (such as fluorocarbon polymers) or glass. The stage residence time of the columns is designed to be short (30 seconds or less).

27. 2. *Liquid-liquid centrifugal contactors (Chemical exchange)

Liquid-liquid centrifugal contactors especially designed or prepared for uranium enrichment using the chemical exchange process. Such contactors use rotation to achieve dispersion of the organic and aqueous streams and then centrifugal force to separate the phases. For corrosion resistance to concentrated hydrochloric acid solutions, the contactors are made of or are lined with suitable plastic materials (such as fluorocarbon polymers) or are lined with glass. The stage residence time of the centrifugal contactors is designed to be short (30 seconds or less).

27. 3. *Uranium reduction systems and equipment (Chemical exchange)

(a) Especially designed or prepared electrochemical reduction cells to reduce uranium from one valence state to another for uranium enrichment using the chemical exchange process. The cell materials in contact with process solutions must be corrosion resistant to concentrated hydrochloric acid solutions.

EXPLANATORY NOTE:
The cell cathodic compartment must be designed to prevent re-oxidation of uranium to its higher valence state. To keep the uranium in the cathodic compartment, the cell may have an impervious diaphragm membrane constructed of special cation exchange material. The cathode consists of a suitable solid conductor such as graphite.

(b) Especially designed or prepared systems at the product end of the cascade for taking the U^{+4} out of the organic stream, adjusting the acid concentration and feeding to the electrochemical reduction cells.

EXPLANATORY NOTE:
These systems consist of solvent extraction equipment for stripping the U^{+4} from the organic stream into an aqueous solution, evaporation and/or other equipment to accomplish solution pH adjustment and control, and pumps or other transfer devices for feeding to the electrochemical reduction cells. A major design concern is to avoid contamination of the aqueous stream with certain metal ions. Consequently for those parts in contact with the process stream, the system is constructed of equipment made of, or protected by, suitable materials (such as glass, fluorocarbon polymers, polyphenyl sulphate, polyether sulphone, and resin-impregnated graphite).

27. 4. *Feed preparation systems (Chemical exchange)

Especially designed or prepared systems for producing high-purity uranium chloride feed solutions for chemical exchange uranium isotope separation plants.

EXPLANATORY NOTE:
These systems consist of dissolution, solvent extraction and/or ion exchange equipment for purification and electrolytic cells for reducing the uranium U^{+6} or U^{+4} to U^{+3}. These systems produce uranium chloride solutions having only a few parts per million of metallic impurities such as chromium, iron, vanadium, molybdenum and other bivalent or higher multi-valent cations. Materials of construction for portions of the system processing high-purity U^{+3}

include glass, fluorocarbon polymers, polyphenyl sulphate or polyether sulphone plastic-lined and resin-impregnated graphite

27. 5. *Uranium oxidation systems (Chemical exchange)

Especially designed or prepared systems for oxidation of U^{+3} to U^{+4} for return to the uranium isotope separation cascade in the chemical exchange enrichment process.

EXPLANATORY NOTE:
These systems may incorporate equipment such as:
Equipment for contacting chlorine and oxygen with the aqueous effluent from the isotope separation equipment and extracting the resultant U^{+4} into the stripped organic stream returning from the product end of the cascade;

Equipment that separates water from hydrochloric acid so that the water and the concentrated hydrochloric acid may be reintroduced to the process at the proper locations.

27. 6. *Fast-reacting ion-exchange resins/adsorbents (Ion exchange)

Fast-reacting ion-exchange resins or adsorbents especially designed or prepared for uranium enrichment using the ion exchange process, including porous macroreticular resins, and/or pellicular structures in which the active chemical exchange groups are limited to a coating on the surface of an inactive porous support structure, and other composite structures in any suitable form including particles or fibres. These ion exchange resins/adsorbents have diameters of 0.2 mm or less and must be chemically resistant to concentrated hydrochloric acid solutions, as well as physically strong enough so as not to degrade in the exchange columns. The resins/adsorbents are especially designed to achieve very fast uranium isotope exchange kinetics (exchange rate half-time of less than 10 seconds) and are capable of operating at a temperature in the range of 100°C to 200°C.

27. 7. *Ion exchange columns (Ion exchange)

Cylindrical columns greater than 1000 mm in diameter for containing and supporting packed beds of ion exchange resin/adsorbent, especially designed or prepared for uranium enrichment using the ion exchange process. These columns are made of, or protected by, materials (such as titanium or fluorocarbon plastics) resistant to corrosion by concentrated hydrochloric acid solutions and are capable of operating at a temperature in the range of 100°C to 200°C and pressures above 0.7 MPa.

27. 8. *Ion exchange reflux systems (Ion exchange)

(a) Especially designed or prepared chemical or electrochemical reduction systems for regeneration of the chemical reducing agent(s) used in ion exchange uranium enrichment cascades; and

(b) Especially designed or prepared chemical or electrochemical oxidation systems for regeneration of the chemical oxidizing agent(s) used in ion exchange uranium enrichment cascades.

EXPLANATORY NOTE:
The ion exchange enrichment process may use, for example, trivalent titanium (Ti^{+3}) as a reducing agent in which case the reduction system would regenerate Ti^{+3} by reducing Ti^{+4}.

The process may use for example trivalent iron (Fe^{+3}) as an oxidant in which case the oxidation system would regenerate Fe^{+3} by oxidizing Fe^{+2}.

28. *Systems, equipment and components for use in laser based enrichment plants.

INTRODUCTORY NOTE:
Present systems for enrichment processes using lasers fall into two categories: those in which the process medium is atomic uranium vapour and those in which the process medium is the vapour of an uranium compound. Common nomenclature for such processes include:
First category - atomic vapor laser isotope separation (AVLIS or SILVA);
Second category - molecular laser isotope separation (MLIS or MOLIS); and
Chemical reaction by isotope selective laser activation (CRISLA).

The systems, equipment and components for laser enrichment plants embrace:

- *i) Devices to feed uranium metal vapor (for selective photo-ionization) or devices to feed the vapor of a uranium compound (for photo-dissociation or chemical activation);*

- *ii) Devices to collect enriched and depleted uranium metals as 'product' and 'tails' in the first category, and devices to collect dissociated or reacted compounds as 'products' and unaffected material as 'tails' in the second category;*

- *iii) Process laser systems to selectively excite the uranium-235 species; and*

- *iv) Feed preparation and product conversion equipment.*

The complexity of the spectroscopy of uranium atoms and compounds may require incorporation of any of a number of available laser technologies.

EXPLANATORY NOTE:
Many of the items listed in this section come into direct contact with uranium metal vapor or liquid or with process gas consisting of UF_6 or a mixture of UF_6 and other gases. All surfaces that come into contact with the uranium or UF_6 are wholly made of, or protected by, corrosion-resistant materials. For the purposes of the section relating to laser-based enrichment items, the materials resistant to corrosion by vapor or liquid uranium metal or uranium alloys include yttria-coated graphite and tantalum; and the materials resistant to corrosion by UF_6 include copper, stainless steel, aluminium, aluminium alloys, nickel or alloys containing 60% or more nickel and UF_6-resistant fully fluorinated hydrocarbon polymers.

28. 1. *Uranium vaporization systems (AVLIS)

Especially designed or prepared uranium vaporization systems which contain high-power strip or scanning electron beam guns with a delivered power on the target of more than 2.5 kW/cm.

28. 2. *Liquid uranium metal handling systems (AVLIS)

Especially designed or prepared liquid metal handling systems for molten uranium or uranium alloys, consisting of crucibles and cooling equipment for the crucibles.

EXPLANATORY NOTE:
The crucibles and other parts of this system that come into contact with molten uranium or uranium alloys are made of, or protected by, material of suitable corrosion and heat resistance. Suitable materials include tantalum, yttria-coated graphite, graphite coated with other rare earth oxides or mixtures thereof.

28. 3. *Uranium metal 'product' and 'tails' collector assemblies (AVLIS)

Especially designed or prepared 'product' and 'tails' collector assemblies for uranium metal in liquid or solid form.

EXPLANATORY NOTE:
Components for these assemblies are made of, or protected by, materials resistant to the heat and corrosion of uranium metal vapor or liquid (such as yttria-coated graphite or tantalum) and may include pipes, valves, fittings, gutters, feed-throughs, heat exchangers and collector plates for magnetic, electrostatic or other separation methods.

28. 4. *Separator module housings (AVLIS)

Especially designed or prepared cylindrical or rectangular vessels for containing the uranium metal vapor source, the electron beam gun and the 'product' and 'tails' collectors.

EXPLANATORY NOTE:
These housings have multiplicity of ports for electrical and water feed-throughs, laser beam windows, vacuum pump connections and instrumentation diagnostics and monitoring. They have provisions for opening and closure to allow refurbishment of internal components.

28. 5. *Supersonic expansion nozzles (MLIS)

Especially designed or prepared supersonic expansion nozzles for cooling mixtures of UF_6 and carrier gas to 150 K or less and which are corrosion resistant to UF_6.

28. 6. *Uranium pentafluoride product collectors (MLIS)

Especially designed or prepared uranium pentafluoride (UF_5) solid product collectors consisting of filter, impact or cyclone-type collectors, or combinations thereof and which are corrosion resistant to the UF_5/UF_6 environment.

28. 7. *UF_6/carrier gas compressors (MLIS)

Especially designed or prepared compressors for UF_6 carrier gas mixtures, designed for long term operation in a UF_6 environment. The components of these compressors that come into contact with process gas are made of, or protected by, materials resistant to corrosion by UF_6.

28. 8. *Rotary shaft seals (MLIS)

Especially designed or prepared rotary shaft seals, with seal feed and seal exhaust connections, for sealing the shaft connecting the compressor rotor with the driver motor so as to ensure a reliable seal against out-leakage of process gas or in-leakage of air or seal gas into the inner chamber of the compressor which is filled with a UF_6/carrier gas mixture.

28. 9. *Fluorination systems (MLIS)

Especially designed or prepared systems for fluorinating UF_5 (solid) to UF_6 (gas).

EXPLANATORY NOTE:
These systems are designed to fluorinate the collected UF_5 powder to UF_6 for subsequent collection in 'product' containers or for transfer as feed to MLIS units for additional enrichment. In one approach the fluorination reaction may be accomplished within the isotopic separation system to react and recover directly off the 'product' collectors. In another approach, the UF_5 powder may be removed/transferred from the 'product' collectors into a suitable reaction vessel (e.g., fluidized-bed reactor, screw reactor or flame tower) for fluorination. In both approaches, equipment for storage and transfer of fluorine (or other suitable fluorinating agents) and for collection and transfer of UF_6 are used.

28. 10. *UF_6 mass spectrometers/ion sources (MLIS)

Especially designed or prepared magnetic or quadrupole mass spectrometers capable of taking 'on-line' samples of feed, 'product' or 'tails', from UF_6 gas streams and having all the following characteristics:

(a) Unit resolution for mass greater than 320;

(b) Ion sources constructed of or lined with nichrome or monel or nickel plated;

(c) Electron bombardment ionization sources; and

(d) Collector system suitable for isotopic analysis.

28. 11. *Feed systems/'product' and 'tails' withdrawal systems (MLIS)

Especially designed or prepared process systems or equipment for enrichment plants made of, or protected by, materials resistant to corrosion by UF_6 including:

(a) Feed autoclaves, ovens, or systems used for passing UF_6 to the enrichment process;

(b) Desublimers (or cold traps) used to remove UF_6 from the enrichment process for subsequent transfer upon heating;

(c) Solidification or liquefaction stations used to remove UF_6 from the enrichment process by compressing and converting UF_6 to a liquid or solid form; and

(d) 'Product' or 'tails' stations used for transferring UF_6 into containers.

28. 12. *UF_6/carrier gas separation systems (MLIS)

Especially designed or prepared process systems for separating UF_6 from carrier gas. The carrier gas may be nitrogen, argon, or other gas.

EXPLANATORY NOTE:
These systems may incorporate equipment such as:

i) Cryogenic heat exchangers or cryoseparators capable of temperatures of -120°C or less, or

ii) Cryogenic refrigeration units capable of temperatures of -120°C or less, or

iii) UF_6 cold traps capable of temperatures of -20°C or less.

28. 13. *Laser systems (AVLIS, MLIS and CRISLA):

Laser systems especially designed or prepared for the separation of uranium isotopes.

EXPLANATORY NOTE:
The laser system for the AVLIS process usually consists of two lasers: a copper vapor laser and a dye laser. The laser system for MLIS usually consists of a CO_2 or excimer laser and a multi-pass optical cell with revolving mirrors at both ends. Lasers or laser systems for both processes require a spectrum frequency stabilizer for operation over extended periods of time.

28. 14. Lasers, laser amplifiers and oscillators as follows:

(a) Copper vapor lasers having both of the following characteristics:

(i) Operating at wavelengths between 500 and 600 nm; and

(ii) An average output power equal to or greater than 40 W;

(b) Argon ion lasers having both of the following characteristics:

(i) Operating at wavelengths between 400 and 515 nm; and

(ii) An average output power greater than 40 W;

(c) Neodymium-doped (other than glass) lasers with an output wavelength between 1000 and 1100 nm having either of the following:

(i) Pulse-excited and Q-switched with a pulse duration equal to or greater than 1 ns, and having either of the following:

(A) A single-transverse mode output with an average output power greater than 40 W; or

(B) A multiple-transverse mode output with an average output power greater than 50 W; or

(ii) Incorporating **frequency doubling to give an output wavelength between 500 and 550 nm with an average output power of greater than 40 W;**

(d) Tunable pulsed single-mode dye laser oscillators having all of the following characteristics:

(i) Operating at wavelengths between 300 and 800 nm;

(ii) An average output power greater than 1 W;

(iii) A repetition rate greater than 1 kHz; and

(iv) Pulse width less than 100 ns;

(e) Tunable pulsed dye laser amplifiers and oscillators having all of the following characteristics:

(i) Operating at wavelengths between 300 and 800 nm;

(ii) An average output power greater than 30 W;

(iii) A repetition rate greater than 1 kHz; and

(iv) Pulse width less than 100 ns;

NOTE
Item 28.14(e) above does not include single mode oscillators.

(f) Alexandrite lasers having all of the following characteristics:

(i) Operating at wavelengths between 720 and 800 nm;

(ii) A bandwidth of 0.005 nm or less;

(iii) A repetition rate greater than 125 Hz; and

(iv) An average output power greater than 30 W;

(g) Pulsed carbon dioxide lasers having all of the following characteristics:

(i) Operating at wavelengths between 9000 and 11000 nm;

(ii) A repetition rate greater than 250 Hz;

(iii) An average output power greater than 500 W; and

(iv) Pulse width of less than 200 ns;

NOTE
Item 28.14(g) above does not include the higher power (typically 1 to 5 kW) industrial CO_2 lasers used in applications such as cutting and welding, as these latter lasers are either continuous wave or are pulsed with a pulse width greater than 200 ns.

(h) Pulsed excimer lasers (XeF, XeCl, KrF) having all of the following characteristics:

(i) Operating at wavelengths between 240 and 360 nm;

(ii) Repetition rate greater than 250 Hz; and

(iii) An average output power greater than 500 W;

(i) Para-hydrogen Raman shifters designed to operate at 16 μm output wavelength and at a repetition rate greater than 250 Hz.

(j) Integrated pulse dye lasers having both of the following characteristics:

(i) A wavelength of 589 nm; and

(ii) An average power greater than 10 W;

28. 15. AVLIS systems for stable isotopes

Atomic vapor laser isotope separation (AVLIS) systems for enriching stable isotopes of biological, medical, or industrial interest.

29. *Systems, equipment, and components for use in plasma separation enrichment plants

INTRODUCTORY NOTE:
In the plasma separation process, a plasma of uranium ions passes through an electric field tuned to the ^{235}U ion resonance frequency so that they preferentially absorb energy and increase the diameter of their corkscrew-like orbits. Ions with a large-diameter path are trapped to produce a product enriched in ^{235}U. The plasma, which is made by ionizing uranium vapor, is contained in a vacuum chamber with a high-strength magnetic field produced by a superconducting magnet. The main technological systems of the process include the uranium plasma generation system, the separator module with superconducting magnet and metal removal systems for the collection of 'product' and 'tails'.

29. 1. *Microwave power sources and antennae

Especially designed or prepared microwave power sources and antennae for producing or accelerating ions and having both of the following characteristics:

(a) Greater than 30 GHz frequency; and

(b) Greater than 50 kW mean power output for ion production.

29. 2. *Ion excitation coils

Especially designed or prepared radio frequency ion excitation coils for frequencies of more than 100 kHz and capable of handling more than 40 kW mean power.

29. 3. *Uranium plasma generation systems

Especially designed or prepared systems for the generation of uranium plasma, which may contain high-power strip or scanning electron beam guns with a delivered power on the target of more than 2.5 kW/cm.

29. 4. *Liquid uranium metal handling systems

Especially designed or prepared liquid metal handling systems for molten uranium or uranium alloys, consisting of crucibles and cooling equipment for the crucibles.

EXPLANATORY NOTE:
The crucibles and other parts of this system that come into contact with molten uranium or uranium alloys are made of, or protected by, materials of suitable corrosion and heat resistance. Suitable materials include tantalum, yttria-coated graphite, graphite coated with other rare earth oxides or mixtures thereof.

29. 5. *Uranium metal 'product' and 'tails' collector assemblies

Especially designed or prepared product and 'tails' collector assemblies for uranium metal in solid form. These collector assemblies are made of, or protected by, materials resistant to the heat and corrosion of uranium metal vapor, such as yttria-coated graphite or tantalum.

29. 6. *Separator module housings

Cylindrical vessels especially designed or prepared for use in plasma separation enrichment plants for containing the uranium plasma source, radio-frequency drive coil and the 'product' and 'tails' collectors.

EXPLANATORY NOTE:
These housings have a multiplicity of ports for electrical feed-throughs, diffusion pump connections and instrumentation diagnostics and monitoring. They have provisions for opening and closure to allow for refurbishment of internal components and are constructed of a suitable non-magnetic material such as stainless steel.

29. 7. *Superconducting solenoidal electromagnets

Superconducting solenoidal electromagnets having all of the following characteristics:

(a) Capable of creating magnetic fields of more than 2 T;

(b) A ratio of length to inner diameter greater than 2;

(c) An inner diameter greater than 300 mm; and

(d) With a magnetic field uniform to better than 1% over the central 50% of the inner volume.

NOTE 1
This item does not prohibit magnets especially designed for and used 'as part of' medical nuclear magnetic resonance (NMR) imaging systems. However, such items shall be reported.

NOTE 2
'As part of' does not necessarily mean physical part in the same shipment. Separate shipments from different sources are allowed, provided the related export documents clearly specify the 'as part of' relationship.

30. *Electromagnetic enrichment plants, systems, equipment and components

INTRODUCTORY NOTE:
In the electromagnetic process uranium metal ions produced by ionization of a salt feed material (typically UCl_4) are accelerated and pass through a magnetic field that has the effect of causing the ions of different isotopes to follow different paths. The major components of an electromagnetic isotope separator include: a magnetic field for ion-beam diversion/separation of the isotopes, an ion source with its acceleration system, and a collection system for the separated ions. Auxiliary systems for the process include the magnet power supply system, the ion source high-voltage power supply system, the vacuum system, and extensive chemical handling systems for recovery of product and cleaning/recycling of components.

30. 1. *Electromagnetic isotope separators

Electromagnetic isotope separators especially designed or prepared for the separation of uranium isotopes and equipment and components therefor, including:

(a) Ion sources:

Especially designed or prepared single or multiple uranium ion sources consisting of a vapor source, ionizer and beam accelerator, constructed of suitable materials such as graphite, stainless steel, or copper and capable of providing a total ion beam current of 50 mA or greater;

(b) Ion collectors

Collector plates consisting of two or more slits and pockets especially designed or prepared for collection of enriched and depleted uranium ion beams and constructed of suitable materials such as graphite or stainless steel;

(c) Vacuum housings :

Especially designed or prepared vacuum housings for uranium electromagnetic separators constructed of suitable non-magnetic materials such as stainless steel and designed for operation at pressures of 0.1 Pa or lower;

EXPLANATORY NOTE:
The housings are especially designed to contain the ion sources, collector plates and water-cooled liners and have provision for diffusion pump connections and openings and closures for removal and reinstallation of these components.

(d) Magnet pole pieces:

Especially designed or prepared magnet pole pieces used to maintain a constant magnetic field within an electromagnetic isotope separator and to transfer the magnetic field between adjoining separators.

30. 2. *High voltage power supplies

Especially designed or prepared high-voltage power supplies for ion sources, having all of the following characteristics:

(a) Capable of continuous operation;

(b) Output voltage of 20,000 V or greater;

(c) Output current of 1 A or greater; and

(d) Voltage regulation of better than 0.1% over a time period of 8 hours.

30. 3. *Magnet power supplies

Especially designed or prepared high-power direct current magnet power supplies having all of the following characteristics:

(a) Capable of continuously producing a current of 500 A or greater;

(b) At a voltage of 100 V or greater; and

(c) With a current or voltage regulation better than 0.1% over a time period of 8 hours.

30. 4. *High-power, direct current power supplies, other than those specified in 30.3, having both of the following characteristics:

(a) Capable of continuously producing over a time period of 8 hours, 100 V or greater with current output of 500 A or greater; and

(b) Current or voltage stability better than 0.1% over a time period of 8 hours.

30. 5. *High-voltage, direct current power supplies, other than those specified in 30.2, having both of the following characteristics:

(a) 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

(b) Current or voltage stability better than 0.1% over a time period of 8 hours.

30. 6. Vacuum pumps having all of the following characteristics:

(a) Input throat size equal to or greater than 380 mm;

(b) Pumping speed equal to or greater than 15 m^3/s; and

(c) Capable of producing an ultimate vacuum better than 13.3 mPa.

TECHNICAL NOTE
The pumping speed is determined at the measurement point with nitrogen gas or air.
The ultimate vacuum is determined at the input of the pump with the input of the pump blocked off.

30. 7. *Electromagnetic isotope separators other than those specified in 30.1 designed for or equipped with single or multiple ion sources capable of providing a total ion beam current of 50 mA or greater.

TECHNICAL NOTE
A single 50 mA ion source cannot produce more than 3 g of separated highly enriched uranium (HEU) per year from natural abundance feed.

NOTE 1
Item 30.7 includes separators capable of enriching stable isotopes as well as those for uranium.

NOTE 2
Item 30.7 includes separators with ion sources and collectors both in the magnetic field and those configurations in which they are external.

• ANALYTICAL INSTRUMENTS AND PROCESS CONTROL SYSTEMS USED IN URANIUM ENRICHMENT

31. *Mass spectrometers

Mass spectrometers capable of measuring ions of 230 atomic mass units or greater and having a resolution of better than 2 parts in 230, and ion sources, as follows:

31. 1. Inductively coupledplasma mass spectrometers (ICP/MS);

31. 2. Glow discharge mass spectrometers (GDMS);

31. 3. Thermal ionization mass spectrometers (TIMS);

31. 4. *Electron bombardment mass spectrometers which have a source chamber constructed from or lined with or plated with materials resistant to UF_6;

31. 5. Molecular beam mass spectrometers having both of the following characteristics:

(a) A source chamber constructed from or lined with or plated with stainless steel or molybdenum, and

(b) equipped with a cold trap capable of cooling to 193 K (-80°C) or less;.

31. 6. *Molecular beam mass spectrometers having a source chamber constructed from or lined with or plated with materials resistant to UF6.

31. 7. *Mass spectrometers equipped with a microfluorination ion source designed for use with actinides or actinide fluorides.

32. Enrichment plant instrumentation and process control systems

Instrumentation for monitoring temperature, pressure, pH, fluid level or flow rate especially designed to be corrosion resistant to UF_6 by being made of, or protected by, any of the following materials:

(a) Stainless steel;

(b) Aluminum;

(c) Aluminium alloys;

(d) Nickel; and

(e) Alloys containing 60% or more nickel

33. *Software for the control of uranium enrichment plants or facilities

• OTHER ISOTOPE SEPARATION PLANTS

34. Heavy water, deuterium and deuterium compound production plants and equipment

INTRODUCTORY NOTE:
Heavy water can be produced by a variety of processes. However, the two processes that have proven to be commercially viable are the water-hydrogen sulfide exchange process (GS process) and the ammonia-hydrogen exchange process.

The GS process is based upon the exchange of hydrogen and deuterium between water and hydrogen sulfide within a series of towers which are operated with the top section cold and the bottom section hot. Water flows down the towers while the hydrogen sulfide gas circulates from the bottom to the top of the towers. A series of perforated trays are used to promote mixing between the gas and the water. Deuterium migrates to the water at low temperatures and to the hydrogen sulfide at high temperatures. Gas or water, enriched in deuterium, is removed from the first stage towers at the junction of the hot and cold sections and the process is repeated in subsequent stage towers. The product of the last stage, water enriched up to 30% in deuterium, is sent to a distillation unit to produce reactor grade heavy water i. e., 99.75% deuterium oxide.

The ammonia-hydrogen exchange process can extract deuterium from synthesis gas through contact with liquid ammonia in the presence of a catalyst. The synthesis gas is fed into exchange towers and then to an ammonia converter. Inside the towers the gas flows from the bottom to the top while the liquid ammonia flows from the top to the bottom. The deuterium is stripped from the hydrogen in the synthesis gas and concentrated in the ammonia. The ammonia then flows into an ammonia cracker at the bottom of the tower while the gas flows into an ammonia converter at the top. Further enrichment takes place in subsequent stages and reactor grade heavy water is produced through final distillation. The synthesis gas feed can be provided by an ammonia plant that, in turn, can be constructed in association with a heavy water ammonia-hydrogen exchange plant. The ammonia-hydrogen exchange process can also use ordinary water as a feed source of deuterium.

Many of the key equipment items for heavy water production plants using the GS or the ammonia-hydrogen exchange processes are common to several segments of the chemical and petroleum industries. This is particularly so for small plants using the GS process. However, few of the items are available 'off-the-shelf'. The GS and the ammonia-hydrogen processes require the handling of large quantities of flammable, corrosive and toxic fluids at elevated pressures. Accordingly, in establishing the design and operating standard for plants and equipment using these processes, careful attention to the materials selection and specifications is required to ensure long service life with high safety and reliability factors. The choice of scale is primarily a function of economics and need. Thus, most of the equipment items would be prepared according to the requirements of the customer.
Finally, it should be noted that, in both the GS and the ammonia-hydrogen exchange process, items of equipment which individually are not especially designed or prepared for heavy water production can be assembled into systems which are especially designed or prepared for producing heavy water. The catalyst production system used in the ammonia-hydrogen exchange process and water distillation systems used for the final concentration of heavy water to reactor grade in either process are examples of such systems.

The items of equipment which are especially designed or prepared for the production of heavy water utilizing either the water-hydrogen sulfide exchange process or the ammonia-hydrogen exchange process include the following:

34. 1. Water-hydrogen sulfide exchange towers

Exchange towers especially designed or prepared for the production of heavy water utilizing the water-hydrogen sulfide exchange process having all of the following characteristics:

(a) Constructed of fine carbon steel (such as ASTM A516);

(b) Diameters of 6 m to 9 m;

(c) Capable of operating at pressures greater than or equal to 2 MPa; and

(d) With a corrosion allowance of 6 mm or greater.

34. 2. Blowers and compressors

Single stage, low head (i.e., 0.2 MPa) centrifugal blowers or compressors for hydrogen sulfide gas circulation (i.e., gas containing more than 70% H_2S) especially designed or prepared for heavy water production utilizing the water-hydrogen sulfide exchange process. These blowers or compressors have a throughput capacity greater than or equal to 56 m^3/second while operating at pressures greater than or equal to 1.8 MPa suction and have seals designed for wet H_2S service.

34. 3. Ammonia-hydrogen exchange towers

Ammonia-hydrogen exchange towers greater than or equal to 35 m in height with diameters of 1.5 m to 2.5 m capable of operating at pressures greater than 15 MPa especially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process. These towers also have at least one flanged axial opening of the same diameter as the cylindrical part through which the tower internals can be inserted or withdrawn.

34. 4. Tower internals and stage pumps

Tower internals and stage pumps especially designed or prepared for towers for heavy water production utilizing the ammonia-hydrogen exchange process. Tower internals include especially designed stage contactors which promote intimate gas/liquid contact. Stage pumps include especially designed submersible pumps for circulation of liquid ammonia within a contacting stage internal to the stage towers.

34. 5. Ammonia crackers

Ammonia crackers with operating pressures greater than or equal to 3 MPa especially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process.

34. 6. Infrared absorption analyzers

Infrared absorption analyzers capable of 'on-line' hydrogen/deuterium ratio analysis where deuterium concentrations are equal to or greater than 90%.

34. 7. Catalytic burners

Catalytic burners for the conversion of enriched deuterium gas into heavy water especially designed or prepared for heavy water production utilizing the ammonia-hydrogen exchange process.

34. 8. Heavy water upgrade systems

Complete heavy water upgrade systems, or columns therefor, especially designed or prepared for the upgrade of heavy water to reactor-grade deuterium concentration.

EXPLANATORY NOTE
These systems, which usually employ water distillation to separate heavy water from light water, are especially designed or prepared to produce reactor-grade heavy water (i.e., typically 99.75% deuterium oxide) from heavy water feedstock of lesser concentration.

34.9. Platinized catalysts

Platinized catalysts especially 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.

34. 10. Specialized packing

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

(a) Made of phosphor bronze mesh chemically treated to improve wettability; and

(b) Designed to be used in vacuum distillation towers.

34. 11. Circulating pumps

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) A capacity greater than 8.5 m^3/h; and

(c) Either of the following characteristics:

(i) For concentrated potassium amide solutions (1% or greater), operating pressure of 1.5-60 MPa; or

(ii) For dilute potassium amide solutions (less than 1%), operating pressure of 20-60 MPa.

34. 12. Turboexpanders

Turboexpanders or turboexpander-compressor sets having both of the following characteristics:

(a) Designed for operation with an outlet temperature of 35 K (- 238 ºC) or less; and

(b) Designed for a throughput of hydrogen gas of 1000 kg/h or greater.

34. 13. Water-hydrogen sulfide exchange tray columns and internal contactors

(a) Water-hydrogen sulfide exchange tray columns, having all of the following characteristics:

(i) Can operate at pressures of 2 MPa or greater;

(ii) Constructed of carbon steel having an austentitic ASTM (or equivalent standard) grain size number of 5 or greater; and

(iii) With a diameter of 1.8 m or greater.

(b) Internal contactors for the water-hydrogen sulfide exchange tray columns specified in item 34.13(a).

TECHNICAL NOTE:
Internal contactors of the columns are segmented trays which have an effective assembled diameter of 1.8 m or greater; are designed to facilitate countercurrent contacting and are constructed of stainless steels with a carbon content of 0.03% or less. These may be sieve trays, valve trays, bubble cap trays, or turbogrid trays.

34. 14. Hydrogen cryogenic distillation columns having all of the following characteristics:

(a) Designed to operate with internal temperatures of -238°C (35 K) or less;

(b) Designed to operate at internal pressure of 0.5 to 5 MPa (5 to 50 atmospheres);

(c) Constructed of either:

(i) Stainless steel of the 300 series with low sulfur content and with an austenitic ASTM (or equivalent standard) grain size number of 5 or greater; or

(ii) Equivalent materials which are both cryogenic and H_2-compatible; and

(d) With internal diameters of 1 m or greater and effective lengths of 5 m or greater.

34. 15. Ammonia synthesis converters

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.

35. *Plants for the separation of lithium 6 and specially designed equipment therefor

Lithium isotope separation facilities or plants, and equipment therefor, as follows:

35. 1. *Facilities or plants for the separation of lithium isotopes;

35. 2. *Equipment for the separation of lithium isotopes, as follows:

(a) Packed liquid-liquid exchange columns especially designed for lithium amalgams;

(b) Mercury or lithium amalgam pumps;

(c) Lithium amalgam electrolysis cells;

(d) Evaporators for concentrated lithium hydroxide solution.

36. * Tritium facilities or plants, and equipment therefor

36. 1. *Facilities or plants for the production, recovery, extraction, concentration or handling of tritium;

36. 2. *Equipment for tritium facilities or plants, as follows:

(a) Hydrogen or helium refrigeration units capable of cooling to 23 K (-250 ºC) or less, with heat removal capacity greater than 150 W;

(b) Hydrogen isotope storage or purification systems using metal hydrides as the storage or purification medium.

NOTE:
See also item 18.

- **URANIUM AND PLUTONIUM CONVERSION PLANTS AND EQUIPMENT**

INTRODUCTORY NOTE: 1
Uranium conversion plants and systems may perform one or more transformations from one uranium chemical species to another, including:

i) Conversion of uranium ore concentrates to UO_3;

ii) Conversion of UO_3 to UO_2;

iii) Conversion of uranium oxides to UF_4 or UF_6;

iv) Conversion of UF_6 to UF_4;

v) Conversion of UF_4 to UF_6;

vi) Conversion of UF_4 to uranium metal;

vii) Conversion of uranium fluorides to UO_2;

viii) Conversion of uranium oxides to UCl_4.

The above listing is not exhaustive. It covers only the major conversion methods. All systems that convert uranium to and from various chemical species are covered by this section, whether or not they are specifically listed.

Many of the key equipment items for uranium conversion plants are common to several segments of the chemical process industry. For example the types of equipment employed in these processes may include furnaces, rotary kilns, fluidized bed reactors, flame tower reactors, liquid centrifuges, distillation columns and liquid-liquid extraction columns. However, few of the items are available 'off-the-shelf'; most would be prepared according to the requirements and specifications of the customer. Particular care in designing for the criticality hazards associated with highly enriched uranium is essential. In some instances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (HF, F_2, ClF_3, and uranium fluorides). ***Finally, it should be noted that, in all of the uranium conversion processes, items of equipment which individually are not especially designed or prepared for uranium conversion can be assembled into systems which are especially designed or prepared for use in uranium conversion.***

INTRODUCTORY NOTE 2
Plutonium conversion plants and systems perform one or more transformations from one plutonium chemical species to another including:

i) Conversion of plutonium nitrate to PuO_2;

ii) Conversion of PuO_2 to PuF_4;

iii) Conversion of PuF_4 to plutonium metal.

Plutonium conversion plants are normally associated with reprocessing facilities, but may also be associated with plutonium fuel fabrication facilities. Many of the key equipment items for plutonium conversion plants are common to several segments of the chemical process *industry. For example, the types of equipment employed in these processes may include: furnaces, rotary kilns, fluidized bed reactors, flame tower reactors, liquid centrifuges, distillation columns, and liquid-liquid extraction columns. Hot cells, glove boxes, and remote manipulators may also be required. However, few of the items are available 'off-the-shelf'; most would be prepared according to the requirements and specifications of the customer. Particular care in designing for the special radiological, toxicity, and criticality hazards associated with plutonium is essential. In some instances, special design and construction considerations are required to address the corrosive properties of some of the chemicals handled (e.g. HF).* ***Finally, it should be noted that, for all plutonium conversion processes, items of equipment which individually are not especially designed or prepared for plutonium conversion can be assembled into systems which are especially designed or prepared for use in plutonium conversion.***

37. Specially designed or prepared systems for the conversion of uranium ore concentrates to UO_3 conversion systems

EXPLANATORY NOTE
Conversion of uranium ore concentrates to UO_3 can be performed by first dissolving the ore in nitric acid and extracting purified uranyl nitrate using a solvent such as tributyl phosphate. Next, the uranyl nitrate is converted to UO_3 either by concentration and denitration, or by neutralization with gaseous ammonia to produce ammonium diuranate with subsequent filtering, drying, and calcining.

38. *Specially designed or prepared systems for the conversion of UO_3 to UF_6

EXPLANATORY NOTE:
Conversion of UO_3 to UF_6 can be performed directly by fluorination. The process requires a source of fluorine gas or chlorine trifluoride.

39. Specially designed or prepared systems for the conversion of UO_3 to UO_2

EXPLANATORY NOTE:
Conversion of UO_3 to UO_2 can be performed through reduction of UO_3 with cracked ammonia gas or hydrogen.

40. *Specially designed or prepared systems for the conversion of UO_2 to UF_4

EXPLANATORY NOTE:
Conversion of UO_2 to UF_4, can be performed by reacting UO_2 with hydrogen fluoride gas (HF) or freon gas at 300-500 °C.

41. *Specially designed or prepared systems for the conversion of UF_4 to UF_6

EXPLANATORY NOTE:
Conversion of UF_4 to UF_6 is performed by exothermic reaction with fluorine in a tower reactor. UF_6 is condensed from the hot effluent gases by passing the effluent stream through a cold trap cooled to -10°C (263 K). The process requires a source of fluorine gas.

42. *Specially designed or prepared systems for the conversion of UF_4 to U metal

EXPLANATORY NOTE:
Conversion of UF_4 to U metal is performed by reduction with magnesium (large batches) or calcium (small batches). The reaction is carried out at temperatures above the melting point of uranium (1130°C).

43. *Specially designed or prepared systems for the conversion of UF_6 to UO_2

EXPLANATORY NOTE:
Conversion of UF_6 to UO_2 can be performed by one of three processes. In the first, UF_6 is reduced and hydrolyzed to UO_2 using hydrogen and steam. In the second, UF_6 is hydrolyzed by solution in water, ammonia is added to precipitate ammonium diuranate, and the diuranate is reduced to UO_2 with hydrogen at 820°C. In the third process, gaseous UF_6, CO_2 and NH_3 are combined in water, precipitating ammonium uranyl carbonate. The ammonium uranyl carbonate is combined with steam and hydrogen at 500-600°C to yield UO_2. UF_6 to UO_2 conversion is often performed as the first stage of a fuel fabrication plant.

44. *Specially designed or prepared systems for the conversion of UF_6 to UF_4

EXPLANATORY NOTE:
Conversion of UF_6 to UF_4 is performed by reduction with hydrogen.

45. *Specially designed or prepared systems for the conversion of UO_2 to UCl_4

EXPLANATORY NOTE:
Conversion of UO_2 to UCl_4 can be performed by reacting UO_2 with CCl_4 at high temperature. In the first, UO_2 is reacted with carbon tetrachloride (CCl_4) at approximately 400°C. In the second, UO_2 is reacted at approximately 700°C in the presence of carbon black (CAS 1333-86-4), carbon monoxide, and chlorine to yield UCl_4.

46. *Fluorine production electrolytic cells

Electrolytic cells for fluorine production with an output capacity greater than 10 g of fluorine per hour and especially designed parts and accessories therefor.

47. *Plutonium nitrate to oxide conversion systems

EXPLANATORY NOTE
The main functions involved in this process are: process feed storage and adjustment, precipitation and solid/liquor separation, calcination, product handling, ventilation, waste management, and process control. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. In most reprocessing facilities, this process involves the conversion of plutonium nitrate to plutonium dioxide. Other processes can involve the precipitation of plutonium oxalate or plutonium peroxide
.

48. *Plutonium metal production systems

EXPLANATORY NOTE
This process usually involves the fluorination of plutonium dioxide, normally with highly corrosive hydrogen fluoride, to produce plutonium fluoride which is subsequently reduced using high purity calcium metal to produce metallic plutonium and calcium fluoride slag. The main functions involved in this process are fluorination (e.g. involving equipment fabricated or lined with a precious metal), metal reduction (e.g. employing ceramic crucibles), slag recovery, product handling, ventilation, waste management, and process control. The process systems are particularly adapted so as to avoid criticality and radiation effects and to minimize toxicity hazards. Other processes include the fluorination of plutonium oxalate or plutonium peroxide followed by reduction to metal.

• NUCLEAR REACTORS AND EQUIPMENT

49. Nuclear reactors and equipment

49. 1. Complete nuclear reactors

Nuclear reactors capable of operation so as to maintain a controlled self-sustaining, fission chain reaction.

EXPLANATORY NOTE:
A nuclear reactor basically includes the items within or attached directly to the reactor vessel, the equipment which controls the level of power in the core, and the components which normally contain or come in direct contact with or control the primary coolant of the reactor core.

49. 2. Nuclear reactor vessels

Metal vessels, or major shop-fabricated parts therefor, especially designed or prepared to contain the core of a nuclear reactor as well as relevant reactor internals.

EXPLANATORY NOTE:
The reactor vessel head is covered by item 49.2 as a major shop-fabricated part of a reactor vessel.

49. 3. Nuclear reactor fuel charging and discharging machines

Manipulative equipment especially designed or prepared for inserting or removing fuel in a nuclear reactor.

EXPLANATORY NOTE:
The items noted in 49.3 are capable of on-load operation or employing technically sophisticated positioning or alignment features to allow complex off-load fueling operations such as those in which direct viewing or access to the fuel is not normally available.

49. 4. Nuclear reactor control rods and equipment

Especially designed or prepared rods, support or suspension structures therefore, rod drive mechanisms or rod guide tubes to control the fission process rate in a nuclear reactor.

49. 5. Nuclear reactor pressure tubes

Tubes which are especially designed or prepared to contain fuel elements and the primary coolant in a reactor at an operating pressure in excess of 50 atmospheres.

49. 6. Zirconium tubes

Zirconium metal and alloys in the form of tubes or assemblies of tubes, especially designed or prepared for use in a reactor and in which the relation of hafnium to zirconium is less than 1:500 parts by weight.

49. 7. Primary coolant pumps

Pumps especially designed or prepared for circulating the primary coolant for nuclear reactors.

EXPLANATORY NOTE:
Especially designed or prepared pumps may include elaborate sealed or multi-sealed system to prevent leakage of primary coolant, canned-driven pumps and pumps with inertial mass systems. This definition encompasses pumps certified to NC-1 (or equivalent) standards.

49. 8. Nuclear reactor internals

Nuclear reactor internals especially designed or prepared for use in a nuclear reactor, including support columns for the core, fuel channels, thermal shields, baffles, core grid plates, and diffuser plates.

EXPLANATORY NOTE 1
'Nuclear reactor internals' are major structures within a reactor vessel which have one or more functions such as supporting the core, maintaining fuel alignment, directing primary coolant flow, providing radiation shields for the reactor vessel, and guiding in-core instrumentation.

EXPLANATORY NOTE: 2
Nuclear reactor internals are normally supplied by the reactor supplier. In some cases, certain internal support components are included in the fabrication of the reactor vessel. These items are sufficiently critical to the safety and reliability of the operation of the reactor (and, therefore, to the guarantees and the liability of the reactor supplier), so that their supply, outside the basic supply arrangement for the reactor itself, would not be common practice. Therefore, although the separate supply of these unique, especially designed and prepared, critical, large and expensive items would not necessarily be considered as falling outside the area of concern, such a mode of supply is considered unlikely.

49. 9. Heat exchangers

Heat exchangers (steam generators) especially designed or prepared for use in the primary coolant circuit of a nuclear reactor.

EXPLANATORY NOTE
Steam generators are especially designed or prepared to transfer the heat generated in the reactor (primary side) to the feed water (secondary side) for steam generation. In the case of liquid metal fast breeder reactor for which an intermediate liquid metal coolant loop is also present, the heat exchangers transferring the heat from the primary side to the intermediate coolant circuit are understood to be within the scope of control in addition to the steam generator .

49. 10. Neutron detection and measuring instruments

Especially designed or prepared neutron detection and measuring instruments for determining neutron flux levels within the core of a nuclear reactor.

EXPLANATORY NOTE
The scope of this entry encompasses in-core and ex-core instrumentation which measures flux levels in a large range, typically from 10^4 neutrons per cm^2 per second to 10^{10} neutrons per cm^2 per second or more. Ex-core refers to those instruments outside the core of a nuclear reactor as defined in paragraph 49, but located within the biological shielding.

49. 11. Deuterium and heavy water

Deuterium, heavy water (deuterium oxide) and any other deuterium compound in which the ratio of deuterium to hydrogen atoms exceeds 1:5000.

49. 12. Nuclear grade graphite

Graphite having a purity level better than 5 parts per million boron equivalent and with a density greater than 1.50 g/cm^3.

EXPLANATORY NOTE
Boron equivalent (BE) may be determined experimentally or is calculated as the sum of BE_z *for impurities (excluding* BE_{carbon} *since carbon is not considered an impurity) including boron, where:*

i) BE_z *(ppm) = CF x concentration of element Z (in ppm);*

ii) CF is the conversion factor : $(s_z \times A_B)$ *divided by* $(s_B \times A_z)$ *;*

iii) s_B *and* s_z *are the thermal neutron capture cross sections (in barns) for naturally occurring boron and element Z respectively.*

49. 13. Nuclear reactor simulators

Electronic simulators especially designed or prepared to provide full mock-up simulation of the operation and control of a nuclear reactor.

• NUCLEAR FUEL FABRICATION PLANTS

50. Fuel element fabrication plants and equipment

INTRODUCTORY NOTE
Nuclear fuel elements are manufactured from one or more source or special fissionable materials. For oxide fuels, the most common type of fuel, equipment for pressing pellets, sintering, grinding and grading will be present. Mixed oxide fuels are handled in glove boxes (or equivalent containment) until they are sealed in the cladding. In all cases, the fuel is hermetically sealed inside a suitable cladding, which is design to be the primary envelope encasing the fuel so as to provide suitable performance and safety during reactor operation. Also, in all cases, precise control of processes, procedures and equipment to extremely high standards is necessary in order to ensure predictable and safe fuel performance.

EXPLANATORY NOTE
Items of equipment that are considered to fall within the meaning of the phrase 'equipment for the fabrication of fuel elements' include the equipment which:

Normally comes in direct contract with, or directly processes, or controls, the production flow of nuclear material;

i) Seals the nuclear material within the cladding;

ii) Checks the integrity of the cladding or the seal; or

iii) Provides for the finishing surface treatment of the sealed fuel.

Such equipment or systems of equipment may include, for example:

i) Fully automatic pellet inspection stations especially designed or prepared for checking the final dimensions and surface defects of the fuel pellets;

ii) Automatic welding machines especially designed or prepared for welding end caps onto the fuel pins or rods;

iii) Automatic test and inspection stations especially designed or prepared for checking the integrity of completed fuel pins or rods.

Typically item iii includes equipment for:

i) X-ray examination of pin or rod end cap welds;

ii) Helium leak detection from pressurized pins or rods; and

iii) Gamma-ray scanning of the pins or rods to check for correct loading of the fuel pellets inside.

• REPROCESSING TECHNOLOGY AND EQUIPMENT

51. *Irradiated Fuel element reprocessing plants and equipment

INTRODUCTORY NOTE:
Reprocessing irradiated fuel separates plutonium and uranium from intensely radioactive fission products and other transuranic elements. Different technical processes can accomplish this separation. However, over the years Purex has become the most commonly used and accepted process. Purex involves the dissolution of irradiated nuclear fuel in nitric acid, followed by separation of the uranium, plutonium, and fission products by solvent extraction using a mixture of tributyl phosphate in an organic diluent.

Purex facilities have process functions similar to each other, including: irradiated fuel element chopping, fuel dissolution, solvent extraction, and process liquor storage. There may also be equipment for thermal denitration of uranium nitrate, conversion of plutonium nitrate to oxide or metal, and treatment of fission product waste liquor to a form suitable for long term storage or disposal. However, the specific type and configuration of the equipment performing these functions may differ between Purex facilities for several reasons, including the type and quantity of irradiated nuclear fuel to be reprocessed and the intended disposition of the recovered materials and the safety and maintenance philosophy incorporated into the design of the facility.

A 'plant for the reprocessing of irradiated fuel elements' includes the equipment and components which normally come in direct contact with, and directly control the irradiated fuel and the major nuclear material and fission product processing streams.

These processes, including the complete systems for plutonium conversion and plutonium metal production, may be identified by the measures taken to avoid criticality (e.g. by geometry), radiation exposure (e.g. by shielding), and toxicity hazards (e.g. by containment).

51. 1. *Irradiated fuel element chopping machines

INTRODUCTORY NOTE:
This equipment breaches the cladding of the fuel to expose the irradiated nuclear material to dissolution. Especially designed metal cutting shears are the most commonly employed, although advanced equipment, such as lasers, may be used.

> Remotely operated equipment especially designed or prepared for use in a reprocessing plant as identified above and intended to cut, chop, or shear irradiated nuclear fuel assemblies, bundles, or rods.

51. 2. *Dissolvers

INTRODUCTORY NOTE:
Dissolvers normally receive the chopped-up spent fuel. In these criticality safe vessels, the irradiated nuclear material is dissolved in nitric acid and the remaining hulls are removed from the process stream.

> Criticality safe tanks (e.g. small diameter, annular, or slab tanks) especially designed or prepared for use in a reprocessing plant as identified above, intended for dissolution of irradiated nuclear fuel, and which are capable of withstanding hot, highly corrosive liquid, and which can be remotely loaded and maintained.

51. 3. *Solvent extractors and solvent extraction equipment

INTRODUCTORY NOTE:
Solvent extractors both receive the solution of irradiated fuel from the dissolvers and the organic solution that separates the uranium, plutonium, and fission products. Solvent extraction equipment is normally designed to meet strict operating parameters, such as long operating lifetimes with no maintenance requirements or adaptability to easy replacement, simplicity of operation and control, and flexibility for variations in process conditions
.

> Especially designed or prepared solvent extractors such as packed or pulse columns, mixer settlers or centrifugal contactors for use in a plant for the reprocessing of irradiated fuel. Solvent extractors must be resistant to the corrosive effect of nitric acid. Solvent extractors are normally fabricated to extremely high standards (including special welding and inspection and quality assurance and quality control techniques) out of low carbon stainless steels, titanium, zirconium, or other high quality materials.

51. 4. *Chemical holding or storage vessels

INTRODUCTORY NOTE:
Three main process liquor streams result from the solvent extraction step. Holding or storage vessels are used in the further processing of all three streams, as follows
:
The pure uranium nitrate solution is concentrated by evaporation and passed to a denitration process where it is converted to uranium oxide. This oxide is reused in the nuclear fuel cycle.

The intensely radioactive fission products solution is normally concentrated by evaporation and stored as a liquor concentrate. This concentrate may be subsequently evaporated and converted to a form suitable for storage or disposal.

The pure plutonium nitrate solution is concentrated and stored pending its transfer to further process steps. In particular, holding or storage vessels for plutonium solutions are designed to avoid criticality problems resulting from changes in concentration and form of this stream
.

> Especially designed or prepared holding or storage vessels for use in a plant for the reprocessing of irradiated fuel. The holding or storage vessels must be resistant to the corrosive effect of nitric acid. They are normally fabricated of materials such as low carbon stainless steels, titanium, or zirconium, or other high quality materials. Holding and storage vessels may be designed for the remote operation and maintenance and may have the following features for control of nuclear criticality:
>
> (a) Walls or internal structures with a boron equivalent of at least 2%; or
>
> (b) A maximum diameter of 175 mm for cylindrical vessels; or
>
> (c) A maximum width of 75 mm for either a slab or annular vessel.

51. 5 Hot cells related equipment especially designed or prepared for the handling or processing of radioisotopes or radiation sources in medical and industrial applications as follows:

(a) High-density (lead glass or other) radiation shielding windows, having all of the following characteristics, and especially designed frames therefor:

(i) A `cold area´ greater than 0.09 m^2;

(ii) A density greater than 3 g/cm^3; and

(iii) A thickness of 100 mm or greater.

TECHNICAL NOTE
In item 51.5(a)(i) above the term `cold area' means the viewing area of the window exposed to the lowest level of radiation in the design application.

(b) Radiation-hardened TV cameras, or lenses therefor, especially designed or rated as radiation hardened to withstand a total radiation dose greater than 5 x 10^4 Gy (silicon) without operational degradation.

TECHNICAL NOTE:
The term Gy (silicon) refers to the energy in Joules per kilogram absorbed by an unshielded silicon sample when exposed to ionising radiation.

(c) ‘Robots' or 'end-effectors', having either of the following characteristics:

(i) Especially designed to comply with national safety standards applicable to handling high explosives (for example, meeting electrical code ratings for high explosives); or

(ii) Especially designed or rated as radiation hardened to withstand a total radiation dose greater than 5 x 10^4 Gy (silicon) without operational degradation;

TECHNICAL NOTE
The term Gy (silicon) refers to the energy in Joules per kilogram absorbed by an unshielded silicon sample when exposed to ionizing radiation.

(iii) Control units especially designed for any of the 'robots' or 'end-effectors' specified in item 51.5(c).

NOTE
Item 51.5(c) above does not include 'robots' especially designed for non-nuclear industrial applications such as automobile paint-spraying booths.

TECHNICAL NOTE 1
In item 51.5(c) above 'robot' means a manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use´sensors´, and has all of the following characteristics:

i) is multifunctional

ii) is capable of positioning or orienting material, parts, tools, or special devices through variable movements in three-dimensional space;

iii) 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.

TECHNICAL NOTE 2
In the above definition ´sensors´ means detectors of a physical phenomenon, the output of which (after conversion into a signal that can be interpreted by a control unit) is able to generate "programs" or modify programmed instructions or numerical "program" data. This includes 'sensors' with machine vision, infrared imaging, acoustical imaging, ta ctile feel, inertial position measuring, optical or acoustic ranging or force or torque measuring capabilities.

TECHNICAL NOTE 3
In the above definition ´user-accessible programmability´ means the facility allowing a user to insert, modify or replace "programs" by means other than:

i) physical change in wiring or interconnections

ii) the setting of function controls including entry of parameters

.
TECHNICAL NOTE 4
The above definition does not include the following devices:

Manipulation mechanisms which are only manually/teleoperator controllable;

Fixed sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic, or electrical means;

Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices operating according to mechanically fixed programmed motions. The "program" is mechanically limited by fixed, but adjustable, stops such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed "program" pattern. Variations or modifications of the "program" pattern (e.g.,changes of pins or exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;

Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The "program" is variable but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;

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.

In item 51.5(d)'end-effectors' are grippers, ´active tooling units´, and any other tooling that is attached to the baseplate on the end of a 'robot' manipulator arm.

In the above definition ´active tooling units´ is a device for applying motive power, process energy or sensing to the workpiece.

(d) Remote manipulators that can be used to provide remote actions in radiochemical separation operations or hot cells, having either of the following characteristics:

(i) A capability of penetrating 0.6 m or more of hot cell wall (through-the-wall operation); <u>or</u>

(ii) A capability of bridging over the top of a hot cell wall with a thickness of 0.6 m or more (over-the-wall operation).

TECHNICAL NOTE
Remote manipulators provide translation of human operator actions to a remote operating arm and terminal fixture. They may be of a master/slave type or operated by joystick or keypad.

51. 6. *Hot cells and related equipment especially designed or prepared for the handling and processing of irradiated nuclear material

EXPLANATORY NOTE:
Small-scale chemical separation of plutonium or uranium or both from irradiated nuclear material requires radiation protection from fission products' gamma activity and from plutonium toxicity. This separation is normally conducted in especially designed or prepared lead- or concrete- shielded cells provided with viewing ports made of high-density glass and remote manipulators. Protection from plutonium toxicity is obtained with an airtight internal lining of the hot cell normally made of low-carbon steel. Hot cells are provided with an air extraction system capable of maintaining a slightly negative pressure and equipped with high efficiency particulate air filters, which prevent the release of aerosols from the hot cell into the environment.

• INDUSTRIAL EQUIPMENT AND MACHINE TOOLS

52. *Machine tools and machine tool control units

NOTE
Items 52-64 list specific types of machine tools and industrial equipment.

52. 1. *Turning, milling and grindng machines having one or more of the following characteristics:

(a) Vacuum chucks suitable for holding hemispherical parts; or

(b) Machines installed within glove boxes or equivalent containment facilities; or

(c) Explosion-proofing features.

52. 2. Machine tools 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, as follows:

(a) Machine tools for turning, grinding, milling or any combination thereof with both of the following characteristics:

(i) Two or more axes that can be coordinated simultaneously for contouring control; and

(ii) One or more of the following characteristics:

(A) Two or more contouring rotary axes; or

(B) One or more contouring tilting spindles; or

(C) Camming (axial displacement) in one revolution of the spindle less (better) than 0.0008 mm total indicator reading (TIR); or

(D) Run out (out-of-true running) in one revolution of the spindle less (better) than 0.0006 mm TIR for grinding or milling machines, 0.0008 mm TIR for turning machines; or

(E) Positioning accuracies, with all compensations available, less (better) than either of the following:

(I) 0.001o on any rotary axis; or

(II) The applicable specification from the following:

(i) 0.004 mm along any linear axis (overall positioning) for grinding machines; or

(ii) 0.006 mm along any linear axis (overall positioning) for milling machines; or

(iii) 0.010 mm along any linear axis (overall positioning) for turning machines; or

(F) Capable of turning or boring of diameters equal to or greater than 2 meters.

(b) Electrical discharge machines (EDM) as follows:

(i) Wire feed EDMs that have five or more axes that can be coordinated simultaneously for contouring control;

(ii) Non-wire feed EDMs that have two or more contouring rotary axes and that can be coordinated simultaneously for contouring control.

(c) Other machine tools for removing metals, ceramics or composites with both of the following characteristics:

(i) Remove material by means of any of the following methods:

(A) Water or other liquid jets, including those employing abrasive additives; or

(B) Electron beam; or

(C) Laser beam; and

(ii) Have two or more rotary axes having both of the following characteristics:

(A) Capable of being coordinated simultaneously for contouring control; and

(B) Capable of a positioning accuracy of less (better) than 0.003°.

52. 3. Numerical control units for machine tools having either of the following characteristics:

(a) Having more than four interpolating axes that can be coordinated simultaneously for contouring control; or

(b) Having two, three, or four interpolating axes that can be coordinated simultaneously for contouring control with one or more of the following characteristics:

(i) Capable of real-time processing of data to modify the tool path during the machining operation by automatic calculation and modification of part program data for machining in two or more axes by means of measuring cycles and access to source data; or

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

(iii) Capable, without modification, according to the manufacturer's technical specifications, of accepting additional boards that would permit increasing the number of interpolating axes that can be coordinated simultaneously for contouring control, above the control levels, even if they do not contain these additional boards.

52. 4. Motion control boards for machine tools specially designed for machine tools having one or more of the following characteristics:

(a) Providing interpolation in more than four axes; <u>or</u>

(b) Capable of real time processing of data to modify the tool path during the machining operation by automatic calculation and modification of part program data for machining in two or more axes by means of measuring cycles and access to source data ; <u>or</u>

(c) Capable of receiving directly (on-line) and processing CAD data for internal preparation of machine instructions.

52.5. Software

(a) Software specially designed or modified for the development, production, or use of equipment listed in 52.2,52.3 or 52.4;

(b) Specific software as follows:

(i) Software to provide adaptive control and having both of the following characteristics:

(A) For flexible manufacturing units (FMUs) that consist at least of equipment described in articles 52 and 54; <u>and</u>

(B) Capable of generating or modifying in real time processing, part program data by using the signals obtained simultaneously by means of at least two detection techniques, such as:

(I) <u>Machine vision (optical ranging);</u>
(II) <u>Infrared imaging;</u>
(III) <u>Acoustical imaging (acoustical ranging);</u>
(IV) <u>Tactile measurement;</u>
(V) <u>Inertial positioning ;</u>
(VI) <u>Force measurement;</u>
(VII) <u>Torque measurement;</u>

(ii) Software for electronic devices other than those listed in 52.3 or 52.4 above that provides numerical control capability equivalent to that specified in 52.3.

52. 6. Components and parts for machine tools

Components and parts for machine tools included in 52.2 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 0.0008 mm TIR;

(b) Linear position feedback units (e.g. inductive-type devices, graduated scales, laser, or infrared systems) having, with compensation, an overall accuracy better than 800 + (600 x L x 10^{-3}) nm, where L equals the effective length in millimetres of the linear measurement;

NOTE
Item 52.6(b) does not cover 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.

(c) Rotary position feedback units (e.g. inductive-type devices, graduated scales, laser, or infrared systems) having, with compensation, an accuracy less (better) than 0.00025° of arc;

NOTE 1
Item 52.6(c)does not cover 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.

NOTE 2
Item 52.6(c) does not cover dimensional inspection machines. Item 54 covers dimensional inspection machines.

d) Slide way assemblies consisting of a minimal assembly of ways, bed, and slide having all of the following characteristics:

(i) A yaw, pitch, or roll of less (better) than 2 seconds of arc TIR (Ref.ISO 230-1) over full travel;

(ii) A horizontal straightness of less (better) than 2 µm per 300 mm length; and

(iii) A vertical straightness of less (better) than 2 µm over full travel per 300 mm length;

(e) Single point diamond-cutting tool inserts having all of the following characteristics:

(i) A flawless and chip-free cutting edge when magnified 400 times in any direction;

(ii) A cutting radius out-of-roundness less (better) than 0.002 mm TIR (also peak-to-peak); and

(iii) A cutting radius between 0.1 and 5.0 mm inclusive.

52. 7. Components and sub-assemblies

(a) Specially designed components or sub-assemblies or printed circuit boards with mounted components and software capable of upgrading, according to the manufacturer's specifications, numerical control units, motion control boards, machine tools, or feedback devices to the specifications described in 52.2, 52.3,52.4, 52.6(b) and 52.6(c);

(b) Compound rotary tables.

52. 8. Technology

(a) Technology for the production of equipment listed in 52.2, 52.3, 52.4, 52.6, and 52.7.

(b) Other technology for either of the following uses:

(i) Development of interactive graphics as an integrated part in numerical control units for preparation or modification of part programs; or

(ii) Development of integration software for incorporation of expert systems for advanced decision support of shop floor operations into numerical control units.

TECHNICAL NOTE
'Accuracy'

Usually measured in terms of inaccuracy, defined as the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

'Adaptive control'

A control system that adjusts the response from conditions detected during the operation (Ref.ISO 2806-1980).

'Camming' (axial displacement)

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 Part 1-1986, paragraph 5.63).

'Compound rotary table'

A table allowing the workpiece to rotate and tilt about two non-parallel axes, which can be coordinated simultaneously for contouring control.

'Contouring control'

Two or more numerically controlled motions operating in accordance with instructions that specify the next required position and the required feed rates to that position. These feed rates are varied in relation to each other so that a desired contour is generated (Ref.ISO 2806-1980).

'Digital computer'

Equipment, which can, in the form of one or more discrete variables:

i) Accept data;

ii) Store data or instructions in fixed or alterable (writable) storage devices;

iii) Process data by means of a stored sequence of instructions which is modifiable; and

iv) 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.

'flexible manufacturing unit' (FMU)

An entity which includes a combination of at least:

i) *A digital computer including its own main storage and its own related equipment; and*

ii) *Two or more of the machines described in items 52, 53, 54 and 55.*

N.B. 'flexible manufacturing unit' (FMU) is sometimes also referred to as 'flexible manufacturing system' (FMS) or 'flexible manufacturing cell' (FMC).

'Laser'

An assembly of components which produce coherent light that is amplified by stimulated emission of radiation.

'Main storage'

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 nonsequentially accessed extended storage.

'Microprogram'
A sequence of elementary instructions, maintained in a special storage, the execution of which is initiated by the introduction of its reference instruction into an instruction register.

'Motion control board'

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.

'Numerical control'

The automatic control of a process performed by a device that makes use of numeric data usually introduced as the operation is in progress (Ref.ISO 2382).

'Part program'

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).

'Positioning accuracy'

Of numerically controlled machine tools is to be determined and presented in conjunction with the requirements below:

i) Test conditions (ISO/230/2 paragraph 3):

a) 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 identically to the way they will be cycled during the accuracy measurements;

b) The machine shall be equipped with any mechanical, electronic, or software compensation to be exported with the machine;

c) Accuracy of measuring equipment for the measurements shall be at least four times more accurate than the expected machine tool accuracy;

d) Power supply for slide drives shall be as follows:

(A) Line voltage variation shall not be greater than ± 10% of nominal rated voltage;

(b) Frequency variation shall not be greater than ± 2 Hz of normal frequency;

(C) Lineouts of interrupted service are not permitted .

ii) Test Program (ISO/230/2 paragraph 4):

a) 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 50mm per minute;

b) The limit of the axis travel to the other without returning to the starting position for each move to the target position;

c) Axes not being measured shall be retained at mid-travel during test of an axis

.

iii) Presentation of test results (ISO/230/2 paragraph 2); The results of the measurements must include:

a) Positioning accuracy and

b) The mean reversal error.

'Program'

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

'Real-time processing'

Processing of data by an electronic computer in response to an external event according to time requirements imposed by the external event.

'Robot'

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:

i) Is multifunctional;

ii) Is capable of positioning or orienting material, parts, tools or special devices through variable movements in three-dimensional space;

iii) Incorporates three or more closed or open loop servo-devices which may include stepping motors; and

iv) 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:

a) Manipulation mechanisms which are only manually/teleoperator controllable;

b) Fixed sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed stops, such as pins or cams. The sequence of motions and the selection of paths or angles are not variable or changeable by mechanical, electronic or electrical means;

c) Mechanically controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is mechanically limited by fixed, but adjustable, stops, such as pins or cams. The sequence of motions and the selection of paths or angles are variable within the fixed program pattern. Variations or modifications of the program pattern (e.g. changes of pins exchanges of cams) in one or more motion axes are accomplished only through mechanical operations;

d) Non-servo-controlled variable sequence manipulation mechanisms which are automated moving devices, operating according to mechanically fixed programmed motions. The program is variable, but the sequence proceeds only by the binary signal from mechanically fixed electrical binary devices or adjustable stops;

e) Stacker cranes defined as Cartesian coordinate manipulator systems manufactured as an integral part of a vertical array of storage bins and designed to access the contents of those bins for storage or retrieval.

f) Robots specially designed for non-nuclear industrial applications such as automobile paint-spraying booths.

'End effector'

End effectors include grippers, active tooling units, and any other tooling that is attached to the base plate on the end of a robot manipulator arm.

'Run out' (out-of-true-running)

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 Part 1-1986, paragraph 5.61).

'Sensors'

Detectors of a physical phenomenon, the output of which (after conversion into a signal that can be interpreted by a controller) is able to generate programs or modify programmed instructions or numerical program data. This includes sensors with machine vision, infrared imaging, acoustical imaging, tactile feel, inertial position measuring, optical or acoustic ranging or force or torque measuring capabilities.

'Software'

A collection of one or more programs or microprograms fixed in any tangible medium of expression.

'Tilting spindle'

A tool-holding spindle that, during the machining process, alters the angular position of its centre line with respect to any other axis.

'User-accessible programmability'

The facility allowing a user to insert, modify or replace programs by means other than:

i) A physical change in wiring or interconnections; or

ii) The setting of function controls including entry of parameters.

53. Spin-forming and flow-forming machines

Flow-forming machines, spin-forming machines capable of flow-forming functions, and mandrels as follows:

53. 1. Machines which have both of the following characteristics:

(a) Three or more rollers (active or guiding); and

(b) Which, according to the manufacturer's technical specification, can be equipped with numerical control units or a computer control.

53. 2. Rotor-forming mandrels designed to form cylindrical rotors of inside diameter between 75 and 400 mm.

NOTE
Item 53.1 above 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.

54. Dimensional inspection machines

Dimensional inspection machines, devices or systems, as follows, and especially designed software therefor.

54. 1. Computer controlled or numerically controlled dimensional inspection machines having both of the following characteristics:

(a) Two or more axes; and

(b) A one-dimensional length 'measurement uncertainty' equal to or better (less) than (6+ L/1000) µm (L is the measured length in millimetres) (Ref: VDI/VDE 2617 parts 1 and 2);

54. 2. Linear and angular displacement measuring devices, as follows:

(a) Linear measuring instruments having any of the following characteristics:

(i) 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; or

(ii) Linear variable differential transformer (LVDT) systems having both of the following characteristics:

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

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

(iii) Measuring systems that have both of the following characteristics:

(A) Contain a laser; and

(B) Maintain for at least 12 hours, over a temperature range of ± 1 K around a standard temperature and a standard pressure:

(I) A resolution over their full scale of 0.1 µm or better; and
(II) A 'measurement uncertainty' equal to or less (better) than (0.2 ±L/2000) µm (L is the measured length in mm)

NOTE
Item 54.2(a)(iii) does not prohibit 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.

(b) Angular measuring instruments having an 'angular position deviation' equal to or less (better) than 0.00025°;

NOTE
Item 54.2(b) does not prohibit 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:

(i) 'Measurement uncertainty' along any linear axis equal to or less (better) than 3.5 µm per 5 mm; and

(ii) 'Angular position deviation' equal to or less than 0.02°.

NOTE
Especially designed software for the systems described in paragraph 54.2(c) includes software for simultaneous measurement of wall thickness and contour.

TECHNICAL NOTE 1
Item 54 includes machine tools that can be used as measuring machines if they meet or exceed the criteria specified for the measuring machine function.

TECHNICAL NOTE 2
Machines described in item 54 are required to be reported if they exceed the threshold specified anywhere within their operating range.

TECHNICAL NOTE 3
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.

TECHNICAL NOTE 4
All parameters of measurement values in this item represent plus/minus, i.e. not total band.
'Measurement uncertainty' The characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95%. It includes the uncorrected systematic deviations, the uncorrected backlash, and the random deviations (Reference: VDI/VDE 2617).

'Resolution'

The least increment of a measuring device; on digital instruments, the least significant bit (Reference:ANSI B-89.1.12).

'Linearity'

(Usually measured in terms of non-linearity) is the maximum deviation of the actual characteristic (average of upscale and downscale readings), positive or negative, from a straight line so positioned as to equalize and minimize the maximum deviations.

'Angular position deviation'

The maximum difference between angular position and the actual, very accurately measured angular position after the workpiece mount of the table has been turned out of its initial position. (Reference: VD1/VDE 2617. Draft: 'Rotary table on coordinate measuring machines').

55. Isostatic presses (cold and hot)

'Isostatic presses', and related equipment, as follows:

55. 1. 'Isostatic presses' having both of the following characteristics:

(a) Capable of achieving a maximum working pressure of 69 MPa or greater; and

(b) A chamber cavity with an inside diameter in excess of 152 mm;

55. 2. Dies, moulds, and controls especially designed for the ´isostatic presses´ specified in item 55.1.

TECHNICAL NOTE 1
In item 55,´isostatic presses' means equipment capable of pressurizing 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.

TECHNICAL NOTE 2
In item 55, 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.

56. *Rotor fabrication and assembly equipment

56. 1. *Rotor assembly equipment for assembly of rotor tube sections, baffles, and end caps;

NOTE
Item 56.1 includes precision mandrels, clamps and shrink fit machines.

56. 2. *Rotor straightening equipment for alignment of rotor tube sections to a common axis;

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.

56. 3. *Bellows-forming mandrels and dies for producing single-convolution bellows.

TECHNICAL NOTE
The bellows referred to in item 56.3 have all of the following characteristics:

i) Inside diameter between 75 and 400 mm;

ii) Length equal to or greater than 12.7 mm;

iii) Single convolution depth greater than 2 mm; and

iv) Made of high-strength aluminium alloys, maraging steel, or high strength 'fibrous or filamentary materials'.

57. *Centrifugal balancing machines

Centrifugal multiplane balancing machines, fixed or portable, horizontal or vertical, as follows; and especially designed software therefor:

57. 1. *Centrifugal balancing machines designed for balancing flexible rotors having a length of 400 mm or more and having all the following characteristics:

(a) A swing or journal diameter of 75 mm or more;

(b) Mass capability of from 0.9 to 23 kg; and

(c) Capable of balancing speed of revolution more that 5000 rpm.

57. 2. *Centrifugal balancing machines designed for balancing hollow cylindrical rotor components and having all the following characteristics:

(a) A journal diameter of 75 mm or more;

(b) Mass capability of from 0.9 to 23 kg;

(c) Capable of balancing to a residual imbalance of 0.010 kg mm/kg per plane or better; and

(d) Belt drive type.

58. *Fibrous and Filamentary material winding mac hines and related equipment

58. 1. *Filament winding machines having all of the following characteristics:

(a) Having motions for positioning, wrapping, and winding fibrous and filamentary material winding coordinated and programmed in two or more axes;

(b) Capable of fabricating composite structures or laminates from 'fibrous or filamentary materials'; and

(c) Capable of winding cylindrical rotors of diameter between 75 and 400 mm and lengths of 400 mm or greater;

58. 2. *Coordinating and programming controls for the machines specified in item 58.1.

58. 3. *Mandrels for the machin es specified in item 58.1.

59. Electron beam welding machines

Electron beam welding machines with a chamber of 0.5 m^3 or more.

60. Plasma spray systems

Plasma spray systems, atmospheric or vacuum .

61. Oxidation furnaces

Vacuum oxidation furnaces with all of the following characteristics:

(a) Having a steam supply capable of introducing slightly superheated steam into the bottom of the furnace at a controlled rate;

(b) Capable of containing a retort of working diameter of 600 mm or more and a workable height of 1200 mm or more; and

(c) Having a radiant heater to uniformly heat the retort to a temperature of 673 K (400 ºC) or more.

TECHNICAL NOTE
Oxidation furnaces are used to deposit a controlled oxide layer on the surface of the centrifuge components made from maraging steel.

62. *High temperature furnaces

62. 1. *Controlled atmosphere (vacuum or inert gas) induction furnaces, and power supplies therefor, as follows:

(a) Furnaces having all of the following characteristics:

(i) Capable of operation at temperatures above 1123 K (850 °C);

(ii) Induction coils 600 mm or less in diameter; and

(iii) Designed for power inputs of 5 kW or more;

TECHNICAL NOTE
Item 62.1(a) does not prohibit furnaces designed for the processing of semiconductor wafers. Such furnaces must, however, be reported to the IAEA.

(b) Power supplies, with a specified output power of 5 kW or more, especially designed for furnaces specified in item 62.1(a).

62. 2. *Vacuum or other controlled environment metallurgical melting and casting furnaces and related equipment as follows:

(a) Arc remelt and casting furnaces having both of the following characteristics:

(i) Consumable electrode capacities between 1000 and 20000 cm^3; and

(ii) Capable of operating with melting temperatures above 1973K (1700°C);

(b) Electron beam melting furnaces and plasma atomization and melting furnaces, having both of the following characteristics:

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

(ii) Capable of operating with melting temperatures above 1473K (1200°C);

(c) Computer control and monitoring systems specially configured for any of the furnaces specified in item 62.2(a) or 62.2(b).

63. Vibration test equipment

Vibration test systems, equipment, components and software therefor, as follows:

63. 1. Electrodynamic vibration test systems, having all of the following characteristics:

(a) Employing feedback or closed loop control techniques and incorporating a digital control unit;

(b) Capable of vibrating at 10 g RMS or more between 20 and 2000 Hz; and

(c) Capable of imparting forces of 50 kN or greater measured ´bare table´;

63. 2. Digital control units, combined with 'especially designed software' for vibration testing, with a real-time bandwidth greater than 5 kHz and being designed for use with the systems listed in 63.1;

63. 3. Vibration thrusters (shaker units), with or without associated amplifiers, capable of imparting a force of 50 kN, measured 'bare table', or greater, which are usable for the systems listed in 63.1;

63. 4. Test piece support structures and electronic units designed to combine multiple shaker units into a complete shaker system capable of providing an effective combined force of 50 kN, measured 'bare table', or greater, which are usable for the systems listed in 63.1;

EXPLANATORY NOTE
The term 'bare table' refers to a flat table or surface with no fixtures or fittings.

63. 5. 'Especially designed software' for use with the systems listed in 63.1 or for the electronic units listed in 63.4.

- ## IMPLOSION SYSTEMS DEVELOPMENT EQUIPMENT

64. *Hydrodynamic experiment equipment

64. 1. *Velocity interferometers for measuring velocities in excess of 1 km per second during time intervals less than 10µs;

NOTE
Item 64.1 includes velocity interferometers such as VISARs (Velocity interferometer systems for any reflector) and DLIs (Doppler laser interferometers).

64. 2. *Manganin gauges for pressures greater than 10 GPa;

64. 3. *Quartz pressure transducers for pressures greater than 10 GPa;

64. 4. *Pindomes;

64. 5. *Schliering systems for measuring the density variations in an explosion;

64. 6. *Pressure transducers capable of measuring absolute pressures at any point in the range 0 to 13 kPa and having both of the following characteristics:

(a) Pressure sensing elements made of or protected by aluminium, aluminium alloy, nickel, or nickel alloy with more than 60% nickel by weight; and

(b) Having either of the following characteristics:

(i) A full scale of less than 13 kPa and an 'accuracy' of better than ± 1% of full scale; or

(ii) A full scale of 13 kPa or greater and an 'accuracy' of better than ± 130 Pa.

TECHNICAL NOTES
In item 64.6 pressure transducers are devices that convert pressure measurements into an electrical signal.

In item 64.6 'accuracy' includes non-linearity, hysteresis, and repeatability at ambient temperature.

65. Flash x-ray equipment

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

(a) Set 1 Characteristics

(i) An accelerator peak electron energy of 500 keV or greater but less than 25 MeV; and

(ii) With a figure of merit (K) of 0.25 or greater; or

(b) Set 2 characteristics

(i) An accelerator peak electron energy of 25 MeV or greater; and

(ii) A peak power greater than 50 MW.

TECHNICAL NOTES:

The figure of merit K is defined as:

$K=1.7 \times 10^{3} V^{2.65} Q$

where V is the peak electron energy in MeV and Q is the total accelerated charge in coulombs if the accelerator beam pulse duration is less than or equal to 1 ms. If the accelerator beam pulse duration is greater than 1 ms, Q is the maximum accelerated charge in 1 ms. Q equals the integral of i with respect to t, over the lesser of 1 ms or the time duration of the beam pulse (Q = òidt) where i is the beam current in amperes and t is the time in seconds.

Peak power = (peak potential in volts) x (peak beam current in amperes).

In machines based on microwave accelerating cavities, the time duration of the beam pulse is the lesser of 1 ms or the duration of the bunched beam packet resulting from one microwave modulator pulse.

In machines based on microwave accelerating cavities, the peak beam current is the average current in the time duration of a bunched beam packet.

66. *Gun systems

Multistage light gas guns or other high-velocity gun systems (coil, electromagnetic, electrothermal, or other advanced systems) capable of accelerating projectiles to 2 km/second or greater.

67. *Mechanical rotating mirror cameras

Mechanical rotating mirror cameras, as follows, and especially designed components therefor:

67. 1. *Framing cameras with recording rates greater than 225,000 frames per second;

67. 2. *Streak cameras with writing speeds greater than 0.5 mm/µs.

NOTE
In item 67 components of such cameras include their synchronizing electronics units and rotor assemblies consisting of turbines, mirrors, and bearings.

68. *Electronic streak and framing cameras and components

68.1. *Electronic streak cameras capable of 50 ns or less time resolution;

68.2. *Streak tubes for cameras specified in item 68.1 above;

68.3. *Electronic (or electronically shuttered) framing cameras capable of 50 ns or less frame exposure time including single frame cameras;

68.4. *Framing tubes and solid-state imaging devices for use with cameras listed in 68.3 above, 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) vidicon tubes, where a fast system allows gating the photoelectons from the photocathode before they impinge on the SIT plate;

(c) Kerr or Pockels 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 especially designed for cameras listed in 68.3.

68. 5. *Electronic modules or assemblies (e.g. plug-ins) designed for use with instrumentation cameras and that enable the performance specifications of 68.1 and 68.3 to be achieved.

68. 6. *Solid-state imaging devices having an area of 40 cm^2 or greater and a quantum efficiency of greater than 50%.

69. Electronic Digital Computers

Electronic digital computers and microprocessors with a composite theoretical performance (CTP) of greater than 28,000 million theoretic al operations per second (MTOPS).

NOTE 1
This item includes parallel clusters, including those assembled from commercial-off-the-shelf (COTS) networking technology, capable of an aggregate performance level exceeding 28,000 MTOPS.

NOTE 2
This item does not include computers essential for medical applications and incorporated in equipment or systems designed or modified for identifiable and dedicated medical applications. Equipment containing computers meeting or exceeding the specifications above must, however, be reported to the IAEA.

70. *Computer codes for nuclear explosives

Hydrodynamics codes, neutronic codes, photon transport codes and/or equation-of-state and related nuclear data and opacity files usable for calculating implosion or gun type weapons.

NOTE
These items include software, equations or data in any form usable for calculations for implosion or gun type weapons.

71. Detonators and multi-point initiator systems

71. 1. Electrically driven explosive detonators as follows:

(a) Exploding bridge (EB);

(b) Exploding bridge wire (EBW);

(c) Slapper; and

(d) Exploding foil initiators (EFI).

NOTE
Item 71.1 does not include detonators using only primary explosives, such as lead azide.

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

71. 2. 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 ms.

71. 3. Optically driven prompt explosive detonators

TECHNICAL NOTE
These detonators are sometimes referred to as laser slappers. The detonators operate by means of laser light evaporating the surface of a flyer or slapper, generating a plasma that drives the flyer across a gap.

72. *Explosive lenses

Explosive lenses designed to uniformly initiate the detonation of the surface of a high explosive charge.

73. *Firing sets and high-current pulse generators

73. 1. *Explosive detonator firing sets designed to drive multiple controlled detonators covered under item 71 above;

73. 2. *Modular electrical pulse generators (pulsers) having all of the following characteristics:

(a) Designed for portable, mobile or ruggedized use;

(b) Enclosed in a dust-tight enclosure;

(c) Capable of delivering their energy in less than 15 µs;

(d) Having an output greater than 100 A;

(e) Having a rise time of less than 10 µs into loads of less than 40 ohms.

NOTE 1
Rise time is defined as the time interval from 10% to 90% current amplitude when driving a resistive load.

NOTE 2
Item 73.2(e) includes xenon flashlamp drivers.

(f) No dimension greater than 25.4 cm;

(g) Weight less than 25 kg; and

(h) Specified for use over an extended temperature range 223 to 373 K (-50°C to 100°C) or specified as suitable for aerospace applications.

74. Switching devices

74. 1. Cold-cathode tubes (including gas krytron tubes and vacuum sprytron tubes), whether gas filled or not, operating similarly to a spark gap, having all of the following characteristics:

(a) Containing three or more electrodes;

(b) Anode peak voltage rating of 2500 V or more;

(c) Anode peak current rating of 100 A or more; and

(d) Anode delay time of 10 µs or less;

74. 2. Triggered spark-gaps having both of the following characteristics:

(a) Anode delay time of 15 µs or less; and

(b) Rated for a peak current of 500 A or more;

74. 3. Modules or assemblies with a fast switching function having all of the following characteristics:

(a) Anode peak voltage rating greater than 2000 V;

(b) Anode peak current rating of 500 A or more; and

(c) Turn-on time of 1 µs or less.

75. Pulse discharge capacitors

Pulse discharge capacitors with either of the following sets of characteristics:

75. 1. Set 1 Characteristics

(a) Voltage rating greater than 1.4 kV,

(b) Energy storage greater than 10 J,

(c) Capacitance greater than 0.5 µF, and

(d) Series inductance less than 50 nH; or

75. 2. Set 2 Characteristics

(a) Voltage rating greater than 750 V,

(b) Capacitance greater than 0.25 µF, and

(c) Series inductance less than 10 nH.

76. High explosives

High explosive substances or mixtures, in any form, containing any of the following:

76. 1. Cyclotetramethylenetetranitramine (HMX);

76. 2. Cyclotrimethylenetrinitramine (RDX);

76. 3. Triaminotrinitrobenzene (TATB);

76. 4. Hexanitrostilbene (HNS), except when contained in pharmaceuticals;

76. 5 Any explosive with a crystal density greater than 1.8 g/cm3 and having a detonation velocity greater than 8000 m/s; or

76. 6. Pentaerythritoltetranitrate (PETN), except when contained in pharmaceuticals.

• OTHER EQUIPMENT

77. *Crucibles

77. 1. *Crucibles made of, or coated with, any of the following materials:

(a) Calcium fluoride (CaF_2);

(b) Calcium zirconate (metazirconate) ($CaZrO_3$);

(c) Cerium sulfide (Ce_2S_3);

(d) Erbium oxide (erbia) (Er_2O_3);

(e) Hafnium oxide (hafnia) (HfO_2);

(f) Magnesium oxide (MgO);

(g) Nitrided niobium-titanium-tungsten alloy (approximately 50% Nb, 30% Ti, 20% W);

(h) Yttrium oxide (yttria) (Y_2O_3); or

(i) Zirconium oxide (zirconia) (ZrO_2);

77. 2. *Crucibles made of or lined with tantalum, having a purity of 99.9% or greater by weight;

77. 3. *Crucibles having both of the following characteristics:

(a) Made of or lined with tantalum having a purity of 98% or greater by weight; and

(b) Coated with tantalum carbide, nitride, boride or any combination of thereof.

78. Neutron generator systems

78. 1. *Neutron generator systems, including tubes, having both of the following characteristics:

(a) Designed for operation without an external vacuum system; and

(b) Utilizing electrostatic acceleration to induce a deuterium-deuterium or tritium-deuterium nuclear reaction.

78. 2. Neutron generator systems that utilize dense plasma focus for deuterium-deuterium or tritium-deuterium reaction.

79. Time delay generation or time interval measurement equipment

79. 1. Digital time delay generators with a resolution of 50 ns or less over time intervals of 1 ms or greater;

79. 2. Multi-channel (three or more) or modular time interval meter and chronometry equipment with time resolution less than 50 ns over time ranges greater than 1 µs.

80. Oscilloscopes

Oscilloscopes, transient recorders and especially designed components therefor as follows:

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

80. 2. Modular analogue oscilloscope systems having either of the following characteristics;

(a) A mainframe with a bandwidth of 1 GHz or greater; or

(b) Plug-in modules with an individual bandwidth of 4 GHz or greater.

80. 3. Analogue sampling oscilloscopes for the analysis of recurring phenomena with an effective bandwidth greater than 4 GHz;

80. 4. 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 1
Especially designed components for analogue oscilloscopes, are:

i) Plug-in units;

ii) External amplifiers;

iii) Pre-amplifiers;

iv) Sampling devices; and

v) Cathode ray tubes.

NOTE 2
'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.

81. High-speed pulse generators

High-speed pulse generators having both of the following characteristics:

(a) Output voltage greater than 6 V into a resistive load of less than 55-ohms; and

(b) 'Pulse transition time' less than 500 ps.

TECHNICAL NOTE
In item 81(b) 'pulse transition time' is defined as the time interval between 10% and 90% voltage amplitude.

82. Pulse amplifiers

Pulse amplifiers having all of the following characteristics:

(a) Gain greater than 6 dBs;

(b) Baseband bandwidth greater than 500 MHz (having the low frequency half-power point at less than 1 MHz and the high frequency half-powered point greater than 500 MHz); and

(c) Output voltage greater than 2 volts into 55 ohms or less. (This corresponds to an output greater than 16 dBm in a 50 ohm system.)

83. Photomultiplier tubes

Photomultiplier tubes having both of the following characteristics:

(a) Photocathode area of greater than 20 cm^2; and

(b) Anode pulse rise time of less than 1 ns.

84. Frequency changers

Frequency changers or generators (also known as converters or inverters), other than those specified in item 23.4, having all of the following characteristics:

(a) A multiphase output capable of providing a power of 40W or greater;

(b) Capable of operating in the frequency range between 600 and 2000 Hz;

(c) Total harmonic distortion better (less) than 10%; and

(d) Frequency control better (less) than 0.1%.

85. Bellows-sealed valves

Valves having all of the following characteristics:

(a) Nominal size of 5 mm or greater;

(b) Having a bellows seal or a diaphragm; and

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

TECHNICAL NOTE
For valves with different inlet and outlet diameter, the nominal size parameter in item 85(a) refers to the smallest diameter.

86. Scroll compressors and vacuum pumps

Bellows-sealed scroll compressors and bellows-sealed scroll-type vacuum pumps in which all surfaces that come in contact with the process gas are made from any of the following materials: aluminium, aluminium alloy, aluminium oxide, stainless steel, nickel, nickel alloy, phosphor bronze, and fluoropolymers.

87. Ion accelerators

Ion accelerators having both of the following characteristics:

(a) Capable of accelerating ions to energies between 120 MeV and 20 GeV; and

(b) Having a figure of merit (K) of 82.0 or greater.

TECHNICAL NOTE
The figure of merit K is defined as $K=I(E-120)$, where I is the average accelerator beam current in mA and E is the final energy in MeV.

• APPENDIX 1: GENERAL PRINCIPLES

The description of an item in the Goods Review List, Nuclear Section includes any such item, whether in new or used condition.

Where the description of any item in the Goods Review List, Nuclear Section contains no qualifications or specifications, it is regarded as including all varieties of that item. Category captions are only for convenience of reference and do not affect the interpretation of item definitions.

The objective of these reviews should not be defeated by the transfer of component parts.

The objectives of these reviews should not be defeated by the transfer to Iraq of any non-reviewed item (including plants) containing one or more reviewable components when the reviewable component or components are the principal element of the item and can be removed or used for other purposes. In judging whether the reviewable component or components are to be considered principal elements, authorities should weigh the factors of quantities, value and technological know-how involved and other special circumstances which might establish the reviewable component or components as the principal element of the item being procured.

• APPENDIX 2: TECHNOLOGY AND SOFTWARE CONTROLS

The transfer of "technology" or "software" directly associated with any item in the Goods Review List, Nuclear Section will be subject to as great a degree of scrutiny and review as the item itself. The transfer of "technology" or "software" for prohibited items is also prohibited.

The approval for transfer to Iraq of any item in the Goods Review List, Nuclear Section which is not proscribed to Iraq may entail the transfer to the same end user of the minimum "technology" or "software" required for the installation, operation, maintenance and repair of the item.

Reviews on transfers of "software" do not apply to:

(a) Software generally available to the public being:

(i) sold from stock at retail selling points without restrictions; and

(ii) designed for installation by the user without further substantial support by the supplier; or

(b) Software "in the public domain".

- **APPENDIX 3: LIST OF NUCLEAR ACTIVITIES PERMITTED UNDER SECURITY COUNCIL RESOLUTION 707**

ANNEX 4 of the OMV Plan is reproduced for convenience

ANNEX 4
LIST OF NUCLEAR ACTIVITIES PERMITTED UNDER SECURITY COUNCIL RESOLUTION 707

The following peaceful applications of isotopes imported from other States after prior approval by the IAEA are permitted:

1. AGRICULTURAL APPLICATIONS

1.1. Soil fertility, irrigation and crop production

1.2. Plant breeding and genetics

1.3. Animal production and health

1.4. Insect and pest control

1.5. Food preservation

1.6. Other uses as approved by the IAEA

2. INDUSTRIAL APPLICATIONS

2.1. Radiography and other non-destructive testing methods

2.2. Industrial process control and quality control

2.3. Radiotracer applications in oil, chemical and metallurgical processes

2.4. Development of water and mineral resources

2.5. Industrial radiation processing

2.6. Other uses as approved by the IAEA

3. MEDICAL APPLICATIONS

3.1. Diagnostic and therapeutic medicine including dosimetry

3.2. Radiotherapy by teletherapy and brachytherapy

3.3. Nutrition and health-related environmental studies

3.4. Other uses as approved by the IAEA

• APPENDIX 4 : DEFINITIONS

'Accuracy'

Usually measured in terms of inaccuracy, defined as the maximum deviation, positive or negative, of an indicated value from an accepted standard or true value.

'Basic scientific research'

Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena and observable facts, not primarily directed toward a specific practical aim or objective.

'Depleted Uranium'

Uranium in which the abundance ratio of the isotope uranium-235 is less than that occurring in natural uranium, e.g. uranium in spent fuel from natural uranium fuelled reactors and tails from uranium enrichment processes.

'Development'

is related to all phases before 'production' such as:

- design
- design research
- design analysis
- design concepts
- assembly and testing of prototypes
- pilot production schemes
- design data
- process of transforming design data into a product
- configuration design
- integration design
- layouts

'Direct-Use Material'

Nuclear material that can be used for the manufacture of nuclear explosives components without transmutation or further enrichment, such as plutonium containing less than 80% plutonium-238, HEU and uranium-233. Chemical compounds, mixtures of direct-use materials (e.g. MOX) and plutonium contained in spent fuel also fall into this category. Unirradiated direct-use material would require less processing time and effort than irradiated direct-use material (contained in spent fuel).

'Enriched Uranium'

Uranium having a higher abundance ratio of the isotope uranium-235 than natural uranium. Enriched uranium is considered as special fissionable material.

'High Enriched Uranium (HEU)'

Uranium enriched to 20% uranium-235 or more. HEU is considered as special fissionable material and as direct-use material.

'In the public domain'

'In the public domain', as it applies herein, means 'technology' or 'software' that has been made available without restrictions upon its further dissemination. (Copyright restrictions do not remove 'technology' or 'software' from being 'in the public domain'.)

'Linearity'

(Usually measured in terms of non-linearity) is the maximum deviation of the actual characteristic (average of upscale and downscale readings), positive or negative, from a straight line so positioned as to equalize and minimize the maximum deviations.

'Low Enriched Uranium (LEU)'

Uranium enriched to less than 20% uranium-235.

'Microprogram'

A sequence of elementary instructions, maintained in a special storage, the execution of which is initiated by the introduction of its reference instruction into an instruction register.

'Mixed Oxide (MOX)'

A reactor fuel consisting of a mixture of the oxides of uranium and plutonium. MOX is used for recycling reprocessed spent fuel (after separation of waste) into thermal nuclear reactors (thermal recycling) and as a fuel for fast breeder reactors. MOX is considered special fissionable material and as direct-use material.

'Natural Uranium'

Uranium as it normally occurs in nature, having an atomic weight of approximately 238 and containing minute quantities of uranium-234, 0.7% uranium-235 and 99.3% uranium-238.

'Plutonium'

A radioactive element which occurs only in trace amounts in nature, with atomic number 94 and symbol Pu. As produced by irradiating uranium fuels, plutonium contains varying percentages of the isotopes 238, 239, 240, 241, and 242. Plutonium is considered as special fissionable material and direct-use material.

'Production'

means all production phases such as:

- construction
- production engineering
- manufacture
- integration
- assembly (mounting)
- inspection
- testing
- quality assurance

'Program'

A sequence of instructions to carry out a process in, or convertible into, a form executable by an electronic computer.

'Software'

A collection of one or more 'programs' or 'microprograms' fixed in any tangible medium of expression.

'Source Material'

- The term "Source Material" means uranium containing the mixture of isotopes occurring in nature; uranium depleted in the isotope 235; thorium; any of the foregoing in the form of metal, alloy, chemical compound, or concentrate.
- The term "source material" is interpreted as not applying to ore or ore residue, in particular to yellowcake, a concentrate consisting essentially of $U_3 0_8$.

'Specially Designed Software'

Refers to the minimum operating systems, diagnostic systems, maintenance systems, and application software necessary to be executed on particular equipment to perform the function for which it was designed. To make other incompatible equipment perform the same function requires:

- modification of this software or
- addition of programs

'Special Fissionable Material'

- The term "Special Fissionable Material" means plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233; any material containing one or more of the foregoing. The term special fissionable material does not include source material.
- The term "Uranium Enriched in the Isotopes 235 or 233" means uranium containing 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 greater than the ratio of the isotope 235 to the isotope 238 occurring in nature.

'Technical assistance'

'Technical assistance' may take forms such as: instruction, skills, training, working knowledge, consulting services.

Note

'Technical assistance' may involve transfer of 'technical data'.

'Technical Data'

'Technical data' may take forms such as blueprints, plans, diagrams, models, formulae, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.

'Technology'

means specific information required for the 'development', 'production', or 'use' of any item contained in the List. This information may take the form of 'technical data' or 'technical assistance'.

'Uranium-233'

An isotope of uranium which is produced by transmutation of thorium-232 and which is considered as special fissionable material and as direct-use material.

'Use'

Operation, installation (including on-site installation), maintenance (checking), repair, overhaul, and refurbishing.

- **APPENDIX 5: INTERNATIONAL SYSTEM OF UNITS AND ABBREVIATIONS**

The International System of Units (SI) is used in this Section. In all cases the physical quantity defined in SI units should be considered the official recommended review value. However, some machine tool parameters are given in their customary units, which are not SI.

Commonly used abbreviations (and their prefixes denoting size) in this Section are as follows:

A ---------------------------ampere(s)
Bq ---------------------- becquerel(s)
ºC ---------------- degree(s) Celsius
CA ---- chemical abstracts service
Ci -- --------------------------- curie(s)
cm ---------------------centimetre(s)
dB ------------------------ decibel(s)
dBm decibel referred to 1 milliwatt
g ----------------------------- gram(s)
g acceleration of gravity (9.81 m/s^2)
GBq -------------- gigabecquerel(s)
GH ------------------------- gigahertz
GPa ------------------- gigapascal(s)
Gy -------------------------------- gray
h -------------------------------hour(s)
Hz ---------------------------------hertz
J---------------------------------joule(s)
K -------------------------------- kelvin
keV -----thousand electron volt(s)
kg ------------------------ kilogram(s)
kHz -------------------------- kilohertz
kN -------------------- kilonewton(s)
kPa -------------------- kilopascal(s)
kV ------------------------ kilovolt(s)
kW -------------------------kilowatt(s)
m ---------------------------- metre(s)
mA -------------------milliampere(s)
MeV ----- million electron volt(s)
MHz --------------------- megahertz
ml -------------------------millilitre(s)
mm ---------------------millimetre(s)
MPa ----------------- megapascal(s)
mPa ------------------- millipascal(s)
MW -------------------- megawatt(s)
µF ---------------------microfarad(s)
µm -------------------- micrometre(s)
µs --------------------microsecond(s)
N ---------------------------newton(s)
nm ----------------------nanometre(s)
ns -------------------- nanosecond(s)
nH ------------------- nanohenry(ies)
ps ----------------------picosecond(s)
RMS ------------- root mean square
rpm -------- revolutions per minute
s --------------------------- second(s)
T ----------------------------- tesla(s)
TIR -------- total indicator reading
V ------------------------------ volt(s)
W -------------------------------watt(s)

GOODS REVIEW LIST
GENERAL NOTES

For Sections A through D, refer to the relevant Technology and Software Notes in the respective Sections

The following three notes apply to Section E, Conventional Section of the Goods Review List

GENERAL TECHNOLOGY NOTE

The export of "technology" which is "required" for the "development", "production" or "use" of items specified as reviewable in the Conventional Section requires review according to the provisions in each Category. This "technology" requires review even when applicable to any non-reviewable item. Review is not required for that "technology" which is the minimum necessary for the installation, operation, maintenance (checking) and repair of those items which do not require review or whose export has been authorized. However, "technology" for entries 1.E.2.e., 1.E.2.f., 8.E.2.a., or 8.E.2.b. requires review.

GENERAL SOFTWARE NOTE

The Lists do not require review of “software” which is either:

1. Generally available to the public by being:

   a. Sold from stock at retail selling points without restriction, by means of:

      1. Over-the-counter transactions;
      2. Mail order transactions; or
      3. Telephone call transactions; and

   b. designed for installation by the user without further substantial support by the supplier; or

Note: Entry 1 of the General Software Note does not release from review “software” covered by Category 5 – Part 2.

2. “In the public domain”

GENERAL MEDICAL NOTE

GOODS REVIEW LIST
GENERAL NOTES

Equipment specially designed for medical end-use that incorporates only items in Section E, Conventional Section of the Goods Review List are not subject to review, unless the end-use stated by the supplier is for a non-medical purpose.

1. A. SYSTEMS, EQUIPMENT AND COMPONENTS

1. A. 1. Components made from fluorinated compounds, as follows:

a. Seals, gaskets, sealants or fuel bladders specially designed for "aircraft" or “aerospace” use, made from more than 50 % by weight of any of the materials ~~control~~for which review is required ~~led~~ by 1.C.9.b. or 1.C.9.c.;

b. Piezoelectric polymers and copolymers made from vinylidene fluoride materials controlled by 1.C.9.a.:

1. In sheet or film form; and
2. With a thickness exceeding 200 µm;

c. Seals, gaskets, valve seats, bladders or diaphragms made from fluoroelastomers containing at least one vinylether group as a constitutional unit, specially designed for "aircraft", aerospace or missile use.

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

a. An organic "matrix" and made from materials ~~controlled~~for which review is required by 1.C.10.c., 1.C.10.d. or 1.C.10.e.; or

Note *1.A.2.a does not controlrequire review of finished or semi-finished items specially designed for purely civilian applications as follows:*
a. Sporting goods;
b. Automotive industry;
c. Machine tool industry;
d. Medical applications.

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

1. Carbon "fibrous or filamentary materials" with:

a. A specific modulus exceeding 10.15×10^6 m; and
b. A specific tensile strength exceeding 17.7×10^4 m; or

2. Materials ~~controlled~~for which review is required by 1.C.10.c.

Note *1.A.2.b. does not ~~control~~require review of finished or semi-finished items specially designed for purely civilian applications as follows:*
a. Sporting goods;
b. Automotive industry;
c. Machine tool industry;
d. Medical applications.

Technical Notes

1. *Specific modulus: Young's modulus in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.*
2. *Specific tensile strength: ultimate tensile strength in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K((23 ± 2)°C) and a relative humidity of (50 ± 5)%.*

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

1. A. 3. Manufacture of non-fluorinated polymeric substances ~~controlled~~for which review is required by 1.C.8.a.3. in film, sheet, tape or ribbon form:

a. With a thickness exceeding 0.254 mm; or

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

Note *1.A.3. does not ~~control~~require review of manufactures when coated or laminated with copper and designed for the production of electronic printed circuit boards.*

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

a. Gas masks, filter canisters and decontamination equipment therefor designed or modified for defence against biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents and specially designed components therefor;

b. Protective suits, gloves and shoes specially designed or modified for defence against biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents;

c. Nuclear, biological and chemical (NBC) detection systems specially designed or modified for detection or identification of biological agents or radioactive materials "adapted for use in war" or chemical warfare (CW) agents and specially designed components therefor.

Note *1.A.4. does not ~~control~~require review of :*
a. Personal radiation monitoring dosimeters;
b. Equipment limited by design or function to protect against hazards specific to civil industries, such as mining, quarrying, agriculture, pharmaceuticals, medical, veterinary, environmental, waste management, or to the food industry.

1. A. 5. Body armour, and specially designed components therefor, not manufactured to military standards or specifications, nor to their equivalents in performance.

Note 1 *1.A.5. does not ~~control~~ require review of individual suits of body armour and accessories therefor, when accompanying their users for his/her own personal protection.*

Note 2 *1.A.5. does not ~~control~~ require review of body armour designed to provide frontal protection only from both fragment and blast from non-military explosive devices.*

1. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

1. B. 1. Equipment for the production of fibres, prepregs, preforms or "composites" ~~controlled~~ for which review is required by 1.A.2. or 1.C.10., as follows, and specially designed components and accessories therefor:

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

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

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

Note *1.B.1.c. does not ~~control~~ require review of 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 ~~controlled~~ for which review is required by 1.C.10.e. by the hot melt method;

f. Non-destructive inspection equipment capable of inspecting defects three dimensionally, using ultrasonic or X-ray tomography and specially designed for "composite" materials.

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

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

a. Airframe or aerospace structures;

b. "Aircraft" or aerospace engines; or

c. Specially designed components for those structures or engines.

1. C. MATERIALS

Technical Note

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

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

Semi-fabricated forms (whether or not coated, plated, drilled or punched):
a. Wrought or worked materials fabricated by rolling, drawing, extruding, forging, impact extruding, pressing, graining, atomising, and grinding, i.e.: angles, channels, circles, discs, dust, flakes, foils and leaf, forging, plate, powder, pressings and stampings, ribbons, rings, rods (including bare welding rods, wire rods, and rolled wire), sections, shapes, sheets, strip, pipe and tubes (including tube rounds, squares, and hollows), drawn or extruded wire;
b. Cast material produced by casting in sand, die, metal, plaster or other types of moulds, including high pressure castings, sintered forms, and forms made by powder metallurgy.

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

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

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

Note 1 1.C.1.a. does not ~~control~~require review of:

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

b. Absorbers having no magnetic loss and whose incident surface is non-planar in shape, including pyramids, cones, wedges and convoluted surfaces;

c. Planar absorbers, having all of the following characteristics:

1. Made from any of the following:

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

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

Technical Note

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

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

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

d. Planar absorbers made of sintered ferrite, having:

1. A specific gravity exceeding 4.4; and

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

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

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

c. Intrinsically conductive polymeric materials with a bulk electrical conductivity exceeding 10,000 S/m (Siemens per metre) or a sheet (surface) resistivity of less than 100 ohms/square, based on any of the following polymers:

1. Polyaniline;
2. Polypyrrole;
3. Polythiophene;
4. Poly phenylene-vinylene; or
5. Poly thienylene-vinylene.

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

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

Note *1.C.2. does not ~~control~~require review of metal alloys, metal alloy powder and alloyed materials for coating substrates.*

Technical Notes
1. *The metal alloys in 1.C.2. are those containing a higher percentage by weight of the stated metal than of any other element.*
2. *Stress-rupture life should be measured in accordance with ASTM standard E-139 or national equivalents.*
3. *Low cycle fatigue life should be measured in accordance with ASTM Standard E-606 'Recommended Practice for Constant-Amplitude Low-Cycle Fatigue Testing' or national equivalents. Testing should be axial with an average stress ratio equal to 1 and a stress-concentration factor (K_t) equal to 1. The average stress is defined as maximum stress minus minimum stress divided by maximum stress.*

. a. Aluminides, as follows:

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

b. Metal alloys, as follows, made from material controlledfor which review is required by 1.C.2.c.:

1. Nickel alloys with:

a. A stress-rupture life of 10,000 hours or longer at 923 K (650°C) at a stress of 676 MPa; or
b. A low cycle fatigue life of 10,000 cycles or more at 823 K (550° C) at a maximum stress of 1,095 MPa;

2. Niobium alloys with:

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

3. Titanium alloys with:

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

4. Aluminium alloys with a tensile strength of:

a. 240 MPa or more at 473 K (200°C); or
b. 415 MPa or more at 298 K (25°C);

5. Magnesium alloys with:

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

c. Metal alloy powder or particulate material, having all of the following characteristics:

1. Made from any of the following composition systems:

Technical Note
X in the following equals one or more alloying elements.

a. Nickel alloys (Ni-Al-X, Ni-X-Al) qualified for turbine engine parts or components, i.e. with less than 3 non-metallic particles (introduced during the manufacturing process) larger than 100 µm in 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 an ~~controlled~~ controlled environment by any of the following processes:

a. "Vacuum atomisation";
b. "Gas atomisation";

c. "Rotary atomisation";
d. "Splat quenching";
e. "Melt spinning" and "comminution";
f. "Melt extraction" and "comminution"; or
g. "Mechanical alloying";

3. Capable of forming materials ~~controlled~~for which review is required by 1.C.2.a. or 1.C.2.b.;

d. Alloyed materials, having all of the following characteristics:

1. Made from any of the composition systems specified in 1.C.2.c.1.;
2. In the form of uncomminuted flakes, ribbons or thin rods; and
3. Produced in an ~~controlled~~controlled environment by any of the following:

a. "Splat quenching";
b. "Melt spinning" or;
c. "Melt extraction";

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

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

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

b. Magnetostrictive alloys, having any of the following characteristics:

1. A saturation magnetostriction of more than 5 x 10^{-4}; or
2. A magnetomechanical coupling factor (k) of more than 0.8; or

c. Amorphous or nanocrystalline alloy strips, having all of the following characteristics:

1. A composition having a minimum of 75 weight percent of iron, cobalt or nickel;
2. A saturation magnetic induction (B_s) of 1.6 T or more; and
3. Any of the following:

a. A strip thickness of 0.02 mm or less; or
b. An electrical resistivity of 2 x 10^{-4} ohm cm or more.

Technical Note

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

1. C. 4. Uranium titanium alloys or tungsten alloys with a "matrix" based on iron, nickel or copper, having all of the following:

a. A density exceeding 17.5 g/cm^3;
b. An elastic limit exceeding 880 MPa;
c. An ultimate tensile strength exceeding 1,270 MPa; and
d. An elongation exceeding 8%.

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

a. Multifilamentary "superconductive" "composite" conductors containing one or more niobium-titanium filaments:

1. Embedded in a "matrix" other than a copper or copper-based mixed "matrix"; or
2. Having a cross-section area less than 0.28 x 10^{-4} mm^2 (6 µm in diameter for circular filaments);

b. "Superconductive" "composite" conductors consisting of one or more "superconductive" filaments other than niobium-titanium, having all of the following:

1. A "critical temperature" at zero magnetic induction exceeding 9.85 K (-263.31°C) but less than 24 K (-249.16°C);
2. A cross-section area less than 0.28 x 10^{-4} mm^2; and
3. Remaining in the "superconductive" state at a temperature of 4.2 K (-268.96°C) when exposed to a magnetic field corresponding to a magnetic induction of 12 T.

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

a. Hydraulic fluids containing, as their principal ingredients, any of the following compounds or materials:

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

Technical Note
For the purpose of 1.C.6.a.1., silahydrocarbon oils contain exclusively silicon, hydrogen and carbon.

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

2. Chlorofluorocarbons, having all of the following:

Technical Note
For the purpose of 1.C.6.a.2., chlorofluorocarbons contain exclusively carbon, fluorine and chlorine.

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

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

1. Phenylene or alkylphenylene ethers or thio-ethers, or their mixtures, containing more than two ether or thio-ether functions or mixtures thereof; or
2. Fluorinated silicone fluids with a kinematic viscosity of less than 5,000 mm^2/s (5,000 centistokes) measured at 298 K (25°C);

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

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

d. Fluorocarbon electronic cooling fluids, having all of the following characteristics:

1. Containing 85% by weight or more of any of the following, or mixtures thereof:

a. Monomeric forms of perfluoropolyalkylether-triazines or perfluoroaliphatic-ethers;
b. Perfluoroalkylamines;
c. Perfluorocycloalkanes; or
d. Perfluoroalkanes;

2. Density at 298 K (25°C) of 1.5 g/ml or more;
3. In a liquid state at 273 K (0°C); and
4. Containing 60% or more by weight of fluorine.

Technical Note
For the purpose of 1.C.6.:

a. Flash point is determined using the Cleveland Open Cup Method described in ASTM D-92 or national equivalents;

b. Pour point is determined using the method described in ASTM D-97 or national equivalents;

c. Viscosity index is determined using the method described in ASTM D-2270 or national equivalents;

d. Thermal stability is determined by the following test procedure or national equivalents:

Twenty ml of the fluid under test is placed in a 46 ml type 317 stainless steel chamber containing one each of 12.5 mm (nominal) diameter balls of M-10 tool steel, 52100 steel and naval bronze (60% Cu, 39% Zn, 0.75% Sn);

The chamber is purged with nitrogen, sealed at atmospheric pressure and the temperature raised to and maintained at 644 ± 6 K (371 ± 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:

1. The loss in weight of each ball is less than 10 mg/mm^2 of ball surface;

2. The change in original viscosity as determined at 311 K (38°C) is less than 25%; and

3. The total acid or base number is less than 0.40;

e. Autogenous ignition temperature is determined using the method described in ASTM E-659 or national equivalents.

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

a. Base materials of single or complex borides of titanium having total metallic impurities, excluding intentional additions, of less than 5,000 ppm, an average particle size equal to or less than 5 µm and no more than 10% of the particles larger than 10 µm;

b. Non-"composite" ceramic materials in crude or semi-fabricated form, composed of borides of titanium with a density of 98% or more of the theoretical density;

Note 1.C.7.b. does not ~~control~~require review of abrasives.

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

1. Made from any of the following materials:

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

2. Having a specific tensile strength exceeding 12.7 x 10^{3}m;

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

e. Precursor materials (i.e., special purpose polymeric or metallo-organic materials) for producing any phase or phases of the materials ~~controlled~~for which review is required by 1.C.7.c., as follows:

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

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

1. Al_2O_3; or
2. Si-C-N.

Note *1.C.7.f. does not ~~control~~ require review of "composites" containing fibres from these systems with a fibre tensile strength of less than 700 MPa at 1,273 K (1,000° C) or fibre tensile creep resistance of more than 1% creep strain at 100 MPa load and 1,273 K (1,000° C) for 100 hours.*

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

a. 1. Bismaleimides;
2. Aromatic polyamide-imides;
3. Aromatic polyimides;
4. Aromatic polyetherimides having a glass transition temperature (T_g) exceeding 513 K (240° C) determined using the dry method described in ASTM D 3418;

Note *1.C.8.a. does not ~~control~~ require review of non-fusible compression moulding powders or moulded forms.*

b. Thermoplastic liquid crystal copolymers having a heat distortion temperature exceeding 523 K (250°C) measured according to ASTM D-648, method A, or national equivalents, with a load of 1.82 N/mm^2 and composed of:

1. Any of the following:

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

2. Any of the following acids:

a. Terephthalic acid;
b. 6-hydroxy-2 naphthoic acid; or
c. 4-hydroxybenzoic acid;

c. Polyarylene ether ketones, as follows:

1. Polyether ether ketone (PEEK);
2. Polyether ketone ketone (PEKK);
3. Polyether ketone (PEK);
4. Polyether ketone ether ketone ketone (PEKEKK);

d. Polyarylene ketones;

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

f. Polybiphenylenethersulphone.

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

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

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

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

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

1. C. 10. "Fibrous or filamentary materials" which may be used in organic "matrix", metallic "matrix" or carbon "matrix" "composite" structures or laminates, as follows:

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

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

Note *1.C.10.a. does not ~~control~~require review of polyethylene.*

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

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

Technical Note
Properties for materials described in 1.C.10.b. should be determined using SACMA recommended methods SRM 12 to 17, or national equivalent tow tests, such as Japanese Industrial Standard JIS-R-7601, Paragraph 6.6.2., and based on lot average.

Note *1.C.10.b. does not ~~control~~require review of fabric made from "fibrous or filamentary materials" for the repair of aircraft structures or laminates, in which the size of individual sheets does not exceed 50 cm x 90 cm.*

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

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

Note *1.C.10.c. does not ~~control~~require review of:*
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 x 10^6 m;
2. Molybdenum and molybdenum alloy fibres;
3. Boron fibres;
4. Discontinuous ceramic fibres with a melting, softening, decomposition or sublimation point lower than 2,043 K (1,770°C) in an inert environment.

d. "Fibrous or filamentary materials":

1. Composed of any of the following:

    a. Polyetherimides ~~controlled~~for which review is required by 1.C.8.a; or
    b. Materials ~~controlled~~for which review is required by 1.C.8.b. to 1.C.8.f.; or

2. Composed of materials ~~controlled~~for which review is required by 1.C.10.d.1.a. or 1.C.10.d.1.b. and "commingled" with other fibres ~~controlled~~for which review is required by 1.C.10.a., 1.C.10.b. or 1.C.10.c.;

e. Resin-impregnated or pitch-impregnated fibres (prepregs), metal or carbon-coated fibres (preforms) or "carbon fibre preforms", as follows:

1. Made from "fibrous or filamentary materials" ~~controlled~~for which review is required by 1.C.10.a., 1.C.10.b. or 1.C.10.c.;

2. Made from organic or carbon "fibrous or filamentary materials":

a. With a specific tensile strength exceeding 17.7 x 10^4 m;
b. With a specific modulus exceeding 10.15 x 10^6 m;
c. Not ~~controlled~~requiring review by 1.C.10.a. or 1.C.10.b.; and
d. When impregnated with materials ~~controlled~~for which review is required by 1.C.8. or 1.C.9.b., having a glass transition temperature (T_g) exceeding 383 K (110°C) or with phenolic or epoxy resins, having a glass transition temperature (T_g) equal to or exceeding 418 K (145°C).

Notes *1.C.10.e. does not ~~control~~require review of:*
1. Epoxy resin "matrix" impregnated carbon "fibrous or filamentary materials" (prepregs) for the repair of aircraft structures or laminates, in which the size of individual sheets of prepreg does not exceed 50 cm x 90 cm;
2. Prepregs when impregnated with phenolic or epoxy resins having a glass transition temperature (Tg) less than 433 K (160°C) and a cure temperature lower than the glass transition temperature.

Technical Note
The glass transition temperature (Tg) for 1.C.10.e. materials is determined using the method described in ASTM D 3418 using the dry method. The glass transition temperature for phenolic and epoxy resins is determined using the method described in ASTM D 4065 at a frequency of 1Hz and a heating rate of 2 K (°C) per minute using the dry method.

Technical Notes
1. Specific modulus: Young's modulus in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.
2. Specific tensile strength: ultimate tensile strength in pascals, equivalent to N/m^2 divided by specific weight in N/m^3, measured at a temperature of (296 ± 2) K ((23 ± 2)°C) and a relative humidity of (50 ± 5)%.

1. C. 11. Metals and compounds, as follows:

a. Metals in particle sizes of less than 60 µm whether spherical, atomised, spheroidal, flaked or ground, manufactured from material consisting of 99% or more of zirconium, magnesium and alloys of these;

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

<u>Note</u> *The metals or alloys listed in 1.C.11.a. ~~are~~ ~~controlled~~ require review whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.*

b. Boron or boron carbide of 85% purity or higher and a particle size of 60 µm or less;

<u>Note</u> *The metals or alloys listed in 1.C.11.b. ~~controlled~~ require review whether or not the metals or alloys are encapsulated in aluminium, magnesium, zirconium or beryllium.*

c. Guanidine nitrate;

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

1. C. 12. Charges and devices specially designed for civil projects, and containing a total quantity not exceeding 0.010 kg of any of the following energetic materials:

a. Cyclotetramethylenetetranitramine (CAS 2691-41-0) (HMX); octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazine; 1,3,5,7-tetranitro-1,3,5,7-tetraza-cyclooctane; (octogen, octogene);

b. Hexanitrostilbene (HNS) (CAS 20062-22-0);

c. Diaminotrinitrobenzene (DATB) (CAS 1630-08-6);

d. Triaminotrinitrobenzene (TATB) (CAS 3058-38-6);

e. Triaminoguanidinenitrate (TAGN) (CAS 4000-16-2);

f. Titanium subhydride of stoichiometry $TiH_{0.65-1.68}$;

g. Dinitroglycoluril (DNGU, DINGU) (CAS 55510-04-8); tetranitroglycoluril (TNGU, SORGUYL) (CAS 55510-03-7);

h. Tetranitrobenzotriazolobenzotriazole (TACOT) (CAS 25243-36-1);

i. Diaminohexanitrobiphenyl (DIPAM) (CAS 17215-44-0);

j. Picrylaminodinitropyridine (PYX) (CAS 38082-89-2);

k. 3-nitro-1,2,4-triazol-5-one (NTO or ONTA) (CAS 932-64-9);

l. Hydrazine (CAS 302-01-2) in concentrations of 70% or more; hydrazine nitrate (CAS 37836-27-4); hydrazine perchlorate (CAS 27978-54-7); unsymmetrical dimethyl hydrazine (CAS 57-14-7); monomethyl (CAS 60-34-4) hydrazine; symmetrical dimethyl hydrazine (CAS 540-73-8);

m. Ammonium perchlorate (CAS 7790-98-9);

n. Cyclotrimethylenetrinitramine (RDX) (CAS 121-82-4); cyclonite; T4; hexahydro-1,3,5-trinitro-1,3,5-triazine; 1,3,5-trinitro-1,3,5-triaza-cyclohexane (hexogen, hexogene);

o. Hydroxylammonium nitrate (HAN) (CAS 13465-08-2); hydroxylammonium perchlorate (HAP) (CAS 15588-62-2);

p. 2-(5-cyanotetrazolato) penta amine-cobalt (III) perchlorate (or CP) (CAS 70247-32-4);

q. cis-bis (5-nitrotetrazolato) tetra amine-cobalt (III) perchlorate (or BNCP);

r. 7-Amino-4,6-dinitrobenzofurazane-1-oxide (ADNBF) (CAS 97096-78-1); amino dinitrobenzofuroxan;

s. 5,7-diamino-4,6-dinitrobenzofurazane-1-oxide (CAS 117907-74-1), (CL-14 or diamino dinitrobenzofuroxan);

t. 2,4,6-trinitro-2,4,6-triazacyclohexanone (K-6 or Keto-RDX) (CAS 115029-35-1);

u. 2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo [3,3,0]-octanone-3 (CAS 130256-72-3) (tetranitrosemiglycouril, K-55 or keto-bicyclic HMX);

v. 1,1,3-trinitroazetidine (TNAZ) (CAS 97645-24-4);

w. 1,4,5,8-tetranitro-1,4,5,8-tetraazadecalin (TNAD) (CAS 135877-16-6);

x. Hexanitrohexaazaisowurtzitane (CAS 135285-90-4) (CL-20 or HNIW); and chlathrates of CL-20;

y. Polynitrocubanes with more than four nitro groups;

z. Ammonium dinitramide (ADN or SR 12) (CAS 140456-78-6);

aa. Trinitrophenylmethylnitramine (tetryl) (CAS 479-45-8);

1. C. 13. Charges and devices specially designed for civil projects, and containing a total quantity not exceeding 0.010 kg of any of the following explosives and propellants meeting the following performance parameters:

a. Any explosive with a detonation velocity exceeding 8,700 m/s or a detonation pressure exceeding 34 GPa (340 kbar);

b. Other organic explosives. yielding detonation pressures of 25 GPa (250 kbar) or more that will remain stable at temperatures of 523 K (250°C) or higher for periods of 5 minutes or longer;

c. Any other United Nations (UN) Class 1.1 solid propellant with a theoretical specific impulse (under standard conditions) of more than 250 s for non-metallised, or more than 270 s for aluminised compositions;

d. Any UN Class 1.3 solid propellant with a theoretical specific impulse of more than 230 s for non-halogenised, 250 s for non-metallised and 266 s for metallised compositions;

1. C. 14.~~12.~~ Materials as follows:

Technical Note
These materials are typically used for nuclear heat sources.

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

Note *1.C.12.a. does not ~~control~~require review of:*
1. Shipments with a plutonium content of 1 g or less;
2. Shipments of 3 "effective grams" or less when contained in a sensing component in instruments.

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

Note *1.C.12.b. does not ~~control~~require review of shipments with a neptunium-237 content of 1 g or less.*

1. D. SOFTWARE

1. D. 1. "Software" specially designed or modified for the "development", "production" or "use" of equipment ~~controlled~~for which review is required by 1.B.

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

1. E. TECHNOLOGY

1. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials ~~controlled~~for which review is required by 1.A.1.b., 1.A.1.c., 1.A.2. to 1.A.5., 1.B. or 1.C.

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

a. "Technology" for the "development" or "production" of polybenzothiazoles or polybenzoxazoles;

b. "Technology" for the "development" or "production" of fluoroelastomer compounds containing at least one vinylether monomer;

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

1. Base materials having all of the following characteristics:

a. Any of the following compositions:
1. Single or complex oxides of zirconium and complex oxides of silicon or aluminium;
2. Single nitrides of boron (cubic crystalline forms);
3. Single or complex carbides of silicon or boron; or
4. Single or complex nitrides of silicon;

b. Total metallic impurities, excluding intentional additions, of less than:

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

c. Being any of the following:

1. Zirconia with an average particle size equal to or less than 1 µm and no more than 10% of the particles larger than 5 µm;
2. Other base materials with an average particle size equal to or less than 5 µm and no more than 10% of the particles larger than 10 µm; or
3. Having all of the following:

   a. Platelets with a length to thickness ratio exceeding 5;
   b. Whiskers with a length to diameter ratio exceeding 10 for diameters less than 2 µm; and
   c. Continuous or chopped fibres less than 10 µm in diameter;

2. Non-"composite" ceramic materials composed of the materials described in 1.E.2.c.1.;

Note *1.E.2.c.2. does not ~~control~~require review of technology for the design or production of abrasives.*

d. "Technology" for the "production" of aromatic polyamide fibres;

e. "Technology" for the installation, maintenance or repair of materials ~~controlled~~for which review is required by 1.C.1.;

f. "Technology" for the repair of "composite" structures, laminates or materials controlledfor which review is required by 1.A.2., 1.C.7.c. or 1.C.7.d.

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

2. A. SYSTEMS, EQUIPMENT AND COMPONENTS~~N.B. For quiet running bearings, see Item 9 on the Munitions List.~~ *

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

Note 2.A.1. does not controlrequire review of balls with tolerances specified by the manufacturer in accordance with ISO 3290 as grade 5 or worse.

a. Ball bearings and solid roller bearings having tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 4 (or ANSI/ABMA Std 20 Tolerance Class ABEC-7 or RBEC-7, or other national equivalents), or better, and having rings, balls or rollers made from monel or beryllium;

Note 2.A.1.a. does not ~~control~~require review of tapered roller bearings.

b. Other ball bearings and solid roller bearings having tolerances specified by the manufacturer in accordance with ISO 492 Tolerance Class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or RBEC-9, or other national equivalents), or better;

Note 2.A.1.b. does not ~~control~~require review of tapered roller bearings.

c. Active magnetic bearing systems using any of the following:

1. Materials with flux densities of 2.0 T or greater and yield strengths greater than 414 MPa;
2. All-electromagnetic 3D homopolar bias designs for actuators; or
3. High temperature (450 K (177°C) and above) position sensors.

2. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

Technical Notes

1. *Secondary parallel contouring axes, (e.g., the w-axis on horizontal boring mills or a secondary rotary axis the centre line of which is parallel to the primary rotary axis) are not counted in the total number of contouring axes. Rotary axes need not rotate over 360°. A rotary axis can be driven by a linear device (e.g., a screw or a rack-and-pinion).*
2. For the purposes of 2.B, the number of axes which can be co-ordinated simultaneously for "contouring control" is the number of axes which affect relative movement between any one workpiece and a tool, cutting head or grinding wheel which is cutting or removing material from the workpiece. This does not include any additional axes which affect other relative movement within the machine. Such axes include:

a. Wheel-dressing systems in grinding machines;
b. Parallel rotary axes designed for mounting of separate workpieces;

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

c. *Co-linear rotary axes designed for manipulating the same workpiece by holding it in a chuck from different ends.*~~Technical Notes contd.~~

3. *Axis nomenclature shall be in accordance with International Standard ISO 841, 'Numerical Control Machines - Axis and Motion Nomenclature'.*
4. *For the purposes of this Category a "tilting spindle" is counted as a rotary axis.*
5. *Stated positioning accuracy levels derived from measurements made according to ISO 230/2 (1997) or national equivalents may be used for each machine tool model instead of individual machine tests. Stated positioning accuracy means the accuracy value provided to national licensing authorities as representative of the accuracy of a machine model.*

Determination of Stated Values

a. *Select five machines of a model to be evaluated;*
b. *Measure the linear axis accuracies according to ISO 230/2 (1997);*
c. *Determine the A-values for each axis of each machine. The method of calculating the A-value is described in the ISO standard;*
d. *Determine the mean value of the A-value of each axis. This mean value A becomes the stated value of each axis for the model (Ax Ay...);*
e. *Since the Category 2 list refers to each linear axis there will be as many stated values as there are linear axes;*
f. *If any axis of a machine model not ~~control~~requiring review ~~led~~ by 2.B.1.a. to 2.B.1.c. has a stated accuracy A of 5 microns for grinding machines and 6.5 microns for milling and turning machines or better, the builder should be required to reaffirm the accuracy level once every eighteen months.*

2. B. 1. Machine tools, as follows, and any combination thereof, for removing (or cutting) metals, ceramics or "composites", which, according to the manufacturer's technical specification, can be equipped with electronic devices for "numerical control":

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

Note 2 *2.B.1. does not ~~control~~require review of 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;*

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

1. Positioning accuracy with "all compensations available" equal to or less (better) than 4.5 µm according to ISO 230/2 (1997) or national equivalents along any linear axis; and

2. Two or more axes which can be coordinated simultaneously for "contouring control";

Note *2.B.1.a. does not ~~control~~ require review of turning machines specially designed for the production of contact lenses.*

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

1. Having all of the following:

a. Positioning accuracy with "all compensations available" equal to or less (better) than 4.5 µm according to ISO 230/2 (1997) or national equivalents along any linear axis; and
b. Three linear axes plus one rotary axis which can be coordinated simultaneously for "contouring control";

2. Five or more axes which can be coordinated simultaneously for "contouring control"; or

3. A positioning accuracy for jig boring machines, with "all compensations available", equal to or less (better) than 3.0 µm according to ISO 230/2 (1997) or national equivalents along any linear axis;

4. Fly cutting machines, having all of the following characteristics:

a. Spindle "run-out" and "camming" less (better) than 0.0004 mm TIR; and
b. Angular deviation of slide movement (yaw, pitch and roll) less (better) than 2 seconds of arc, TIR, over 300 mm of travel.

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

1. Having all of the following:

a. Positioning accuracy with "all compensations available" equal to or less (better) than 3.0 µm according to ISO 230/2 (1997) or national equivalents[4] along any linear axis; and
b. Three or more axes which can be coordinated simultaneously for "contouring control"; or

2. Five or more axes which can be coordinated simultaneously for "contouring control";

Notes *2.B.1.c. does not ~~control~~require review of grinding machines, as follows:*
1. Cylindrical external, internal, and external-internal grinding machines having all the following characteristics:
a. Limited to cylindrical grinding; and
b. Limited to a maximum workpiece capacity of 150 mm outside diameter or length.
2. Machines designed specifically as jig grinders having any of the following characteristics:
a. The c-axis is used to maintain the grinding wheel normal to the work surface; or

b. The a-axis is configured to grind barrel cams.

3. Tool or cutter grinding machines limited to the production of tools or cutters.

4. Crank shaft or cam shaft grinding machines.

5. Surface grinders.

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

e. Machine tools for removing metals, ceramics or "composites" having all of the following characteristics:

1. Removing material by means of any of the following:

a. Water or other liquid jets, including those employing abrasive additives;

b. Electron beam; or

c. "Laser" beam; and

2. Having two or more rotary axes which:

a. Can be coordinated simultaneously for "contouring control"; and

b. Have a positioning accuracy of less (better) than 0.003°;

f. Deep-hole-drilling machines and turning machines modified for deep-hole-drilling, having a maximum depth-of-bore capability exceeding 5,000 mm and specially designed components therefor.

2. B. 2. Not used.

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

2. B. 4. Hot "isostatic presses", having all of the following, and specially designed components and accessories therefor:

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

b. Any of the following:

1. A maximum working pressure exceeding 207 MPa;

2. A controlled thermal environment exceeding 1,773 K (1,500°C); or

3. A facility for hydrocarbon impregnation and removal of resultant gaseous degradation products.

Technical Note

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

N.B. For specially designed dies, moulds and tooling see Items 1.B.3. and~~,~~ 9.B.9.

~~*and ML18. of the Munitions List.*~~*

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

a. "Stored programme controlled" chemical vapour deposition (CVD) production equipment having all of the following:

1. Process modified for one of the following:

a. Pulsating CVD;
b. Controlled nucleation thermal deposition (CNTD); or
c. Plasma enhanced or plasma assisted CVD; and

2. Any of the following:

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

b. "Stored programme controlled" ion implantation production equipment having beam currents of 5 mA or more;

c. "Stored programme controlled" electron beam physical vapour deposition (EB-PVD) production equipment incorporating power systems rated for over 80 kW, having any of the following:

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

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

d. "Stored programme controlled" plasma spraying production equipment having any of the following characteristics:

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

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 µm/h or more;

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

g. "Stored programme controlled" ion plating production equipment allowing for the *in situ* measurement of any of the following:

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

Note 2.B.5.a., 2.B.5.b., 2.B.5.e., 2.B.5.f. and 2.B.5.g. do not ~~control~~require review of chemical vapour deposition, cathodic arc, sputter deposition, ion plating or ion implantation equipment specially designed for cutting or machining tools.

2. B. 6. Dimensional inspection or measuring systems and equipment, as follows:

a. Computer controlled, "numerically controlled" or "stored programme controlled" dimensional inspection machines, having a three dimensional length (volumetric) "measurement uncertainty" equal to or less (better) than (1.7 + L/1,000) µm (L is the measured length in mm) tested according to ISO 10360-2;

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

1. Linear measuring instruments having any of the following:

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 voltage differential transformer systems having all of the following characteristics:

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

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

c. Measuring systems having all of the following:

1. Containing a "laser"; and

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

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

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

Note *2.B.6.b.1. does not control require review of 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.*

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

Note *2.B.6.b.2. does not ~~control~~require review of optical instruments, such as autocollimators, using collimated light to detect angular displacement of a mirror.*

c. Equipment for measuring surface irregularities, by measuring optical scatter as a function of angle, with a sensitivity of 0.5 nm or less (better).

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

Note 2 *A machine described in 2.B.6. ~~is controlled~~ requires review if it exceeds the control review threshold anywhere within its operating range.*

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

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

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

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

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

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

2. B. 8. Assemblies or units, specially designed for machine tools, or dimensional inspection or measuring systems and equipment, as follows:

a. Linear position feedback units (e.g., inductive type devices, graduated scales, infrared systems or "laser" systems) having an overall "accuracy" less (better) than $(800 + (600 \times L \times 10^{-3}))$ nm (L equals the effective length in mm);
N.B. *For "laser" systems see also Note to 2.B.6.b.1.*

b. Rotary position feedback units (e.g., inductive type devices, graduated scales, infrared systems or "laser" systems) having an "accuracy" less (better) than 0.00025°;
N.B. *For "laser" systems see also Note to 2.B.6.b.1.*

c. "Compound rotary tables" and "tilting spindles", capable of upgrading, according to the manufacturer's specifications, machine tools to or above the levels specified in 2.B.

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

a. Two or more controlled axes of which at least two can be coordinated simultaneously for "contouring control"; and

b. A roller force more than 60 kN.

Technical Note
Machines combining the function of spin-forming and flow-forming are for the purpose of 2.B.9. regarded as flow-forming machines.

2. C. MATERIALS - None

2. D. SOFTWARE

1. "Software", other than that ~~controlled~~ required for review by 2.D.2., specially designed or modified for the "development", "production" or "use" of equipment required for review by 2.A. or 2.B.

2. "Software" for electronic devices, even when residing in an electronic device or system, enabling such devices or systems to function as a "numerical control"

unit, capable of co-ordinating simultaneously more than 4 axes for "contouring control".

Note 2.D.2. does not ~~control~~ require review of "software" specially designed or modified for the operation of machine tools ~~not controlled~~ for which review is not required by Category 2.

2. E. TECHNOLOGY

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

2. E. 2. "Technology" according to the General Technology Note for the "production" of equipment ~~controlled~~ for which review is required by 2.A. or 2.B.

2. E. 3. 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;

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

d. "Technology" for the "development" of generators of machine tool instructions (e.g., part programmes) from design data residing inside "numerical control" units;

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

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

N.B. *This Table should be read to ~~control~~require review of 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~~ require review for the application of 'silicides' to 'Carbon-carbon, Ceramic and Metal "matrix" "composites"' substrates, ~~but are not controlled~~ but do not require review for the application of 'silicides' to 'Cemented tungsten carbide (16), Silicon carbide (18)' substrates. In the second case, the 'Resultant Coating' is not listed in the paragraph under column 3 directly across from the paragraph under column 2 listing 'Cemented tungsten carbide (16), Silicon carbide (18)'.*

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)*	2. Substrate	3. Resultant Coating
A. Chemical Vapour Deposition (CVD)	"Superalloys"	Aluminides for internal passages
	Ceramics (19) and Low-expansion glasses (14)	Silicides Carbides Dielectric layers (15) Diamond Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Aluminides Alloyed aluminides (2) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Diamond Diamond-like carbon (17)
	Sensor window materials (9)	Dielectric layers (15) Diamond Diamond-like carbon (17)

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

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
B. Thermal-Evaporation Physical Vapour Deposition (TE-PVD)		
B.1. Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD)	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5) Modified zirconia (12) Silicides Aluminides Mixtures thereof (4)
	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15)
	Corrosion resistant steel (7)	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15) Borides Beryllium
	Sensor window materials (9)	Dielectric layers (15)
	Titanium alloys (13)	Borides Nitrides

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
B.2. Ion assisted resistive heating Physical Vapour Deposition (PVD) (Ion Plating)	Ceramics (19) and Low-expansion glasses (14)	Dielectric layers (15) Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
B.3. Physical Vapour Deposition (PVD): "Laser" Vaporization	Ceramics (19) and Low-expansion glasses (14)	Silicides Dielectric layers (15) Diamond-like carbon (17)
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Dielectric layers (15)
	Cemented tungsten carbide (16), Silicon carbide	Dielectric layers (15)
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Dielectric layers (15)
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon

TABLE - DEPOSITION TECHNIQUES

1.	Coating Process (1)	2. Substrate	3. Resultant Coating
B.4.	Physical Vapour Deposition (PVD): Cathodic Arc Discharge	"Superalloys"	Alloyed silicides Alloyed aluminides (2) MCrAlX (5)
		Polymers (11) and Organic "matrix" "composites"	Borides Carbides Nitrides Diamond-like carbon (17)
C.	Pack cementation (see A above for out-of-pack cementation) (10)	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Mixtures thereof (4)
		Titanium alloys (13)	Silicides Aluminides Alloyed aluminides (2)
		Refractory metals and alloys (8)	Silicides Oxides
D.	Plasma spraying	"Superalloys"	MCrAlX (5) Modified zirconia (12) Mixtures thereof (4) Abradable Nickel-Graphite Abradable materials containing Ni-Cr-Al Abradable Al-Si-Polyester Alloyed aluminides (2)
		Aluminium alloys (6)	MCrAlX (5) Modified zirconia (12) Silicides Mixtures thereof (4)
		Refractory metals and alloys (8)	Aluminides Silicides

Carbides

TABLE - DEPOSITION TECHNIQUES

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

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
F. (continued)	Titanium alloys (13)	Borides Nitrides Oxides Silicides Aluminides Alloyed aluminides (2) Carbides
	Carbon-carbon, Ceramic and Metal "matrix" "composites"	Silicides Carbides Refractory metals Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Cemented tungsten carbide (16), Silicon carbide (18)	Carbides Tungsten Mixtures thereof (4) Dielectric layers (15) Boron nitride
	Molybdenum and Molybdenum alloys	Dielectric layers (15)
	Beryllium and Beryllium alloys	Borides Dielectric layers (15) Beryllium
	Sensor window materials (9)	Dielectric layers (15) Diamond-like carbon (17)
	Refractory metals and alloys (8)	Aluminides Silicides Oxides Carbides

TABLE - DEPOSITION TECHNIQUES

1. Coating Process (1)	2. Substrate	3. Resultant Coating
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. The term 'mixtures thereof' includes infiltrated material, graded compositions, co-deposits and multilayer deposits and are obtained by one or more of the coating processes specified in the Table.

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

   a. CoCrAlY coatings which contain less than 22 weight percent of chromium, less than 7 weight percent of aluminium and less than 2 weight percent of yttrium;
   b. CoCrAlY coatings which contain 22 to 24 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.5 to 0.7 weight percent of yttrium; or
   c. NiCrAlY coatings which contain 21 to 23 weight percent of chromium, 10 to 12 weight percent of aluminium and 0.9 to 1.1 weight percent of yttrium.

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

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

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

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

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

TABLE - DEPOSITION TECHNIQUES - NOTES

10~~11.~~ 'Polymers', as follows: polyimide, polyester, polysulphide, polycarbonates and polyurethanes.

11.~~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.

12~~13.~~ 'Titanium alloys' refers only to aerospace alloys having an ultimate tensile strength of 900 MPa or more measured at 293 K (20°C).

13.~~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).

14.~~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.

15.~~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.

16.~~17.~~ "Technology" specially designed to deposit diamond-like carbon on any of the following is not required for review:
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.

17.~~18.~~ 'Silicon carbide' does not include cutting and forming tool materials.

18.~~19.~~ Ceramic substrates, as used in this entry, does not include ceramic materials containing 5% by weight, or greater, clay or cement content, either as separate constituents or in combination.

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

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

a. Chemical Vapour Deposition (CVD) is an overlay coating or surface modification coating process wherein a metal, alloy, "composite", dielectric or ceramic is deposited upon a heated substrate. Gaseous reactants are decomposed or combined in the vicinity of a substrate resulting in the deposition of the desired elemental, alloy or compound material on the substrate. Energy for this decomposition or chemical reaction process may be provided by the heat of the substrate, a glow discharge plasma, or "laser" irradiation.

N.B.1 CVD includes the following processes: directed gas flow out-of-pack deposition, pulsating CVD, controlled nucleation thermal deposition (CNTD), plasma enhanced or plasma assisted CVD processes.

N.B.2 Pack denotes a substrate immersed in a powder mixture.

N.B.3 The gaseous reactants used in the out-of-pack process are produced using the same basic reactions and parameters as the pack cementation process, except that the substrate to be coated is not in contact with the powder mixture.

b. Thermal Evaporation-Physical Vapour Deposition (TE-PVD) is an overlay coating process conducted in a vacuum with a pressure less than 0.1 Pa wherein a source of thermal energy is used to vaporize the coating material. This process results in the condensation, or deposition, of the evaporated species onto appropriately positioned substrates.

The addition of gases to the vacuum chamber during the coating process to synthesize compound coatings is an ordinary modification of the process.

The use of ion or electron beams, or plasma, to activate or assist the coating's deposition is also a common modification in this technique. The use of monitors to provide in-process measurement of optical characteristics and thickness of coatings can be a feature of these processes.

Specific TE-PVD processes are as follows:

1. Electron Beam PVD uses an electron beam to heat and evaporate the material which forms the coating;
2. Ion Assisted Resistive Heating PVD employs electrically resistive heating sources in combination with impinging ion beam(s) to produce a controlled and uniform flux of evaporated coating species;
3. "Laser" Vaporization uses either pulsed or continuous wave "laser" beams to vaporize the material which forms the coating;

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table - continued:

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

N.B. This definition does not include random cathodic arc deposition with non-biased substrates.

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

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

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

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

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

N.B.1 Low pressure means less than ambient atmospheric pressure.

N.B.2 High velocity refers to nozzle-exit gas velocity exceeding 750 m/s calculated at 293 K (20°C) at 0.1 MPa.

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

TABLE - DEPOSITION TECHNIQUES - TECHNICAL NOTE

Processes specified in Column 1 of the Table - continued:

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

N.B.1 The Table refers only to triode, magnetron or reactive sputter deposition which is used to increase adhesion of the coating and rate of deposition and to radio frequency (RF) augmented sputter deposition used to permit vaporisation of non-metallic coating materials.

N.B.2 Low-energy ion beams (less than 5keV) 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.

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

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

1. "Technology" for pretreatments of the substrates listed in the Table, as follows:

   a. Chemical stripping and cleaning bath cycle parameters, as follows:

      1. Bath composition

         a. For the removal of old or defective coatings, corrosion product or foreign deposits;
         b. For preparation of virgin substrates;

      2. Time in bath;

      3. Temperature of bath;

      4. Number and sequences of wash cycles;

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

   c. Heat treatment cycle parameters, as follows:

      1. Atmosphere parameters, as follows:

         a. Composition of the atmosphere;
         b. Pressure of the atmosphere;

      2. Temperature for heat treatment;

      3. Time of heat treatment;

   d. Substrate surface preparation parameters, as follows:

      1. Grit blasting parameters, as follows:

         a. Grit composition;
         b. Grit size and shape;
         c. Grit velocity;

      2. Time and sequence of cleaning cycle after grit blast;

      3. Surface finish parameters;

      4. Application of binders to promote adhesion;

   e. Masking technique parameters, as follows:

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

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

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 follow s:

         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;

TABLE - DEPOSITION TECHNIQUES - STATEMENT OF UNDERSTANDING

4. Coating composition;
5. Coating and substrates bonding;
6. Microstructural uniformity;

c. Criteria for optical properties assessment (measured as a function of wavelength):

1. Reflectance;
2. Transmission;
3. Absorption;
4. Scatter;

5. "Technology" and parameters related to specific coating and surface modification processes listed in the Table, as follows:

a. For Chemical Vapour Deposition (CVD):

1. Coating source composition and formulation;
2. Carrier gas composition;
3. Substrate temper ature;
4. Time-temperature-pressure cycles;
5. Gas control and part manipulation;

b. For Thermal Evaporation - Physical Vapour Deposition (PVD):

1. Ingot or coating material source composition;
2. Substrate temperature;
3. Reactive gas composition;
4. Ingot feed rate or material vaporisation rate;
5. Time-temperature-pressure cycles;
6. Beam and part manipulation;
7. "Laser" parameters, as follows:

a. Wave length;
b. Power density;
c. Pulse length;
d. Repetition ratio;
e. Source;

c. For Pack Cementation:

1. Pack composition and formulation;
2. Carrier gas composition;
3. Time-temperature-pressure cycles;

d. For Plasma Spraying:

1. Powder composition, preparation and size distributions;
2. Feed gas composition and parameters;
3. Substrate temperature;

4. Gun power parameters;
5. Spray distance;
6. Spray angle;
7. Cover gas composition, pressure and flow rates;
8. Gun control and part manipulation;

e. For Sputter Deposition:

1. Target composition and fabrication;
2. Geometrical positioning of part and target;
3. Reactive gas composition;
4. Electrical bias;
5. Time-temperature-pressure cycles;
6. Triode power;
7. Part manipulation;

f. For Ion Implantation:

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

g. For Ion Plating:

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

3. A. SYSTEMS, EQUIPMENT AND COMPONENTS

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

Note 2 *The ~~control~~review status of integrated circuits described in 3.A.1.a.3. to 3.A.1.a.9. or 3.A.1.a.12. which are unalterably programmed or designed for a specific function for another equipment is determined by the ~~control~~review status of the other equipment.*

N.B. *When the manufacturer or applicant cannot determine the ~~control~~ review status of the other equipment, the ~~control~~review status of the integrated circuits is determined in 3.A.1.a.3. to 3.A.1.a.9. and 3.A.1.a.12.*

If the integrated circuit is a silicon-based "microcomputer microcircuit" or microcontroller microcircuit described in 3.A.1.a.3. having an operand (data) word length of 8 bit or less, the ~~control~~ review status of the integrated circuit is determined in 3.A.1.a.3.

3. A. 1. Electronic components, as follows:

a. General purpose integrated circuits, as follows:

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

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

1. Integrated circuits, designed or rated as radiation hardened to withstand any of the following:

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

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

2. "Microprocessor microcircuits", "microcomputer microcircuits", microcontroller microcircuits, storage integrated circuits manufactured from a compound semiconductor, analogue-to-digital converters, digital-to-analogue converters, electro-optical or "optical integrated circuits" designed for "signal processing", field

programmable logic devices, neural network integrated circuits, custom integrated circuits for which either the function is unknown or the ~~control~~review status of the equipment in which the integrated circuit will be used is unknown, Fast Fourier Transform (FFT) processors, electrical erasable programmable read-only memories (EEPROMs), flash memories or static random-access memories (SRAMs), having any of the following:

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

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

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

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

a. A "composite theoretical performance" ("CTP") of 6,500 million theoretical operations per second (Mtops) or more and an arithmetic logic unit with an access width of 32 bit 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 that provides a direct external interconnection between parallel "microprocessor microcircuits" with a transfer rate exceeding 150 Mbyte/s;

4. 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 8bit or more, but less than 12 bit, with a total conversion time of less than 5 ns;
2. A resolution of 12 bit with a total conversion time of less than 200 ns; or
3. A resolution of more than 12 bit with a total conversion time of less than 2 µs;

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

Technical Note

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

6. Electro-optical and "optical integrated circuits" designed for "signal processing" having all of the following:

   a. One or more than one internal "laser" diode;
   b. One or more than one internal light detecting element; and
   c. Optical waveguides;

. 7. Field programmable logic devices having any of the following:

   a. An equivalent usable gate count of more than 30,000 (2 input gates);
   b. A typical "basic gate propagation delay time" of less than 0.4 ns; or
   c. A toggle frequency exceeding 133 MHz;

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

   N.B. Field programmable logic devices are also known as field programmable gate or field programmable logic arrays.

8. Not used.

9. Neural network integrated circuits;

10. Custom integrated circuits for which the function is unknown, or the ~~control~~review status of the equipment in which the integrated circuits will be used is unknown to the manufacturer, having any of the following:

   a. More than 1,000 terminals;
   b. A typical "basic gate propagation delay time" of less than 0.1 ns; or
   c. An operating frequency exceeding 3 GHz;

11. Digital integrated circuits, other than those described in 3.A.1.a.3 to 3.A.1.a.10. and 3.A.1.a.12., based upon any compound semiconductor and having any of the following:

    a. An equivalent gate count of more than 3000 (2 input gates); or
    b. A toggle frequency exceeding 1.2 GHz;

12. Fast Fourier Transform (FFT) processors having a rated execution time for an N-point complex FFT of less than (N $\log_2$ N)/20,480 ms, where N is the number of points;

    Technical Note
    When N is equal to 1,024 points, the formula in 3.A.1.a.12. gives an execution time of 500 µs.

b. Microwave or millimetre wave components, as follows:

1. Electronic vacuum tubes and cathodes, as follows:

   Note *3.A.1.b.1. does not ~~control~~ require review of tubes designed or rated for operation in any frequency band which meets all of the following characteristics:*
   a. Does not exceed 31 GHz; and
   b. Is "allocated by the ITU" for radio-communications services, but not for radio-determination.

   a. Travelling wave tubes, pulsed or continuous wave, as follows:

      1. Operating at frequencies exceeding 31 GHz;

      2. Having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;

      3. ~~3.~~ Coupled cavity tubes, or derivatives thereof, with a “fractional bandwidth” up to 7% and a peak power up to 2.5 kW~~;, with a "fractional bandwidth" of more than 7% or a peak power exceeding 2.5 kW~~;

      4. Coupled cavity tubes, or derivatives thereof, with a “fractional bandwidth” of more than 7% or a peak power exceeding 2.5 kW;

      5. Helix tubes, or derivatives thereof, with any of the following characteristics:

         a. An "instantaneous bandwidth" from half an octave through one octave, and average power (expressed in kW) times frequency (expressed in GHz) from 0.2 through 0.5;

b. An "instantaneous bandwidth" of half an octave or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than 0.4;

6.~~4.~~ Helix tubes, or derivatives thereof, with any of the following characteristics:

a. An "instantaneous bandwidth" of more than ~~one octave~~ one octave, and average power (expressed in kW) times frequency (expressed in GHz) of more than ~~0.5~~0.5;

b. An "instantaneous bandwidth" from half an octave through one octave, ~~of one octave~~ or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than ~~1~~1; or

c. Being"space qualified";

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

c. Impregnated cathodes designed for electronic tubes producing a continuous emission current density at rated operating conditions exceeding 5 A/cm²;

b. 2. Microwave integrated circuits or modules having all of the following:

a. Containing "monolithic integrated circuits" having one or more active circuit elements; and

b. Operating at frequencies exceeding 3 GHz;

Note 1 *3.A.1.b.2. does not ~~control~~require review of circuits or modules for equipment designed or rated for operation in any frequency band which meets all of the following characteristics:*

a. Does not exceed 31 GHz; and

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

Note 2 *3.A.1.b.2. does not ~~control~~ require review of broadcast satellite equipment designed or rated to operate in the frequency range of 40.5 to 42.5 GHz.*

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

4. Microwave solid state amplifiers, having any of the following:

a. Operating frequencies exceeding 10.5 GHz and an "instantaneous bandwidth" of more than half an octave; or
b. Operating 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 µs having any of the following:

a. A band-pass bandwidth of more than 0.5% of centre frequency; or
b. A band-stop bandwidth of less than 0.5% of centre frequency;

6. Microwave assemblies capable of operating at frequencies exceeding 31 GHz;

7. Mixers and converters designed to extend the frequency range of equipment described in 3.A.2.c., 3.A.2.e. or 3.A.2.f. beyond the limits stated therein;

8. Microwave power amplifiers containing tubes ~~controlled~~ for which review is required by 3.A.1.b. and having all of the following:

a. Operating frequencies above 3 GHz;
b. An average output power density exceeding 80 W/kg; and
c. A volume of less than 400 cm^3;

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

c. Acoustic wave devices, as follows, and specially designed components therefor:

1. Surface acoustic wave and surface skimming (shallow bulk) acoustic wave devices (i.e., "signal processing" devices employing elastic waves in materials), having any of the following:

a. A carrier frequency exceeding 2.5 GHz;

b. A carrier frequency exceeding 1 GHz, but not exceeding 2.5 GHz, and having any of the following:

1. A frequency side-lobe rejection exceeding 55 dB;
2. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
3. A bandwidth greater than 250 MHz; or
4. A dispersive delay of more than 10 µs; or

c. A carrier frequency of 1 GHz or less, having any of the following:

1. A product of the maximum delay time and the bandwidth (time in µs and bandwidth in MHz) of more than 100;
2. A dispersive delay of more than 10 µs; or
3. A frequency side-lobe rejection exceeding 55 dB and a bandwidth greater than 50 MHz;

2. Bulk (volume) acoustic wave devices (i.e., "signal processing" devices employing elastic waves) which permit the direct processing of signals at frequencies exceeding 1 GHz;

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

d. Electronic devices and circuits containing components, manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents, with any of the following:

1. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than 10^{-14} J; or

2. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000;

e. High energy devices, as follows:

1. Batteries and photovoltaic arrays, as follows:

Note *3.A.1.e.1. does not ~~control~~ require review of batteries with volumes equal to or less than 27 cm³ (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:

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

Note 3.A.1.e.3. does not ~~control~~require review of "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance Imaging (MRI) medical equipment.

3. 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 8T or "overall current density" in the winding of more than 300 A/mm^2;

f. Rotary input type shaft absolute position encoders having any of the following:

1. A resolution of better than 1 part in 265,000 (18 bit resolution) of full scale; or

2. An accuracy better than ± 2.5 seconds of arc.

g. Hydrogen/hydrogen-isotope thyratrons of ceramic-metal construction and rated for a peak current of 500 A or more.

3. A. 2. General purpose electronic equipment, as follows:

a. Recording equipment, as follows, and specially designed test tape therefor:

1. Analogue instrumentation magnetic tape recorders, including those permitting the recording of digital signals (e.g., using a high density digital recording (HDDR) module), having any of the following:

a. A bandwidth exceeding 4 MHz per electronic channel or track;
b. A bandwidth exceeding 2 MHz per electronic channel or track and having more than 42 tracks; or
c. A time displacement (base) error, measured in accordance with applicable IRIG or EIA documents, of less than ± 0.1 µs;

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

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

Note *3.A.2.a.2. does not ~~control~~require review of digital video magnetic tape recorders specially designed for television recording using a signal format, which may include a compressed signal format, standardised or recommended by the ITU, the IEC, the SMPTE, the EBU or the IEEE for civil television applications.*

3. Digital instrumentation magnetic tape data recorders employing helical scan techniques or fixed head techniques, having any of the following:

a. A maximum digital interface transfer rate exceeding 175 Mbit/s; or
b. Being "space qualified";

~~Note 3.A.2.a.3 does not control analogue magnetic tape recorders equipped with HDDR conversion electronics and configured to record only digital data.~~

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

. 5. Waveform digitisers and transient recorders having all of the following:

a. Digitising rates equal to or more than 200 million samples per second and a resolution of 10 bits or more; and
b. A continuous throughput of 2 Gbit/s or more;

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

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

c. "Signal analysers", as follows:

1. "Signal analysers" capable of analysing frequencies in the range from 4 through 31 GHz;

2.~~1.~~ "Signal analysers" capable of analysing frequencies exceeding 31 GHz;

3.~~2.~~ "Dynamic signal analysers" having a "real-time bandwidth" exceeding 500 kHz;

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

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

1. A maximum frequency in the range from 4 through 31 Ghz;

2.~~1~~ A maximum synthesised frequency exceeding 31 GHz;

3.~~2.~~ A "frequency switching time" from one selected frequency to another of less than 1 ms; or

4.~~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 3.A.2.d.2, 3.A.2.d.3, and 3.A.2.d.4 do~~es~~ not ~~control~~ require review of 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.

e. ~~e.~~ Network analysers with any of the following:

1. a maximum operating frequency from 4 through 40 GHz;

2. a maximum operating frequency exceeding 40 GHz;

f. Microwave test receivers having any ~~all~~ of the following:

1. A maximum operating frequency from 4 through 40 GHz; or

2. A maximum operating frequency exceeding 40 GHz.~~; and~~

~~2. Being capable of measuring amplitude and phase simultaneously;~~

g. Atomic frequency standards having any of the following:

1. Long-term stability (aging) less (better) than 1×10^{-11}/month; or

2. Being "space qualified..

Note 3.A.2.g.1. does not ~~control~~ require review of non-"space qualified" rubidium standards.

h. Radiation and radioisotope detection and simulation equipment, analysers, and Nuclear Instrumentation Module (NIM) componentry and mainframes.

3. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

3. B. 1. Equipment for the manufacturing of semiconductor devices or materials, as follows, and specially designed components and accessories therefor:

a. "Stored programme controlled" equipment designed for epitaxial growth, as follows:

1. Equipment capable of producing a layer thickness uniform to less than ± 2.5% across a distance of 75 mm or more;
2. Metal organic chemical vapour deposition (MOCVD) reactors specially designed for compound semiconductor crystal growth by the chemical reaction between materials ~~controlled~~ for which review is required by 3.C.3 or 3.C.4.;

3. Molecular beam epitaxial growth equipment using gas or solid sources;

b. "Stored programme controlled" equipment designed for ion implantation, having any of the following:

1. A beam energy (accelerating voltage) exceeding 1 MeV;
2. Being specially designed and optimised to operate at a beam energy (accelerating voltage) of less than 2 keV;
3. Direct write capability; or
4. Being capable of high energy oxygen implant into a heated semiconductor material "substrate";

c. "Stored programme controlled" anisotropic plasma dry etching equipment, as follows:

1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:

a. Designed or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or
b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

2. Equipment specially designed for equipment ~~controlled~~ for which review is required by 3.B.1.e. and having any of the following:

a. Designed or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or
b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

d. "Stored programme controlled" plasma enhanced CVD equipment, as follows:

1. Equipment with cassette-to-cassette operation and load-locks, and having any of the following:

a. Designed according to the manufacturer's specifications or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or
b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

2. Equipment specially designed for equipment ~~controlled~~ for which review is required by 3.B.1.e. and having any of the following:

a. Designed according to the manufacturer's specifications or optimised to produce critical dimensions of 0.3 µm or less with ±5% 3 sigma precision; or

b. Designed for generating less than 0.04 particles/cm^2 with a measurable particle size greater than 0.1 µm in diameter;

. e. "Stored programme controlled" automatic loading multi-chamber central wafer handling systems, having all of the following:

1. Interfaces for wafer input and output, to which more than two pieces of semiconductor processing equipment are to be connected; and
2. Designed to form an integrated system in a vacuum environment for sequential multiple wafer processing;

Note *3.B.1.e. does not ~~control~~ require review of automatic robotic wafer handling systems not designed to operate in a vacuum environment.*

f. "Stored programme controlled" lithography equipment, as follows:

1. Align and expose step and repeat (direct step on wafer) or step and scan (scanner) equipment for wafer processing using photo-optical or X-ray methods, having any of the following:

a. A light source wavelength shorter than 350 nm; or
b. Capable of producing a pattern with a minimum resolvable feature size of 0.5 µm or less;

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

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

where the K factor = 0.7.
MRF = minimum resolvable feature size.

2. Equipment specially designed for mask making or semiconductor device processing using deflected focussed electron beam, ion beam or "laser" beam, having any of the following:

a. A spot size smaller than 0.2 µm;
b. Being capable of producing a pattern with a feature size of less than 1 µm; or
c. An overlay accuracy of better than ± 0.20 µm (3 sigma);

g. Masks and reticles designed for integrated circuits ~~controlled~~ for which review is required by 3.A.1.;

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

3. B. 2. "Stored programme controlled" test equipment, specially designed for testing finished or unfinished semiconductor devices, as follows, and specially designed components and accessories therefor:

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 333 MHz;

Note *3.B.2.b. does not ~~control~~ require review of test equipment specially designed for testing:*
1. "Electronic assemblies" or a class of "electronic assemblies" for home or entertainment applications;
2. ~~Uncontrolled e~~Electronic components, "electronic assemblies" or integrated circuits for which review is not required;
3. Memories.

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

c. For testing microwave integrated circuits ~~controlled~~ for which review is required by 3.A.1.b.2.;

d. Equipment specially designed for the manufacture of electron tubes, optical elements and specially designed components therefor;

e. The following items specially designed for the manufacture, assembly, packaging, test, and design of semiconductor devices, integrated circuits, and assemblies with a minimum feature size of 1.0 micrometers:

1. Equipment and materials for plasma etch, chemical vapor deposition (CVD), lithography, mask lithography, masks, and photoresists;

2. Equipment specially designed for ion implantation, ion-enhanced or photo-enhanced diffusion, having any of the following characteristics:

a. Beam energy (accelerating voltage) exceeding 200 keV; *or*
b. Optimized to operate at a beam energy (accelerating voltage) of less than 10 keV.

3. Surface finishing equipment for the processing of semiconductor wafers as follows:

a. Specially designed equipment for backside processing of wafers thinner than 100 micrometers and the subsequent separation thereof; *or*

b. Specially designed equipment for achieving a surface roughness of the active surface of a processed wafer with a 2-sigma value of 2 micrometers or less, total indicator reading (TIR);

4. Equipment, other than general-purpose computers, specially designed for computer-aided design (CAD) of semiconductor devices or integrated circuits;

5. Equipment for the assembly of integrated circuits, as follows:

a. Stored program controlled die bonders having all of the following characteristics:

1. Specially designed for hybrid integrated circuits;
2. X-Y stage positioning travel exceeding 37.5 mm x 37.5 mm; *and*
3. Placement accuracy in the X-Y plane of finer than +/- 10 micrometers;

b. Stored program controlled equipment for producing multiple bonds in a single operation (e.g. beam lead bonders, chip carrier bonders, tape bonders)

c. Semiautomatic or hot cap sealers, in which the cap is heated locally to a higher temperature than the body of the package, specially designed for ceramic microcircuit packages and that have a throughput equal to or more than one package per minute;

3. C. MATERIALS

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

a. Silicon;

b. Germanium;

c. Silicon Carbide; or

d. III/V compounds of gallium or indium.

Technical Note
III/V compounds are polycrystalline or binary or complex monocrystalline products consisting of elements of groups IIIA and VA of Mendeleyev's periodic classification table (e.g., gallium arsenide, gallium-aluminium arsenide, indium phosphide).

3. C. 2. Resist materials, as follows, and "substrates" coated with resists for which review is required:

a. Positive resists designed for semiconductor lithography specially adjusted (optimised) for use at wavelengths below 350 nm ;

b. All resists designed for use with electron beams or ion beams, with a sensitivity of 0.01 µcoulomb/mm^2 or better;

c. All resists designed for use with X-rays, with a sensitivity of 2.5 mJ/mm^2 or better;

d. All resists optimised for surface imaging technologies, including silylated resists.

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

3. C. 3. Organo-inorganic compounds, as follows:

a. Organo-metallic compounds of aluminium, gallium or indium having a purity (metal basis) better than 99.999%;

b. Organo-arsenic, organo-antimony and organo-phosphorus compounds having a purity (inorganic element basis) better than 99.999%.

Note *3.C.3. only controls requires review of compounds whose metallic, partly metallic or non-metallic element is directly linked to carbon in the organic part of the molecule.*

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

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

3. D. SOFTWARE

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

3. D. 2. "Software" specially designed for the "use" of "stored programme controlled" equipment ~~controlled by~~ for which review is required by 3.B.

3. D. 3. Computer-aided-design (CAD) "software", having all of the following:

a. Designed for the "development" of semiconductor devices or integrated circuits; and

b. Designed to perform or use any of the following:

1. Design rules or circuit verification rules;
2. Simulation of the physically laid out circuits; or
3. Lithographic processing simulators for design.

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.

Note 1 *3.D.3. does not ~~control~~require review of "software" specially designed for schematic entry, logic simulation, placing and routing, layout verification or pattern generation tape.*

Note 2 *Libraries, design attributes or associated data for the design of semiconductor devices or integrated circuits are considered as "technology."*

3. D. 4. "Software" for the "development", "production", or "use" of Radiation and radioisotope detection and simulation equipment, analysers, and Nuclear Instrumentation Module (NIM) componentry and mainframes.

3. E. TECHNOLOGY

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

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

Note *3.E.1. and 3.E.2. do not ~~control~~require review of "technology" for the "development" or "production" of:*
a. Microwave transistors operating at frequencies below 31 GHz;
b. Integrated circuits ~~controlled~~ for which review is required by 3.A.1.a.3. to 3.A.1.a.12., having all of the following:
1. Using "technology" of 0.7 µm or more; and
2. Not incorporating multi-layer structures.

Technical Note

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

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

    a. Vacuum microelectronic devices;

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

    c. "Superconductive" electronic devices;

    d. Substrates of films of diamond for electronic components;

    e. Substrates of silicon-on-insulator (SOI) for integrated circuits in which the insulator is silicon dioxide;

    f. Substrates of silicon carbide for electronic components.

4. COMPUTERS

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

Note 2 Control units which directly interconnect the buses or channels of central processing units, "main storage" or disk controllers are not regarded as telecommunications equipment described in Category 5, Part 1 (Telecommunications).

N.B. For the ~~control~~review status of "software" specially designed for packet switching, see Category 5.D.1. (Telecommunications).

Note 3 Computers, related equipment and "software" performing cryptographic, cryptanalytic, certifiable multi-level security or certifiable user isolation functions, or which limit electromagnetic compatibility (EMC), must also be evaluated against the performance characteristics in Category 5, Part 2 ("Information Security").

4. A. SYSTEMS, EQUIPMENT AND COMPONENTS

1. Electronic computers and related equipment, as follows, and "electronic assemblies" and specially designed components therefor:

   a. Specially designed to have any of the following characteristics:

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

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

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

         a. Total Dose 5×10^3 Gy (Si);
         b. Dose Rate Upset 5×10^6 Gy (Si)/sec; or
         c. Single Event Upset 1×10^{-7} Error/bit/day;

   b. Having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security").

      Note *4.A.1.b. does not ~~control~~require review of electronic computers and related equipment when accompanying their user for the user's personal use.*

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

a. Containing "digital computers" ~~controlled~~ for which review is required by 4.A.3.;

b. Containing analogue-to-digital converters having all 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.

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

Note 1 *4.A.3. includes the following:*
a. Vector processors;
b. Array processors;
c. Digital signal processors;
d. Logic processors;
e. Equipment designed for "image enhancement";
f. Equipment designed for "signal processing."

Note 2 *The ~~control~~review status of the "digital computers" and related equipment described in 4.A.3 is determined by the ~~control~~review status of other equipment or systems provided:*
a. The "digital computers" or related equipment are essential for the operation of the other equipment or systems;
b. The "digital computers" or related equipment are not a "principal element" of the other equipment or systems; and
N.B.1 *The ~~control~~review 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~~review status of the other equipment even if it exceeds the "principal element" criterion.*
N.B.2 *For the ~~control~~review status of "digital computers" or related equipment for telecommunications equipment, see Category 5, Part 1 (Telecommunications).*
c. The "technology" for the "digital computers" and related equipment is determined by 4.E.

a. Designed or modified for "fault tolerance";

Note *For the purposes of 4.A.3.a., "digital computers" and related equipment are not considered to be designed or modified for "fault tolerance" if they utilise any of the following:*
1. Error detection or correction algorithms in "main storage";
2. The interconnection of two "digital computers" so that, if the active central processing unit fails, an idling but mirroring central processing unit can continue the system's functioning;

3. *The interconnection of two central processing units by data channels or by using shared storage to permit one central processing unit to perform other work until the second central processing unit fails, at which time the first central processing unit takes over in order to continue the system's functioning; or*
4. *The synchronisation of two central processing units by "software" so that one central processing unit recognises when the other central processing unit fails and recovers tasks from the failing unit.*

b. "Digital computers" having a "composite theoretical performance" ("CTP") exceeding 28,000 Mtops;

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

Note 1 *4.A.3.c. applies only to "electronic assemblies" and programmable interconnections not exceeding the limit in 4.A.3.b. when shipped as unintegrated "electronic assemblies". It does not apply to "electronic assemblies" inherently limited by nature of their design for use as related equipment ~~controlled~~ for which review is required by 4.A.3.d., or 4.A.3.e.*

Note 2 *4.A.3.c. does not ~~control~~require review of "electronic assemblies" specially designed for a product or family of products whose maximum configuration does not exceed the limit of 4.A.3.b.*

d. Graphics accelerators and graphics coprocessors exceeding a "three dimensional Vector Rate" of 200,000,000;

e. Equipment performing analogue-to-digital conversions exceeding the limits in 3.A.1.a.5;

f. Not used;

g. Equipment specially designed to provide external interconnection of "digital computers" or associated equipment which allows communications at data rates exceeding 1,25 Gbyte/s.

Note *4.A.3.g. does not ~~control~~require review of internal interconnection equipment (e.g., backplanes, buses), passive interconnection equipment, "network access controllers" or "communications channel controllers".*

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

a. "Systolic array computers";

b. "Neural computers";

c. "Optical computers".

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

4. C. MATERIALS – None

4. D. SOFTWARE

Note The ~~control~~review status of "software" for the "development", "production", or "use" of equipment described in other Categories is dealt with in the appropriate Category. The ~~control~~review status of "software" for equipment described in this Category is dealt with herein.

1. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" ~~controlled~~ for which review is required by 4.A. or 4.D.

2. "Software" specially designed or modified to support "technology" controlled for which review is required by 4.E.

3. Specific "software", as follows:

   a. Operating system "software", "software" development tools and compilers specially designed for "multi-data-stream processing" equipment, in "source code";

   b. Not used;

   c. "Software" having characteristics or performing functions exceeding the limits in Category 5, Part 2 ("Information Security");

   Note 4.D.3.c. does not ~~control~~require review of "software" when accompanying its user for the user's personal use.

   d. Operating systems specially designed for "real time processing" equipment which guarantees a "global interrupt latency time" of less than 20 µs.

4. E. TECHNOLOGY

1. "Technology" according to the General Technology Note, for the "development", "production" or "use" of equipment or "software" ~~controlled~~ for which review is required by 4.A. or 4.D.

TECHNICAL NOTE ON "COMPOSITE THEORETICAL PERFORMANCE" ("CTP")

Abbreviations used in this Technical Note

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

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

Outline of "CTP" calculation method

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

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

Details for these steps are given in the following sections.

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

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

TECHNICAL NOTE ON "CTP"

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

Step 1: The effective calculating rate R

For "CEs" Implementing: Note Every "CE" must be evaluated independently.	Effective calculating Rate, R
XP only (R xp)	$\frac{1}{3*(t_{xp\ add})}$ if no add is implemented use: $\frac{1}{(t_{xp\ mult})}$ If neither add nor multiply is implemented use the fastest available arithmetic operation as follows: $\frac{1}{3*t_{xp}}$ See Notes X & Z
FP only (R fp)	$\max \frac{1}{t_{fp\ add}}, \frac{1}{t_{fp\ mult}}$ See Notes X & Y
Both FP and XP (R)	Calculate both R xp, R fp
For simple logic processors not implementing any of the specified arithmetic operations.	$\frac{1}{3*t_{log}}$ Where t_{log} is the execute time of the XOR, or for logic hardware not implementing the XOR, the fastest simple logic operation. See Notes X & Z

For special logic processors not using any of the specified arithmetic or logic operations.	R = R' * WL/64 Where 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.

TECHNICAL NOTE ON "CTP"

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

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

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

"CEs" which perform different types of arithmetic or logic operations in a single machine cycle are to be treated as multiple separate "CEs" performing simultaneously (e.g., a "CE" performing an addition and a multiplication in one cycle is to be treated as two "CEs", the first performing an addition in one cycle and the second performing a multiplication in one cycle).
If a single "CE" has both scalar function and vector function, use the shorter execution time value.

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

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

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

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

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

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

TECHNICAL NOTE ON "CTP"

Note Z

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

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

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

Step 2: TP for each supported operand length WL

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

$$TP = R * L,$$
$$\text{where } L = (1/3 + WL/96)$$

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.

TECHNICAL NOTE ON "CTP"

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

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

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

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

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

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

Note 3 Simultaneous operations are assumed to exist when the computer manufacturer claims concurrent, parallel or simultaneous operation or execution in a manual or brochure for the computer.

Note 4 "CTP" values are not to be aggregated for "CE" combinations (inter)connected by "Local Area Networks", Wide Area Networks, I/O shared connections/devices, I/O controllers and any communication interconnection implemented by software.

TECHNICAL NOTE ON "CTP"

Note 5 "CTP" values must be aggregated for multiple "CEs" specially designed to enhance performance by aggregation, operating simultaneously and sharing memory,- or multiple memory/"CE"-combinations operating simultaneously utilising specially designed hardware.

This aggregation does not apply to "electronic assemblies" described in 4.A.3.c.

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

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:

$$C_2 = C_3 = C_4 = ... = C_n = 0.75$$

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

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

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

provided:

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

N.B. This does not apply to items ~~controlled~~ for which review is required 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.

TECHNICAL NOTE ON "CTP"

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

$C_i = 0.75 * k_i$ ($i = 2, \ldots, 32$) (see Note below)
$= 0.60 * k_i$ ($i = 33, \ldots, 64$)
$= 0.45 * k_i$ ($i = 65, \ldots, 256$)
$= 0.30 * k_i$ ($i > 256$)

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

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

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

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

$TP_1 \geq TP_2 \geq \ldots \geq TP_n$, and

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

$C_i \geq C_{i+1}$

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

Part 1 - TELECOMMUNICATIONS

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

Note 2 *"Digital computers", related equipment or "software", when essential for the operation and support of telecommunications equipment described in this Category, are regarded as specially designed components, provided they are the standard models customarily supplied by the manufacturer. This includes operation, administration, maintenance, engineering or billing computer systems.*

5. A. 1. SYSTEMS, EQUIPMENT AND COMPONENTS

a. Any type of telecommunications equipment having any of the following characteristics, functions or features:

1. Specially designed to withstand transitory electronic effects or electromagnetic pulse effects, both arising from a nuclear explosion;

2. Specially hardened to withstand gamma, neutron or ion radiation; or

3. Specially designed to operate outside the temperature range from 218 K (-55°C) to 397 K (124°C).~~*Note 5.A.1.a.3. applies only to electronic equipment.*~~

Note *5.A.1.a.2. ~~and 5.A.1.a.3.~~ does not ~~control~~require review of equipment designed or modified for use on board satellites.*

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

1. Being underwater communications systems having any of the following characteristics:

a. An acoustic carrier frequency outside the range from 20 kHz to 60 kHz;

b. Using an electromagnetic carrier frequency below 30 kHz; or

c. Using electronic beam steering techniques;

2. Being radio equipment operating in the 1.5 MHz to 87.5 MHz band and having any of the following characteristics:

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

b. Having all of the following:

1. Automatically predicting and selecting frequencies and "total digital transfer rates" per channel to optimise the transmission; and

2. Incorporating a linear power amplifier configuration having a capability to support multiple signals simultaneously at an output power of 1 kW or more in the 1.5 MHz to 30 MHz frequency range or 250 W or more in the 30 MHz 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;

3. Being radio equipment employing “spread spectrum” techniques, including “frequency hopping” techniques, having any of the following characteristics:

a. User programmable spreading codes; or

b. A total transmitted bandwidth which is 100 or more times the bandwidth of any one information channel and in excess of 50 kHz;

Note 5.A.1.b.3 does not require review of cellular telephone equipment conforming to the following standards: AMPS, NMT, TACS, TDMA, NADC, PDC, GSM, or IS-95 CDMA.

4. Being digitally controlled radio receivers having all of the following:

a. More than 1,000 channels;

b. A "frequency switching time" of less than 1 ms;

c. Automatic searching or scanning of a part of the electromagnetic spectrum; and

d. Identification of the received signals or the type of transmitter; or

Note 5.A.1.b.4. does not ~~control~~require review of radio equipment specially designed for use with civil cellular radio-communications systems.

5. Being radio relay communications equipment designed for use at frequencies of 7.9 through 10.55 GHz or exceeding 40 GHz and assemblies and components therefor;

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

c. Optical fibre ~~communication~~ cables of more than 5 m in length, drawn fibers of glass or other materials optimized for manufacture and use as optical telecommunications transmission medium, optical terminals and optical amplifiers.~~, optical fibres and accessories, as follows:~~

~~1. Optical fibres of more than 500 m in length, specified by the manufacturer as being capable of withstanding a proof test tensile stress of 2 x 10⁹ N/m² or more;~~

~~*Technical Note*~~

~~*Proof Test: on-line or off-line production screen testing that dynamically applies a prescribed tensile stress over a 0.5 to 3 m length of fibre at a running rate of 2 to 5 m/s while passing between capstans approximately 150 mm in diameter. The ambient temperature is a nominal 293 K and relative humidity 40%. Equivalent national standards may be used for executing the proof test.*~~

~~2. Optical fibre cables and accessories designed for underwater use.~~

~~*Note 5.A.1.c.2. does not control standard civil telecommunication cables and accessories.*~~

N.B.1 For underwater umbilical cables, and connectors therefor, see 8.A.2.a.3.

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

d. ~~"Electronically steerable p~~Phased array antennae, containing active elements and distributed components, and designed to permit electronic control of beam shaping and pointing, except for landing systems with instruments meeting ICAO standards (microwave landing systems (MLS)). ~~" operating above 31 GHz.~~

~~Note 5.A.1.d. does not control "electronically steerable phased array antennae" for landing systems with instruments meeting ICAO standards covering microwave landing systems (MLS).~~

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

a. Equipment and specially designed components or accessories therefor, specially designed for the "development", "production" or "use" of equipment, functions or features ~~controlled~~ for which review is required by Category 5 - Part 1.

Note 5.B.1.a. does not ~~control~~ require review of optical fibre characterization equipment not using semiconductor "lasers".

b. Equipment and specially designed components or accessories therefor, specially designed for the "development" of any of the following telecommunication transmission or "stored programme controlled" switching equipment:

1. Equipment employing digital techniques, including "Asynchronous Transfer Mode" ("ATM"), designed to operate at a "total digital transfer rate" exceeding 1.5 Gbit/s;

2. Equipment employing a "laser" and having any of the following:

   a. A transmission wavelength exceeding 1750 nm;

   b. Performing "optical amplification";

   c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques); or

   d. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

   Note *5.B.1.b.2.d. does not ~~control~~ require review of equipment specially designed for the "development" of commercial TV systems.*

3. Equipment employing "optical switching";

4. Radio equipment employing quadrature-amplitude-modulation (QAM) techniques above level 128; or

5. Equipment employing "common channel signalling" operating in either non-associated or quasi- associated mode of operation.

5. C. 1. MATERIALS - ~~None~~ Preforms of glass or other materials optimized for manufacture and use as optical telecommunications transmission medium.

5. D. 1. SOFTWARE

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment, functions or features ~~controlled~~ for which review is required by Category 5 - Part 1.

b. "Software" specially designed or modified to support "technology" controlled for which review is required by 5.E.1.

c. Specific "software" as follows:

   1. "Software" specially designed or modified to provide characteristics, functions or features of equipment ~~controlled~~ for which review is required by 5.A.1. or 5.B.1.;

   2. Not used;

   3. "Software", other than in machine-executable form, specially designed for "dynamic adaptive routing."

d. "Software" specially designed or modified for the "development" of any of the following telecommunication transmission or "stored programme controlled" switching equipment:

1. Equipment employing digital techniques, including "Asynchronous Transfer Mode" ("ATM"), designed to operate at a "total digital transfer rate" exceeding 1.5 Gbit/s;

2. Equipment employing a "laser" and having any of the following:

a. A transmission wavelength exceeding 1750 nm; or

b. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

Note 5.D.1.d.2.b. does not ~~contro~~require review ofl "software" specially designed or modified for the "development" of commercial TV systems.

3. Equipment employing "optical switching"; or

4. Radio equipment employing quadrature-amplitude-modulation (QAM) techniques above level 128.

5. E. 1. TECHNOLOGY

a. "Technology" according to the General Technology Note for the "development", "production" or "use" (excluding operation) of equipment, functions or features or "software" ~~controlled~~ for which review is required by Category 5 - Part 1.

b. Specific "technologies", as follows:

1. "Required" "technology" for the "development" or "production" of telecommunications equipment specially designed to be used on board satellites;

2. "Technology" for the "development" or "use" of "laser" communication techniques with the capability of automatically acquiring and tracking signals and maintaining communications through exoatmosphere or sub-surface (water) media;

3. "Technology" for the "development" of digital cellular radio systems;

4. "Technology" for the "development" of "spread spectrum" techniques, including "frequency hopping" techniques.

c. "Technology" according to the General Technology Note for the "development" or "production" of any of the following telecommunication transmission or "stored programme controlled" switching equipment, functions or features:

1. Equipment employing digital techniques, including "Asynchronous Transfer Mode" ("ATM"), designed to operate at a "total digital transfer rate" exceeding 1.5 Gbit/s;

2. Equipment employing a "laser" and having any of the following:

   a. A transmission wavelength exceeding 1750 nm;

   b. Performing "optical amplification" using praseodymium-doped fluoride fibre amplifiers (PDFFA);

   c. Employing coherent optical transmission or coherent optical detection techniques (also called optical heterodyne or homodyne techniques);

   d. Employing wavelength division multiplexing techniques exceeding 8 optical carriers in a single optical window; or

   e. Employing analogue techniques and having a bandwidth exceeding 2.5 GHz;

   Note 5.E.1.c.2.e. does not ~~control~~ require review of "technology" for the "development" or "production" of commercial TV systems.

3. Equipment employing "optical switching";

4. Radio equipment having any of the following:

   a. Quadrature-amplitude-modulation (QAM) techniques above level 128; or

   b. Operating at input or output frequencies exceeding 31 GHz; or

   Note 5.E.1.c.4.b. does not ~~control~~ require review of "technology" for the "development" or "production" of equipment designed or modified for operation in any frequency band which is "allocated by the ITU" for radio-communications services, but not for radio-determination.

5. Equipment employing "common channel signalling" operating in either non-associated or quasi-associated mode of operation.

Part 2 - "INFORMATION SECURITY"

Note 1 *The ~~control~~review status of "information security" equipment, "software", systems, application specific "electronic assemblies", modules, integrated circuits, components or functions is determined in Category 5, Part 2 even if they are components or "electronic assemblies" of other equipment.*

~~Note 2 Category 5 – Part 2 does not control products when accompanying their~~ user for the user's personal use*Note 32* *Cryptography Note*

5.A.2. and 5.D.2. do not ~~control~~require review of items that meet all of the following:

a. Generally available to the public by being sold, without restriction, from stock at retail selling points by means of any of the following:

1. Over-the-counter transactions;

2. Mail order transactions;

3. Electronic transactions; or

4. Telephone call transactions;

b. The cryptographic functionality cannot easily be changed by the user;

c. Designed for installation by the user without further substantial support by the supplier; and

d. Not used;

e. When necessary, details of the items are accessible and will be provided, upon request, to the appropriate authority in the exporter's country in order to ascertain compliance with conditions described in paragraphs a. to c. above.

Technical Note

In Category 5 - Part 2, parity bits are not included in the key length.

5. A. 2. SYSTEMS, EQUIPMENT AND COMPONENTS

a. Systems, equipment, application specific "electronic assemblies", modules and integrated circuits for "information security", as follows, and other specially designed components therefor:

N.B. *For the ~~control~~review status of global navigation satellite systems receiving equipment containing or employing decryption (i.e. GPS or GLONASS), see 7.A.5.*

1. Designed or modified to use "cryptography" employing digital techniques performing any cryptographic function ~~other than authentication or digital signature~~ having any of the following:

Technical Note

1. Authentication and digital signature functions include their ~~associated key management function.~~

~~*2. Authentication includes all aspects of access control where there is no encryption of files or text except as directly related to the*~~

~~*protection of passwords, Personal Identification Numbers (PINs) or similar data to prevent unauthorised access.*~~

~~*3.*~~ *"Cryptography" does not include "fixed" data compression or coding techniques.*

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

a. A "symmetric algorithm" ~~employing a key length in excess of~~ 56 bits; or

b. An "asymmetric algorithm" ~~where the security of the algorithm is based on any of the following:~~

~~1. Factorisation of integers in excess of 512 bits (e.g., RSA);~~

~~2. Computation of discrete logarithms in a multiplicative group of a finite field of size greater than 512 bits (e.g., Diffie-Hellman over Z/pZ); or~~

~~3. Discrete logarithms in a group other than mentioned in 5.A.2.a.1.b.2. in excess of 112 bits (e.g., Diffie-Hellman over an elliptic curve)~~;

2. Designed or modified to perform cryptanalytic functions;

3. Not used;

4. Specially designed or modified to reduce the compromising emanations of information-bearing signals beyond what is necessary for health, safety or electromagnetic interference standards;

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

6. Designed or modified to provide certified or certifiable "multilevel security" or user isolation at a level exceeding Class ~~B2~~C2 of the Trusted Computer System Evaluation Criteria (TCSEC) or equivalent;

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

8. Designed or modified to use analog encryption or scrambling techniques;

Note *5.A.2. does not ~~control~~require review of:*

a. "Personalised smart cards" where the cryptographic capability is restricted for use in equipment or systems excluded from

~~control~~review under entries b. to f. of this Note. If a "personalised smart card" has multiple functions, the ~~control~~review status of each function is assessed individually.

b. *Receiving equipment for radio broadcast, pay television or similar restricted audience broadcast of the consumer type, without digital encryption except that exclusively used for sending the billing or programme-related information back to the broadcast providers;*

c. *Equipment where the cryptographic capability is not user-accessible and which is specially designed and limited to allow any of the following:*
   1. *Execution of copy-protected software;*
   2. *Access to any of the following:*
      a. *Copy-protected contents stored on read-only media; or*
      b. *Information stored in encrypted form on media (e.g., in connection with the protection of intellectual property rights) when the media is offered for sale in identical sets to the public; or*
   3. *One-time copying of copyright protected audio/video data.*

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

Technical Note

'Money transactions' in 5.A.2. Note d. includes the collection and settlement of fares or credit functions.

e. *Portable or mobile radiotelephones for civil use (e.g., for use with commercial civil cellular radiocommunications systems) that are not capable of end-to-end encryption;*

f. *Cordless telephone equipment not capable of end-to-end encryption where the maximum effective range of unboosted cordless operation (i.e., a single, unrelayed hop between terminal and home basestation) is less than 400 metres according to the manufacturer's specifications.*

5. B. 2. TEST, INSPECTION AND PRODUCTION EQUIPMENT

a. Equipment specially designed for:

1. The "development" of equipment or functions ~~controlled~~ for which review is required by Category 5 - Part 2, including measuring or test equipment;

2. The "production" of equipment or functions ~~controlled~~for which review is required by Category 5 - Part 2, including measuring, test, repair or production equipment.

b. Measuring equipment specially designed to evaluate and validate the "information security" functions ~~controlled~~for which review is required by 5.A.2. or 5.D.2.

5. C. 2. MATERIALS - None

5. D. 2. SOFTWARE

a. "Software" specially designed or modified for the "development", "production" or "use" of equipment or "software" ~~controlled~~for which review is required by Category 5 - Part 2;

b. "Software" specially designed or modified to support "technology" ~~controlled~~for which review is required by 5.E.2.;

c. Specific "software", as follows:

1. "Software" having the characteristics, or performing or simulating the functions of the equipment ~~controlled~~for which review is required by 5.A.2. or 5.B.2.;

2. "Software" to certify "software" ~~controlled~~for which review is required by 5.D.2.c.1.

Note *5.D.2. does not ~~control~~require review of:*
a. "Software" required for the "use" of equipment excluded from ~~contro~~review under the Note to 5.A.2.;
b. "Software" providing any of the functions of equipment excluded from controreview l under the Note to 5.A.2.

5. E. 2. TECHNOLOGY

a. "Technology" according to the General Technology Note for the "development", "production" or "use" of equipment or "software" ~~controlled~~for which review is required by Category 5 - Part 2.

6. A. SYSTEMS, EQUIPMENT AND COMPONENTS

6. A. 1. ACOUSTICS

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

1. Active (transmitting or transmitting-and-receiving) systems, equipment and specially designed components therefor, as follows:
~~*Note 6.A.1.a.1. does not control:*~~
~~a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding ± 20°, and~~

~~limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;~~

~~b. Acoustic beacons, as follows:~~

~~1. Acoustic emergency beacons;~~

~~2. Pingers specially designed for relocating or returning to an underwater position.~~

a. Wide-swath bathymetric survey systems designed for sea bed topographic mapping, having all of the following:

1. Being designed to take measurements at an angle exceeding 20° from the vertical; ~~2. Being designed to measure depths exceeding 600 m below the water surface;~~ and

~~3~~2. Being designed to provide any of the following:

a. Incorporation of multiple beams any of which is less than 1.9°; or

b. Data accuracies of better than 0.3% of water depth across the swath averaged over the individual measurements within the swath;

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 µPa at 1 m) for equipment with an operating frequency in the band from 10 kHz to 24 kHz inclusive;

3. Sound pressure level exceeding 235 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band between 24 kHz and 30 kHz;

4. Forming beams of less than 1° on any axis and having an operating frequency of less than 100 kHz;

5. Designed to operate with an unambiguous display range exceeding 5,120 m; or

6. Designed to withstand pressure during normal operation at depths exceeding 1,000 m and having transducers with any of the following:

a. Dynamic compensation for pressure; or
b. Incorporating other than lead zirconate titanate as the transduction element;

c. Acoustic projectors, including transducers, incorporating piezoelectric, magnetostrictive, electrostrictive, electrodynamic or hydraulic elements operating individually or in a designed combination, having any of the following:

Note 1 The ~~control~~review status of acoustic projectors, including transducers, specially designed for other equipment is determined by the ~~control~~review status of the other equipment.

Note 2 6.A.1.a.1.c. does not ~~control~~require review of electronic sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosive) 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; or

Technical Note
Acoustic power density is obtained by dividing the output acoustic power by the product of the area of the radiating surface and the frequency of operation.

3. Side-lobe suppression exceeding 22 dB;

d. Acoustic systems, equipment and specially designed components for determining the position of surface vessels or underwater vehicles designed to operate at a range exceeding 1,000 m with a positioning accuracy of less than 10 m rms (root mean square) when measured at a range of 1,000 m;

Note 6.A.1.a.1.d. includes:
a. Equipment using coherent "signal processing" between two or more beacons and the hydrophone unit carried by the surface vessel or underwater vehicle;
b. Equipment capable of automatically correcting speed-of-sound propagation errors for calculation of a point.

2. Passive (receiving, whether or not related in normal application to separate active equipment) systems, equipment and specially designed components therefor, as follows:

a. Hydrophones having any of the following characteristics:

Note *The ~~control~~ review status of hydrophones specially designed for other equipment is determined by the ~~control~~review status of the other equipment.*

1. Incorporating continuous flexible sensors or assemblies of discrete sensor elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;

2. Having any of the following sensing elements:

   a. Optical fibres;
   b. Piezoelectric polymers; or
   c. Flexible piezoelectric ceramic materials;

3. A hydrophone sensitivity better than ~~-180~~ -220 dB at any depth with no acceleration compensation;

4. When designed to operate at depths exceeding 35 m with acceleration compensation; or

5. Designed for operation at depths exceeding 1,000 m;

Technical Note
Hydrophone sensitivity is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydrophone sensor, without a pre-amplifier, is placed in a plane wave acoustic field with an rms pressure of 1 µPa. For example, a hydrophone of -160 dB (reference 1V per µPa) would yield an output voltage of 10^{-8} V in such a field, while one of -220 dB sensitivity would yield only 10^{-11} V output. Thus, -160 dB is better than -220 dB.

b. Towed acoustic hydrophone arrays having any of the following:

1. Hydrophone group spacing of less than 12.5 m;

2. Designed or able to be modified to operate at depths exceeding ~~35~~ 15 m;

Technical Note

'Able to be modified' in 6.A.1.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. Heading sensors with an accuracy better than +/- 0.5 degrees;

controlled by 6.A.1.a.2.d.;

4. Longitudinally reinforced array hoses;

5. An assembled array of less than 40 mm in diameter;

6. Multiplexed hydrophone group signals designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; or

7. Hydrophone characteristics specified in 6.A.1.a.2.a.;

c. Processing equipment, specially designed for towed acoustic hydrophone arrays~~, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes~~;

d. Heading sensors with ~~having all of the following:~~
1. an accuracy of better than ± 0.5°. ~~Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m~~;

e. Bottom or bay cable systems having any of the following:

1. Incorporating hydrophones specified in 6.A.1.a.2.a.; or

2. Incorporating multiplexed hydrophone group signal modules having all of the following characteristics:

a. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; and

b. Capable of being operationally interchanged with towed acoustic hydrophone array modules;

f. Processing equipment, specially designed for bottom or bay cable systems~~, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes~~;

b. Correlation-velocity sonar log equipment designed to measure the horizontal speed of the equipment carrier relative to the sea~~ bed at distances between the carrier and the sea bed exceeding 500 m~~.

6. A. 2. OPTICAL SENSORS

a. Optical detectors, as follows:

Note 6.A.2.a. does not ~~control~~require review of germanium or silicon photodevices.

1. "Space-qualified" solid-state detectors, as follows:

a. "Space-qualified" solid-state detectors, having all of the following:

1. A peak response in the wavelength range exceeding 10 nm but not exceeding 300 nm; and

2. A response of less than 0.1% relative to the peak response at a wavelength exceeding 400 nm;

b. "Space-qualified" solid-state detectors, having all of the following:

1. A peak response in the wavelength range exceeding 900 nm but not exceeding 1,200 nm; and

2. A response "time constant" of 95 ns or less;

c. "Space-qualified" solid-state detectors having a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

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.~~1. A microchannel plate~~ for electron image amplification with a hole pitch (centre-to-centre spacing) of 15 µm or less~~; and

~~3.~~2. Photocathodes, as follows:

a. S-20, S-25 or multialkali photocathodes ~~with a luminous sensitivity exceeding 240 µA/lm~~;
b. GaAs or GaInAs photocathodes;
c. Other III-V compound semiconductor photocathodes;

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

b. Specially designed components, as follows:

1. Microchannel plates ~~having a hole pitch (centre to centre spacing) of 15 µm or less~~;
2. GaAs or GaInAs photocathodes;
3. Other III-V compound semiconductor photocathodes;

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

3. Non-"space-qualified" "focal plane arrays," as follows:

Technical Note
Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays".

Note 1 *6.A.2.a.3. includes photoconductive arrays and photovoltaic arrays.*

Note 2 *6.A.2.a.3. does not ~~control~~require review of:*
a. Silicon "focal plane arrays";
b. Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;
c. Pyroelectric detectors using any of the following:
1. Triglycine sulphate and variants;
2. Lead-lanthanum-zirconium titanate and variants;
3. Lithium tantalate;
4. Polyvinylidene fluoride and variants; or
5. Strontium barium niobate and variants.

a. Non-"space-qualified" "focal plane arrays," having all of the following:

1. Individual elements with a peak response within the wavelength range exceeding 900 nm but not exceeding 1,050 nm; and

2. A response "time constant" of less than 0.5 ns;

b. Non-"space-qualified" "focal plane arrays", having all of the following:

1. Individual elements with a peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,200 nm; and

2. A response "time constant" of 95 ns or less;

c. Non-"space-qualified" "focal plane arrays", having individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm.

b. "Monospectral imaging sensors" and "multispectral imaging sensors" designed for remote sensing applications, having any of the following:

1. An Instantaneous-Field-Of-View (IFOV) of less than 200 μr (microradians); or

2. Being specified for operation in the wavelength range exceeding 400 nm but not exceeding 30,000 nm and having all the following;

a. Providing output imaging data in digital format; and

b. Being any of the following:

1. "Space-qualified"; or
2. Designed for airborne operation, using other than silicon detectors, and having an IFOV of less than 2.5 mr (milliradians).

c. Direct view imaging equipment operating in the visible or infrared spectrum, incorporating any of the following:

1. Image intensifier tubes that utilize a microchannel plate (MCP) and an S-20, S-25, GaAs, or GaInAs photocathode ~~having the characteristics listed in 6.A.2.a.2.a~~; or

2. "Focal plane arrays" having the characteristics listed in 6.A.2.a.3.

Technical Note

'Direct view' refers to imaging equipment, operating in the visible or infrared spectrum, that presents a visual image to a human observer without converting the image into an electronic signal for television display, and that cannot record or store the image photographically, electronically or by any other means.

~~*Note 6.A.2.c. does not control the following equipment incorporating other than GaAs or GaInAs photocathodes:*~~

~~*a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;*~~

~~*b. Medical equipment;*~~

~~*c. Industrial equipment used for inspection, sorting or analysis*~~ *of the properties of materials;*

~~*d. Flame detectors for industrial furnaces;*~~

~~*e. Equipment specially designed for laboratory use.*~~

d. Special support components for optical sensors, as follows:

1. "Space-qualified" cryocoolers;

2. Non-"space-qualified" cryocoolers, having a cooling source temperature below 218 K (-55°C), as follows:

   a. Closed cycle type with a specified Mean-Time-To-Failure (MTTF), or Mean-Time-Between-Failures (MTBF), exceeding 2,500 hours;

   b. Joule-Thomson (JT) self-regulating minicoolers having bore (outside) diameters of less than 8 mm;

3. Optical sensing fibres specially fabricated either compositionally or structurally, or modified by coating, to be acoustically, thermally, inertially, electromagnetically or nuclear radiation sensitive.

e. "Space qualified" "focal plane arrays" having more than 2,048 elements per array and having a peak response in the wavelength range exceeding 300 nm but not exceeding 900 nm.

6. A. 3. CAMERAS

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

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

Note Instrumentation cameras, ~~controlled~~ for which review is required by 6.A.3.a.3. to 6.A.3.a.5., with modular structures should be *evaluated by their maximum capability, using plug-ins available according to the camera manufacturer's specifications.*

1. High-speed cinema recording cameras using any film format from 8 mm to 16 mm inclusive, in which the film is continuously advanced throughout the recording period, and that are capable of recording at framing rates exceeding 13,150 frames/s;

   Note *6.A.3.a.1. does not ~~control~~require review of cinema recording cameras designed for civil purposes.*

2. Mechanical high speed cameras, in which the film does not move, capable of recording at rates exceeding 1,000,000 frames/s for the full framing height of 35 mm film, or at proportionately higher rates for lesser frame heights, or at proportionately lower rates for greater frame heights;

3. Mechanical or electronic streak cameras having writing speeds exceeding 10 mm/µs;

4. Electronic framing cameras having a speed exceeding 1,000,000 frames/s;

5. Electronic cameras, having all of the following:

   a. An electronic shutter speed (gating capability) of less than 1 µs per full frame; and

   b. A read out time allowing a framing rate of more than 125 full frames per second.

6. Plug-ins, having all of the following characteristics:

   a. Specially designed for instrumentation cameras which have modular structures and ~~which are controlled~~ for which review is required by 6.A.3.a.; and

   b. Enabling these cameras to meet the characteristics specified in 6.A.3.a.3., 6.A.3.a.4. or 6.A.3.a.5., according to the manufacturer's specifications.

b. Imaging cameras, as follows:

   Note *6.A.3.b. does not ~~control~~require review of 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 x 10^6 "active pixels" per solid state array for monochrome (black and white) cameras;

b. More than 4 x 10^6 "active pixels" per solid state array for colour cameras incorporating three solid state arrays; or

c. More than 12 x 10^6 "active pixels" for solid state array colour cameras incorporating one solid state array;

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

2. Scanning cameras and scanning camera systems, having all of the following:

a. Linear detector arrays with more than 8,192 elements per array; and

b. Mechanical scanning in one direction;

3. Imaging cameras incorporating image intensifier tubes that utilize a microchannel plate (MCP) and an S-20, S-25, GaAs, or GaInAs photocathode ~~having the characteristics listed in 6.A.2.a.2.a.~~;

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

Note *6.A.3.b.4 does not ~~control~~require review of imaging cameras incorporating linear "focal plane arrays" with twelve elements or fewer, not employing time-delay-and-integration within the element, designed for any of the following:*
a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
b. Industrial equipment used for inspection or monitoring of heat flows in buildings, equipment or industrial processes;
c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
d. Equipment specially designed for laboratory use; or
e. Medical equipment.

6. A. 4. OPTICS

a. Optical mirrors (reflectors), as follows:

1. "Deformable mirrors" having either continuous or multi-element surfaces, and specially designed components therefor, capable of

dynamically repositioning portions of the surface of the mirror at rates exceeding 100 Hz;

2. Lightweight monolithic mirrors having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 10 kg;

3. Lightweight "composite" or foam mirror structures having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 2 kg;

4. Beam steering mirrors more than 100 mm in diameter or length of major axis, which maintain a flatness of lambda/2 or better (lambda is equal to 633 nm) having a control bandwidth exceeding 100 Hz.

b. Optical components made from zinc selenide (ZnSe) or zinc sulphide (ZnS) with transmission in the wavelength range exceeding 3,000 nm but not exceeding 25,000 nm and having any of the following:

1. Exceeding 100 cm^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. Raw substrates, processed substrates having surface coatings (single-layer or multi-layer, metallic or dielectric, conducting, semiconducting or insulating) or having protective films;

3. Segments or assemblies of mirrors designed to be assembled in space into an optical system with a collecting aperture equivalent to or larger than a single optic 1 m in diameter;

4. Manufactured from "composite" materials having a coefficient of linear thermal expansion equal to or less than 5×10^{-6} in any coordinate direction.

d. Optical control equipment, as follows:

1. Specially designed to maintain the surface figure or orientation of the "space-qualified" components ~~controlled by~~ for which review is required by 6.A.4.c.1. or 6.A.4.c.3.;

2. Having steering, tracking, stabilisation or resonator alignment bandwidths equal to or more than 100 Hz and an accuracy of 10 µr (microradians) or less;

3. Gimbals having all of the following:

   a. A maximum slew exceeding 5°;

   b. A bandwidth of 100 Hz or more;
   c. Angular pointing errors of 200 µr (microradians) or less; and

   d. Having any of the following:

      1. Exceeding 0.15 m but not exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 2 r (radians)/s^2; or
      2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 r (radians)/s^2;

4. Specially designed to maintain the alignment of phased array or phased segment mirror systems consisting of mirrors with a segment diameter or major axis length of 1 m or more.

e. Aspheric optical elements having all of the following characteristics:

1. The largest dimension of the optical-aperture is greater than 400 mm;

2. The surface roughness is less than 1 nm (rms) for sampling lengths equal to or greater than 1 mm; and

3. The coefficient of linear thermal expansion's absolute magnitude is less than $3x10^{-6}$/K at 25 ° C;

Technical Notes
1. *An 'aspheric optical element' is any element used in an optical system whose imaging surface or surfaces are designed to depart from the shape of an ideal sphere.*
2. *Manufacturers are not required to measure the surface roughness listed in 6.A.4.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the ~~control~~ review parameter.*

Note 6.A.4.e. does not ~~control~~require review of aspheric optical elements having any of the following:*
a. A largest optical-aperture dimension less than 1 m and a focal length to aperture ratio equal to or greater than 4.5:1;

b. A largest optical-aperture dimension equal to or greater than 1 m and a focal length to aperture ratio equal to or greater than 7:1;
c. Being designed as Fresnel, flyeye, stripe, prism or diffractive optical elements;
d. Being fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than $2.5x10^{-6}$ /K at 25 °C; or
e. Being an x-ray optical element having inner mirror capabilities (e.g. tube-type mirrors).

N.B. For aspheric optical elements specially designed for lithography equipment, see Item 3.B.1.

6. A. 5. LASERS

"Lasers," components and optical equipment, as follows:

Note 1 Pulsed "lasers" include those that run in a continuous wave (CW) mode with pulses superimposed.
Note 2 Pulse-excited "lasers" include those that run in a continuously excited mode with pulse excitation superimposed.
Note 3 The ~~control~~review 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 having any of the following:

1. An output energy exceeding 50 mJ per pulse; or
2. An average output power exceeding 1 W;

b. An output wavelength exceeding 150 nm but not exceeding 190 nm and having any of the following:

1. An output energy exceeding 1.5 J per pulse; or
2. An average output power exceeding 120 W;

c. An output wavelength exceeding 190 nm but not exceeding 360 nm and having any of the following:

1. An output energy exceeding 10 J per pulse; or
2. An average output power exceeding 500 W; or

d. An output wavelength exceeding 360 nm and having any of the following:

1. An output energy exceeding 1.5 J per pulse; or
2. An average output power exceeding 30 W;

N.B. *For excimer "lasers" specially designed for lithography equipment, see 3.B.1.*

2. Metal vapour "lasers", as follows:

a. Copper (Cu) "lasers" having an average output power exceeding 20 W;

b. Gold (Au) "lasers" having an average output power exceeding 5 W;

c. Sodium (Na) "lasers" having an output power exceeding 5 W;

d. Barium (Ba) "lasers" having an average output power exceeding 2 W;

3. Carbon monoxide (CO) "lasers" having any of the following:

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 15 kW;

b. A pulsed output having a "pulse duration" exceeding 10 µs and having any of the following:

1. An average output power exceeding 10 kW; or
2. A pulsed "peak power" exceeding 100 kW; or

c. A pulsed output having a "pulse duration" equal to or less than 10 µs; and having any of the following:

1. A pulse energy exceeding 5 J per pulse; 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", as follows:

      1. Oxygen Iodine (O_2-I) "lasers";
      2. Deuterium Fluoride-Carbon dioxide (DF-CO_2) "lasers";

6. Krypton ion or argon ion "lasers" having any of the following:

   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;

7. Other gas "lasers", having any of the following:

   Note *6.A.5.a.7. does not ~~control~~require review of nitrogen "lasers".*

   a. An output wavelength not exceeding 150 nm and having any of the following:

      1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      2. An average or CW output power exceeding 1 W;

   b. An output wavelength exceeding 150 nm but not exceeding 800 nm and having any of the following:

      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 having any of the following:

      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 1,400 nm and an average or CW output power exceeding 1 W.

b. Semiconductor "lasers", as follows:

1. Individual single-transverse mode semiconductor "lasers", having all of the following:
   a. A wavelength of less than 950 nm or more than 2000 nm; and

   b. An average or CW output power exceeding 100 mW;

2. Individual, multiple-transverse mode semiconductor "lasers" having all of the following:

   a. A wavelength of less than 950 nm or more than 2000 nm; and

   b. An average or CW output power exceeding 10 W.

3. Individual arrays of individual semiconductor "lasers", having any of the following:

   a. A wavelength of less than 950 nm and an average or CW output power exceeding 60 W; or

   b. A wavelength equal to or greater than 2000 nm and an average or CW output power exceeding 10 W;

Technical Note
Semiconductor "lasers" are commonly called "laser" diodes.

Note 1 *6.A.5.b. includes semiconductor "lasers" having optical output connectors (e.g. fibre optic pigtails).*

Note 2 The ~~control~~review status of semiconductor "lasers" specially designed for other equipment is determined by the ~~control~~ review status of the other equipment.

c. Solid state "lasers", as follows:

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

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

   a. An output wavelength less than 600 nm and having any of the following:

      1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      2. An average or CW output power exceeding 1 W;

b. An output wavelength of 600 nm or more but not exceeding 1,400 nm and having any of the following:

1. An output energy exceeding 1 J per pulse and a pulsed "peak power" exceeding 20 W; or
2. An average or CW output power exceeding 20 W; or

c. An output wavelength exceeding 1,400 nm and having any of the following:

1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
2. An average or CW output power exceeding 1 W;

2. Non-"tunable" "lasers", as follows:

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

a. Neodymium glass "lasers", as follows:

1. "Q-switched lasers" having any of the following:

a. An output energy exceeding 20 J but not exceeding 50 J per pulse and an average output power exceeding 10 W; or
b. An output energy exceeding 50 J per pulse;

2. Non-"Q-switched lasers" having any of the following:

a. An output energy exceeding 50 J but not exceeding 100 J per pulse and an average output power exceeding 20 W; or
b. An output energy exceeding 100 J per pulse;

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

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

1. Pulse-excited, mode-locked, "Q-switched lasers" having a "pulse duration" of less than 1 ns and having any of the following:

a. A "peak power" exceeding 5 GW;
b. An average output power exceeding 10 W; or
c. A pulsed energy exceeding 0.1 J;

2. Pulse-excited, "Q-switched lasers" having a pulse duration equal to or more than 1ns, and having any of the following:

   a. A single-transverse mode output having:
      1. A "peak power" exceeding 100 MW;
      2. An average output power exceeding 20 W; or
      3. A pulsed energy exceeding 2 J; or

   b. A multiple-transverse mode output having:

      1. A "peak power" exceeding 400 MW;
      2. An average output power exceeding 2 kW; or
      3. A pulsed energy exceeding 2 J;

3. Pulse-excited, non-"Q-switched lasers", having:

   a. A single-transverse mode output having:

      1. A "peak power" exceeding 500 kW; or
      2. An average output power exceeding 150 W; or

   b. A multiple-transverse mode output having:

      1. A "peak power" exceeding 1 MW; or
      2. An average power exceeding 2 kW;

4. Continuously excited "lasers" having:

   a. A single-transverse mode output having:

      1. A "peak power" exceeding 500 kW; or
      2. An average or CW output power exceeding 150 W; or

   b. A multiple-transverse mode output having:

      1. A "peak power" exceeding 1 MW; or
      2. An average or CW output power exceeding 2 kW;

c. Other non-"tunable" "lasers", having any of the following:

1. A wavelength less than 150 nm and having any of the following:

   a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:

a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or

b. An average or CW output power exceeding 30 W;

3. A wavelength exceeding 800 nm but not exceeding 1,400 nm, as follows:

a. "Q-switched lasers" having:

1. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 50 W; or

2. An average output power exceeding:

a. 10 W for single-transverse mode "lasers";
b. 30 W for multiple-transverse mode "lasers";

b. Non-"Q-switched lasers" having:

1. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 50 W; or

2. An average or CW output power exceeding 50 W; or

4. A wavelength exceeding 1,400 nm and having any of the following:

a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

d. Dye and other liquid "lasers", having any of the following:

1. A wavelength less than 150 nm and:

a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:

   a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 20 W;

   b. An average or CW output power exceeding 20 W; or

   c. A pulsed single longitudinal mode oscillator having an average output power exceeding 1 W and a repetition rate exceeding 1 kHz if the "pulse duration" is less than 100 ns;

d. 3. A wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:

   a. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 10 W; or
   b. An average or CW output power exceeding 10 W; or

4. A wavelength exceeding 1,400 nm and having any of the following:

   a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
   b. An average or CW output power exceeding 1 W;

5. "Lasers" with an output power of 100 mW or greater.

e. Components, as follows:

1. Mirrors cooled either by active cooling or by heat pipe cooling;

Technical Note
Active cooling is a cooling technique for optical components using flowing fluids within the subsurface (nominally less than 1 mm below the optical surface) of the optical component to remove heat from the optic.

2. Optical mirrors or transmissive or partially transmissive optical or electro-optical components specially designed for use with ~~controlled~~ "lasers" for which review is required;

f. Optical equipment, as follows:

1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront having any of the following:

   a. Frame rates equal to or more than 100 Hz and phase discrimination of at least 5% of the beam's wavelength; or

b. Frame rates equal to or more than 1,000 Hz and phase discrimination of at least 20% of the beam's wavelength;

2. "Laser" diagnostic equipment capable of measuring "SHPL" system angular beam steering errors of equal to or less than 10 µrad;

3. Optical equipment and components specially designed for a phased-array "SHPL" system for coherent beam combination to an accuracy of lambda/10 at the designed wavelength, or 0.1 µm, whichever is the smaller;

4. Projection telescopes specially designed for use with "SHPL" systems.

6. A. 6. MAGNETOMETERS

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

Note *6.A.6. does not ~~control~~require review of instruments specially designed for biomagnetic measurements for medical diagnostics.*

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 any of the following:

1. 0.05 nT rms/square root Hz at frequencies of less than 1 Hz;
2. 1×10^{-3} nT rms/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; or
3. 1×10^{-4} nT rms/square root Hz at frequencies exceeding 10 Hz;

c. Fibre optic "magnetometers" having a "noise level" (sensitivity) lower (better) than 1 nT rms per square root Hz;

d. "Magnetic gradiometers" using multiple "magnetometers" ~~controlled by~~ for which review is required by 6.A.6.a., 6.A.6.b. or 6.A.6.c.;

e. Fibre optic "intrinsic magnetic gradiometers" having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.3 nT/m rms per square root Hz;

f. "Intrinsic magnetic gradiometers", using "technology" other than fibre-optic "technology", having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.015 nT/m rms per square root Hz;

g. Magnetic compensation systems for magnetic sensors designed for operation on mobile platforms;

h. "Superconductive" electromagnetic sensors, containing components manufactured from "superconductive" materials and having all of the following:

1. Being designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents (including Josephson effect devices or "superconductive" quantum interference devices (SQUIDS));

2. Being designed for sensing electromagnetic field variations at frequencies of 1 kHz or less; and:

3. Having any of the following characteristics:

a. Incorporating thin-film SQUIDS with a minimum feature size of less than 2µm and with associated input and output coupling circuits;
b. Designed to operate with a magnetic field slew rate exceeding 1 x 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.

6. A. 7 GRAVIMETERS

Gravity meters (gravimeters) and gravity gradiometers, as follows:

a. Gravity meters designed or modified for ground use having a static accuracy of less (better) than 10 µgal;

Note *6.A.7.a. does not ~~control~~require review of ground gravity meters of the quartz element (Worden) type.*

b. Gravity meters designed for mobile platforms, having all of the following:

1. A static accuracy of less (better) than 0.7 mgal; and
2. An in-service (operational) accuracy of less (better) than 0.7 mgal having a time-to-steady-state registration of less than 2 minutes under any combination of attendant corrective compensations and motional influences;

c. Gravity gradiometers.

6. A. 8. RADAR

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

Note *6.A.8. does not ~~control~~require review of:*
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. All airborne radar equipment and specially designed components therefor, not including radars specially designed for meteorological use or Mode 3, Mode C. or Mode S civilian air traffic control equipment specially designed to operate only in the 960-1215 MHz band;

Note: This entry does not require initial review of airborne radar equipment installed as original equipment in civil-certified aircraft operating in Iraq.

b. All ground-based primary radar systems that are capable of aircraft detection and tracking;

c.~~a~~ Operating at frequencies from 40 GHz to 230 GHz and having an average output power exceeding 100 mW;

d.~~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.

e.~~c.~~ Capable of operating simultaneously on more than two carrier frequencies;

f.~~d~~. Capable of operating in synthetic aperture (SAR), inverse synthetic aperture (ISAR) radar mode, or sidelooking airborne (SLAR) radar mode;

g.~~e.~~ Incorporating "electronically steerable phased array antennae";

h.~~f.~~ Capable of heightfinding non-cooperative targets;

Note *6.A.8.h. does not ~~control~~require review of precision approach radar (PAR) equipment conforming to ICAO standards.*

i.~~g.~~ Specially designed for airborne (balloon or airframe mounted) operation and having Doppler "signal processing" for the detection of moving targets;

j.~~h.~~ Employing processing of radar signals using any of the following:

1. "Radar spread spectrum" techniques; or
2. "Radar frequency agility" techniques;

k.~~i. Providing ground-based operation with a maximum "instrumented range" exceeding 185 km;~~

~~*Note 6.A.8.i. does not control:*~~

~~*a. Fishing ground surveillance radar;*~~

~~*b. Ground radar equipment specially designed for enroute air traffic control, provided that all the following conditions are met:*~~

~~*1. It has a maximum "instrumented range" of 500 km or less;*~~

~~*2. It is configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres;*~~

~~*3. It contains no provisions for remote control of the radar scan rate from the enroute ATC centre; and*~~

~~*4. It is to be permanently installed.*~~

~~*c. Weather balloon tracking radars.*~~

Being "laser" radar or Light Detection and Ranging (LIDAR) equipment, having any of the following:

1. "Space-qualified"; or
2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 µr (microradians);

Note 6.A.8.k. does not ~~control~~ require review of LIDAR equipment specially designed for surveying or for meteorological observation.

l. Having "signal processing" sub-systems using "pulse compression," with any of the following:

1. A "pulse compression" ratio exceeding 150; or

2. A pulse width of less than 200 ns; or

m. Having data processing sub-systems with any of the following:

1. "Automatic target tracking" providing, at any antenna rotation, the predicted target position beyond the time of the next antenna beam passage;

Note 6.A.8.m.1. does not ~~control~~require review of 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 6.A.8.m.4. does not ~~control~~require review of systems, equipment and assemblies used for marine traffic control.

9. Non-X-ray explosive detection equipment.

6. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

6. B. 1. ACOUSTICS - None

6. B. 2. OPTICAL SENSORS - None

6. B. 3. CAMERAS - None

6. B. 4. OPTICS

Optical equipment, as follows:

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 6.B.4. does not ~~control~~require review of microscopes.

6. B. 5. LASERS - None

6. B. 6. MAGNETOMETERS - None

6. B. 7. GRAVIMETERS

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

6. B. 8 RADAR

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

6. C. MATERIALS

6. C. 1. ACOUSTICS - None

6. C. 2. OPTICAL SENSORS

Optical sensor materials, as follows:

a. Elemental tellurium (Te) of purity levels of 99.9995% or more;

b. Single crystals (including epitaxial wafers) of any of the following:

1. Cadmium zinc telluride with zinc content of less than 6% by mole fraction;
2. Cadmium telluride (CdTe) of any purity level; or
3. Mercury cadmium telluride (HgCdTe) of any purity level.

Technical Note
Mole fraction is defined as the ratio of moles of ZnTe to the sum of the moles of CdTe and ZnTe present in the crystal.

6. C. 3. CAMERAS - None

6. C. 4 OPTICS

Optical materials, as follows:

a. Zinc selenide (ZnSe) and zinc sulphide (ZnS) "substrate blanks" produced by the chemical vapour deposition process, having any of the following:

1. A volume greater than 100 cm^3; or
2. A diameter greater than 80 mm having a thickness of 20 mm or more;

b. Boules of the following electro-optic materials:

1. Potassium titanyl arsenate (KTA);
2. Silver gallium selenide ($AgGaSe_2$);
3. Thallium arsenic selenide (Tl_3AsSe_3, also known as TAS);

c. Non-linear optical materials, having all of the following:

1. Third order susceptibility (chi 3) of 10^{-6} m^2/V^2 or more; and
2. A response time of less than 1 ms;

d. "Substrate blanks" of silicon carbide or beryllium beryllium (Be/Be) deposited materials exceeding 300 mm in diameter or major axis length;

e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride (ZrF_4) and hafnium fluoride (HfF_4), having all of the following:

1. A hydroxyl ion (OH^-) concentration of less than 5 ppm;
2. Integrated metallic purity levels of less than 1 ppm; and
3. High homogeneity (index of refraction variance) less than 5×10^{-6};

f. Synthetically produced diamond material with an absorption of less than 10^{-5} cm^{-1} for wavelengths exceeding 200 nm but not exceeding 14,000 nm.

6. C. 5. LASERS

Synthetic crystalline "laser" host material in unfinished form, as follows:

a. Titanium doped sapphire;
b. Alexandrite.

6. C. 6. MAGNETOMETERS - None

6. C. 7. GRAVIMETERS - None

6. C. 8. RADAR - None.

6. D. SOFTWARE

1. "Software" specially designed for the "development" or "production" of equipment ~~controlled~~ for which review is required by 6.A.2, 6.A.3, 6.A.4, 6.A.5., 6.A.8 or 6.B.8.

2. "Software" specially designed for the "use" of equipment ~~controlled~~ for which review is required by 6.A.2.b., 6.A.8 or 6.B.8.

3. Other "software", as follows:

a. ACOUSTICS

"Software," as follows:

1. "Software" specially designed for acoustic beam forming for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;

2. "Source code" for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;

3. "Software" specially designed for acoustic beam forming for the "real time processing" of acoustic data for passive reception using bottom or bay cable systems;

4. "Source code" for the "real time processing" of acoustic data for passive reception using bottom or bay cable systems;

. b. OPTICAL SENSORS - None

c. CAMERAS - None

d. OPTICS - None

e. LASERS - None

f. MAGNETOMETERS

"Software", as follows:

1. "Software" specially designed for magnetic compensation systems for magnetic sensors designed to operate on mobile platforms;

2. "Software" specially designed for magnetic anomaly detection on mobile platforms;

g. GRAVIMETERS

"Software" specially designed to correct motional influences of gravity meters or gravity gradiometers;

h RADAR

"Software," as follows:

1. Air Traffic Control "software" application "programmes" hosted on general purpose computers located at Air Traffic Control centres and capable of any of the following:

   a. Processing and displaying more than 150 simultaneous "system tracks"; or
   b. Accepting radar target data from more than four primary radars;

2. "Software" for the design or "production" of radomes which:

   a. Are specially designed to protect the "electronically steerable phased array antennae" ~~controlled~~ for which review is required by 6.A.8.e.; and
   b. Result in an antenna pattern having an 'average side lobe level' more than 40 dB below the peak of the main beam level.

   Technical Note
   'Average side lobe level' in 6.D.3.h.2.b. is measured over the entire array excluding the angular extent of the main beam and the first two side lobes on either side of the main beam.

6. E. TECHNOLOGY

6. E. 1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" ~~controlled by~~ for which review is required by 6.A., 6.B., 6.C. or 6.D.

6. E. 2. "Technology" according to the General Technology Note for the "production" of equipment or materials ~~controlled by~~for which review is required by 6.A., 6.B. or 6.C.

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

a. ACOUSTICS - None

b. OPTICAL SENSORS - None

c. CAMERAS - None

d. OPTICS

"Technology," as follows:

1. Optical surface coating and treatment "technology" "required" to achieve uniformity of 99.5% or better for optical coatings 500 mm or more in diameter or major axis length and with a total loss (absorption and scatter) of less than 5×10^{-3};
   N.B. See also 2.E.3.f.

2. Optical fabrication "technology" using single point diamond turning techniques to produce surface finish accuracies of better than 10 nm rms on non-planar surfaces exceeding $0.5\ m^2$;

e. LASERS

"Technology" "required" for the "development", "production" or "use" of specially designed diagnostic instruments or targets in test facilities for "SHPL" testing or testing or evaluation of materials irradiated by "SHPL" beams;

f. MAGNETOMETERS

"Technology" "required" for the "development" or "production" of fluxgate "magnetometers" or fluxgate "magnetometer" systems, having any of the following:

1. A "noise level" of less than 0.05 nT rms per square root Hz at frequencies of less than 1 Hz; or

2. A "noise level" of less than 1×10^{-3} nT rms per square root Hz at frequencies of 1 Hz or more.

g. GRAVIMETERS - None

h. RADAR - None

6. A. SYSTEMS, EQUIPMENT AND COMPONENTS

6. A. 1. ACOUSTICS

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

1. Active (transmitting or transmitting-and-receiving) systems, equipment and specially designed components therefor, as follows:
~~*Note 6.A.1.a.1. does not control:*~~
~~a. Depth sounders operating vertically below the apparatus, not including a scanning function exceeding ± 20°, and limited to measuring the depth of water, the distance of submerged or buried objects or fish finding;~~
~~b. Acoustic beacons, as follows:~~
~~1. Acoustic emergency beacons;~~
~~2. Pingers specially designed for relocating or returning to an underwater position.~~

a. Wide-swath bathymetric survey systems designed for sea bed topographic mapping, having all of the following:

1. Being designed to take measurements at an angle exceeding 20° from the vertical; ~~2. Being designed to measure depths exceeding 600 m below the water surface;~~ and

~~3~~2. Being designed to provide any of the following:

a. Incorporation of multiple beams any of which is less than 1.9°; or

b. Data accuracies of better than 0.3% of water depth across the swath averaged over the individual measurements within the swath;

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 µPa at 1 m) for equipment with an operating frequency in the band from 10 kHz to 24 kHz inclusive;

3. Sound pressure level exceeding 235 dB (reference 1 µPa at 1 m) for equipment with an operating frequency in the band between 24 kHz and 30 kHz;

4. Forming beams of less than 1° on any axis and having an operating frequency of less than 100 kHz;

5. Designed to operate with an unambiguous display range exceeding 5,120 m; or

6. Designed to withstand pressure during normal operation at depths exceeding 1,000 m and having transducers with any of the following:

a. Dynamic compensation for pressure; or
b. Incorporating other than lead zirconate titanate as the transduction element;

c. Acoustic projectors, including transducers, incorporating piezoelectric, magnetostrictive, electrostrictive, electrodynamic or hydraulic elements operating individually or in a designed combination, having any of the following:

Note 1 The ~~control~~review status of acoustic projectors, including transducers, specially designed for other equipment is determined by the ~~control~~review status of the other equipment.

Note 2 6.A.1.a.1.c. does not ~~control~~require review of electronic sources which direct the sound vertically only, or mechanical (e.g., air gun or vapour-shock gun) or chemical (e.g., explosive) 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; or

Technical Note
Acoustic power density is obtained by dividing the output acoustic power by the product of the area of the radiating surface and the frequency of operation.

3. Side-lobe suppression exceeding 22 dB;

d. Acoustic systems, equipment and specially designed components for determining the position of surface vessels or underwater vehicles designed to operate at a range exceeding 1,000 m with a positioning accuracy of less than 10 m rms (root mean square) when measured at a range of 1,000 m;

Note 6.A.1.a.1.d. includes:
a. Equipment using coherent "signal processing" between two or more beacons and the hydrophone unit carried by the surface vessel or underwater vehicle;
b. Equipment capable of automatically correcting speed-of-sound propagation errors for calculation of a point.

2. Passive (receiving, whether or not related in normal application to separate active equipment) systems, equipment and specially designed components therefor, as follows:

a. Hydrophones having any of the following characteristics:

<u>Note</u> *The ~~control~~ review status of hydrophones specially designed for other equipment is determined by the ~~control~~review status of the other equipment.*

1. Incorporating continuous flexible sensors or assemblies of discrete sensor elements with either a diameter or length less than 20 mm and with a separation between elements of less than 20 mm;

2. Having any of the following sensing elements:

   a. Optical fibres;
   b. Piezoelectric polymers; <u>or</u>
   c. Flexible piezoelectric ceramic materials;

3. A hydrophone sensitivity better than ~~-180~~ -220 dB at any depth with no acceleration compensation;

4. When designed to operate at depths exceeding 35 m with acceleration compensation; <u>or</u>

5. Designed for operation at depths exceeding 1,000 m;

<u>Technical Note</u>
Hydrophone sensitivity is defined as twenty times the logarithm to the base 10 of the ratio of rms output voltage to a 1 V rms reference, when the hydrophone sensor, without a pre-amplifier, is placed in a plane wave acoustic field with an rms pressure of 1 µPa. For example, a hydrophone of -160 dB (reference 1V per µPa) would yield an output voltage of 10^{-8} V in such a field, while one of -220 dB sensitivity would yield only 10^{-11} V output. Thus, -160 dB is better than -220 dB.

b. Towed acoustic hydrophone arrays having any of the following:

1. Hydrophone group spacing of less than 12.5 m;

2. Designed or able to be modified to operate at depths exceeding ~~35~~ 15 m;

<u>Technical Note</u>

'Able to be modified' in 6.A.1.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. Heading sensors with an accuracy better than +/- 0.5 degrees;

controlled by 6.A.1.a.2.d.;

4. Longitudinally reinforced array hoses;

5. An assembled array of less than 40 mm in diameter;

6. Multiplexed hydrophone group signals designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; or

7. Hydrophone characteristics specified in 6.A.1.a.2.a.;

c. Processing equipment, specially designed for towed acoustic hydrophone arrays~~, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes~~;

d. Heading sensors with ~~having all of the following:~~
1. an accuracy of better than ± 0.5°. ~~Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m~~;

e. Bottom or bay cable systems having any of the following:

1. Incorporating hydrophones specified in 6.A.1.a.2.a.; or

2. Incorporating multiplexed hydrophone group signal modules having all of the following characteristics:

a. Designed to operate at depths exceeding 35 m or having an adjustable or removable depth sensing device in order to operate at depths exceeding 35 m; and

b. Capable of being operationally interchanged with towed acoustic hydrophone array modules;

f. Processing equipment, specially designed for bottom or bay cable systems~~, having "user accessible programmability" and time or frequency domain processing and correlation, including spectral analysis, digital filtering and beamforming using Fast Fourier or other transforms or processes~~;

b. Correlation-velocity sonar log equipment designed to measure the horizontal speed of the equipment carrier relative to the sea~~ bed at distances between the carrier and the sea bed exceeding 500 m~~.

6. A. 2. OPTICAL SENSORS

a. Optical detectors, as follows:

Note *6.A.2.a. does not ~~control~~require review of germanium or silicon photodevices.*

1. "Space-qualified" solid-state detectors, as follows:

a. "Space-qualified" solid-state detectors, having all of the following:

1. A peak response in the wavelength range exceeding 10 nm but not exceeding 300 nm; and

2. A response of less than 0.1% relative to the peak response at a wavelength exceeding 400 nm;

b. "Space-qualified" solid-state detectors, having all of the following:

1. A peak response in the wavelength range exceeding 900 nm but not exceeding 1,200 nm; and

2. A response "time constant" of 95 ns or less;

c. "Space-qualified" solid-state detectors having a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm;

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.~~1. A microchannel plate~~ for electron image amplification with a hole pitch (centre-to-centre spacing) of 15 µm or less~~; and

~~3.~~2. Photocathodes, as follows:

a. S-20, S-25 or multialkali photocathodes ~~with a luminous sensitivity exceeding 240 μA/lm~~;
b. GaAs or GaInAs photocathodes;
c. Other III-V compound semiconductor photocathodes;

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

b. Specially designed components, as follows:

1. Microchannel plates ~~having a hole pitch (centre-to-centre spacing) of 15 μm or less~~;
2. GaAs or GaInAs photocathodes;
3. Other III-V compound semiconductor photocathodes;

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

3. Non-"space-qualified" "focal plane arrays," as follows:

Technical Note
Linear or two-dimensional multi-element detector arrays are referred to as "focal plane arrays".

Note 1 *6.A.2.a.3. includes photoconductive arrays and photovoltaic arrays.*

Note 2 *6.A.2.a.3. does not ~~control~~require review of:*
a. Silicon "focal plane arrays";
b. Multi-element (not to exceed 16 elements) encapsulated photoconductive cells using either lead sulphide or lead selenide;
c. Pyroelectric detectors using any of the following:
1. Triglycine sulphate and variants;
2. Lead-lanthanum-zirconium titanate and variants;
3. Lithium tantalate;
4. Polyvinylidene fluoride and variants; or
5. Strontium barium niobate and variants.

a. Non-"space-qualified" "focal plane arrays," having all of the following:

1. Individual elements with a peak response within the wavelength range exceeding 900 nm but not exceeding 1,050 nm; and

2. A response "time constant" of less than 0.5 ns;

b. Non-"space-qualified" "focal plane arrays", having all of the following:

1. Individual elements with a peak response in the wavelength range exceeding 1,050 nm but not exceeding 1,200 nm; and

2. A response "time constant" of 95 ns or less;

c. Non-"space-qualified" "focal plane arrays", having individual elements with a peak response in the wavelength range exceeding 1,200 nm but not exceeding 30,000 nm.

c. "Monospectral imaging sensors" and "multispectral imaging sensors" designed for remote sensing applications, having any of the following:

1. An Instantaneous-Field-Of-View (IFOV) of less than 200 µr (microradians); or

2. Being specified for operation in the wavelength range exceeding 400 nm but not exceeding 30,000 nm and having all the following;

a. Providing output imaging data in digital format; and

b. Being any of the following:

1. "Space-qualified"; or
2. Designed for airborne operation, using other than silicon detectors, and having an IFOV of less than 2.5 mr (milliradians).

c. Direct view imaging equipment operating in the visible or infrared spectrum, incorporating any of the following:

1. Image intensifier tubes that utilize a microchannel plate (MCP) and an S-20, S-25, GaAs, or GaInAs photocathode ~~having the characteristics listed in 6.A.2.a.2.a~~; or

2. "Focal plane arrays" having the characteristics listed in 6.A.2.a.3.

Technical Note

'Direct view' refers to imaging equipment, operating in the visible or infrared spectrum, that presents a visual image to a human observer without converting the image into an electronic signal for television display, and that cannot record or store the image photographically, electronically or by any other means.

~~*Note 6.A.2.c. does not control the following equipment incorporating other than GaAs or GaInAs photocathodes:*~~

~~*a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;*~~

~~*b. Medical equipment;*~~

~~*c. Industrial equipment used for inspection, sorting or analysis*~~ *of the properties of materials;*

~~*d. Flame detectors for industrial furnaces;*~~

~~*e. Equipment specially designed for laboratory use.*~~

d. Special support components for optical sensors, as follows:

1. "Space-qualified" cryocoolers;

2. Non-"space-qualified" cryocoolers, having a cooling source temperature below 218 K (-55°C), as follows:

   a. Closed cycle type with a specified Mean-Time-To-Failure (MTTF), or Mean-Time-Between-Failures (MTBF), exceeding 2,500 hours;

   b. Joule-Thomson (JT) self-regulating minicoolers having bore (outside) diameters of less than 8 mm;

3. Optical sensing fibres specially fabricated either compositionally or structurally, or modified by coating, to be acoustically, thermally, inertially, electromagnetically or nuclear radiation sensitive.

e. "Space qualified" "focal plane arrays" having more than 2,048 elements per array and having a peak response in the wavelength range exceeding 300 nm but not exceeding 900 nm.

6. A. 3. CAMERAS

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

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

Note Instrumentation cameras, ~~controlled~~ for which review is required by 6.A.3.a.3. to 6.A.3.a.5., with modular structures should be *evaluated by their maximum capability, using plug-ins available according to the camera manufacturer's specifications.*

1. High-speed cinema recording cameras using any film format from 8 mm to 16 mm inclusive, in which the film is continuously advanced throughout the recording period, and that are capable of recording at framing rates exceeding 13,150 frames/s;

   Note 6.A.3.a.1. *does not ~~control~~require review of cinema recording cameras designed for civil purposes.*

2. Mechanical high speed cameras, in which the film does not move, capable of recording at rates exceeding 1,000,000 frames/s for the full framing height of 35 mm film, or at proportionately higher rates for lesser frame heights, or at proportionately lower rates for greater frame heights;

3. Mechanical or electronic streak cameras having writing speeds exceeding 10 mm/µs;

4. Electronic framing cameras having a speed exceeding 1,000,000 frames/s;

5. Electronic cameras, having all of the following:

   a. An electronic shutter speed (gating capability) of less than 1 µs per full frame; and

   b. A read out time allowing a framing rate of more than 125 full frames per second.

6. Plug-ins, having all of the following characteristics:

   a. Specially designed for instrumentation cameras which have modular structures and ~~which are controlled~~ for which review is required by 6.A.3.a.; and
   b. Enabling these cameras to meet the characteristics specified in 6.A.3.a.3., 6.A.3.a.4. or 6.A.3.a.5., according to the manufacturer's specifications.

b. Imaging cameras, as follows:

   Note 6.A.3.b. *does not ~~control~~require review of television or video cameras specially designed for television broadcasting.*

1. Video cameras incorporating solid state sensors, having any of the following:

a. More than 4×10^6 "active pixels" per solid state array for monochrome (black and white) cameras;

b. More than 4×10^6 "active pixels" per solid state array for colour cameras incorporating three solid state arrays; or

c. More than 12×10^6 "active pixels" for solid state array colour cameras incorporating one solid state array;

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

2. Scanning cameras and scanning camera systems, having all of the following:

a. Linear detector arrays with more than 8,192 elements per array; and

b. Mechanical scanning in one direction;

3. Imaging cameras incorporating image intensifier tubes that utilize a microchannel plate (MCP) and an S-20, S-25, GaAs, or GaInAs photocathode ~~having the characteristics listed in 6.A.2.a.2.a.~~;

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

Note *6.A.3.b.4 does not ~~control~~require review of imaging cameras incorporating linear "focal plane arrays" with twelve elements or fewer, not employing time-delay-and-integration within the element, designed for any of the following:*
a. Industrial or civilian intrusion alarm, traffic or industrial movement control or counting systems;
b. Industrial equipment used for inspection or monitoring of heat flows in buildings, equipment or industrial processes;
c. Industrial equipment used for inspection, sorting or analysis of the properties of materials;
d. Equipment specially designed for laboratory use; or
e. Medical equipment.

6. A. 4. OPTICS

a. Optical mirrors (reflectors), as follows:

1. "Deformable mirrors" having either continuous or multi-element surfaces, and specially designed components therefor, capable of

dynamically repositioning portions of the surface of the mirror at rates exceeding 100 Hz;

2. Lightweight monolithic mirrors having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 10 kg;

3. Lightweight "composite" or foam mirror structures having an average "equivalent density" of less than 30 kg/m^2 and a total mass exceeding 2 kg;

4. Beam steering mirrors more than 100 mm in diameter or length of major axis, which maintain a flatness of lambda/2 or better (lambda is equal to 633 nm) having a control bandwidth exceeding 100 Hz.

b. Optical components made from zinc selenide (ZnSe) or zinc sulphide (ZnS) with transmission in the wavelength range exceeding 3,000 nm but not exceeding 25,000 nm and having any of the following:

1. Exceeding 100 cm^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. Raw substrates, processed substrates having surface coatings (single-layer or multi-layer, metallic or dielectric, conducting, semiconducting or insulating) or having protective films;

3. Segments or assemblies of mirrors designed to be assembled in space into an optical system with a collecting aperture equivalent to or larger than a single optic 1 m in diameter;

4. Manufactured from "composite" materials having a coefficient of linear thermal expansion equal to or less than 5×10^{-6} in any coordinate direction.

d. Optical control equipment, as follows:

1. Specially designed to maintain the surface figure or orientation of the "space-qualified" components ~~controlled by~~ for which review is required by 6.A.4.c.1. or 6.A.4.c.3.;

2. Having steering, tracking, stabilisation or resonator alignment bandwidths equal to or more than 100 Hz and an accuracy of 10 µr (microradians) or less;

3. Gimbals having all of the following:

   a. A maximum slew exceeding 5°;

   b. A bandwidth of 100 Hz or more;

   c. Angular pointing errors of 200 µr (microradians) or less; and

   d. Having any of the following:

      1. Exceeding 0.15 m but not exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 2 r (radians)/s^2; or

      2. Exceeding 1 m in diameter or major axis length and capable of angular accelerations exceeding 0.5 r (radians)/s^2;

4. Specially designed to maintain the alignment of phased array or phased segment mirror systems consisting of mirrors with a segment diameter or major axis length of 1 m or more.

e. Aspheric optical elements having all of the following characteristics:

1. The largest dimension of the optical-aperture is greater than 400 mm;

2. The surface roughness is less than 1 nm (rms) for sampling lengths equal to or greater than 1 mm; and

3. The coefficient of linear thermal expansion's absolute magnitude is less than $3x10^{-6}$/K at 25 ° C;

Technical Notes

1. *An 'aspheric optical element' is any element used in an optical system whose imaging surface or surfaces are designed to depart from the shape of an ideal sphere.*
2. *Manufacturers are not required to measure the surface roughness listed in 6.A.4.e.2. unless the optical element was designed or manufactured with the intent to meet, or exceed, the ~~control~~ review parameter.*

Note *6.A.4.e. does not ~~control~~ require review of aspheric optical elements having any of the following:*

a. A largest optical-aperture dimension less than 1 m and a focal length to aperture ratio equal to or greater than 4.5:1;

b. A largest optical-aperture dimension equal to or greater than 1 m and a focal length to aperture ratio equal to or greater than 7:1;

c. Being designed as Fresnel, flyeye, stripe, prism or diffractive optical elements;

d. Being fabricated from borosilicate glass having a coefficient of linear thermal expansion greater than $2.5x10^{-6}$ /K at 25 °C; or

e. Being an x-ray optical element having inner mirror capabilities (e.g. tube-type mirrors).

N.B. For aspheric optical elements specially designed for lithography equipment, see Item 3.B.1.

6. A. 5. LASERS

"Lasers," components and optical equipment, as follows:

Note 1 Pulsed "lasers" include those that run in a continuous wave (CW) mode with pulses superimposed.

Note 2 Pulse-excited "lasers" include those that run in a continuously excited mode with pulse excitation superimposed.

Note 3 The ~~control~~review 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 having any of the following:

1. An output energy exceeding 50 mJ per pulse; or
2. An average output power exceeding 1 W;

b. An output wavelength exceeding 150 nm but not exceeding 190 nm and having any of the following:

1. An output energy exceeding 1.5 J per pulse; or
2. An average output power exceeding 120 W;

c. An output wavelength exceeding 190 nm but not exceeding 360 nm and having any of the following:

1. An output energy exceeding 10 J per pulse; or
3. An average output power exceeding 500 W; or

d. An output wavelength exceeding 360 nm and having any of the following:

1. An output energy exceeding 1.5 J per pulse; or
2. An average output power exceeding 30 W;

N.B. For excimer "lasers" specially designed for lithography equipment, see 3.B.1.

2. Metal vapour "lasers", as follows:

a. Copper (Cu) "lasers" having an average output power exceeding 20 W;

b. Gold (Au) "lasers" having an average output power exceeding 5 W;

c. Sodium (Na) "lasers" having an output power exceeding 5 W;

d. Barium (Ba) "lasers" having an average output power exceeding 2 W;

3. Carbon monoxide (CO) "lasers" having any of the following:

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 15 kW;

b. A pulsed output having a "pulse duration" exceeding 10 µs and having any of the following:

1. An average output power exceeding 10 kW; or
2. A pulsed "peak power" exceeding 100 kW; or

c. A pulsed output having a "pulse duration" equal to or less than 10 µs; and having any of the following:

1. A pulse energy exceeding 5 J per pulse; 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", as follows:

      1. Oxygen Iodine (O_2-I) "lasers";
      2. Deuterium Fluoride-Carbon dioxide (DF-CO_2) "lasers";

6. Krypton ion or argon ion "lasers" having any of the following:

   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;

7. Other gas "lasers", having any of the following:

   Note *6.A.5.a.7. does not ~~control~~require review of nitrogen "lasers".*

   a. An output wavelength not exceeding 150 nm and having any of the following:

      1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      2. An average or CW output power exceeding 1 W;

   b. An output wavelength exceeding 150 nm but not exceeding 800 nm and having any of the following:

      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 having any of the following:

      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 1,400 nm and an average or CW output power exceeding 1 W.

b. Semiconductor "lasers", as follows:

1. Individual single-transverse mode semiconductor "lasers", having all of the following:
   a. A wavelength of less than 950 nm or more than 2000 nm; and

   b. An average or CW output power exceeding 100 mW;

2. Individual, multiple-transverse mode semiconductor "lasers" having all of the following:

   a. A wavelength of less than 950 nm or more than 2000 nm; and

   b. An average or CW output power exceeding 10 W.

3. Individual arrays of individual semiconductor "lasers", having any of the following:

   a. A wavelength of less than 950 nm and an average or CW output power exceeding 60 W; or

   b. A wavelength equal to or greater than 2000 nm and an average or CW output power exceeding 10 W;

Technical Note
Semiconductor "lasers" are commonly called "laser" diodes.

Note 1 *6.A.5.b. includes semiconductor "lasers" having optical output connectors (e.g. fibre optic pigtails).*

Note 2 *The ~~control~~review status of semiconductor "lasers" specially designed for other equipment is determined by the ~~control~~ review status of the other equipment.*

c. Solid state "lasers", as follows:

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

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

   a. An output wavelength less than 600 nm and having any of the following:

      1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
      2. An average or CW output power exceeding 1 W;

b. An output wavelength of 600 nm or more but not exceeding 1,400 nm and having any of the following:

1. An output energy exceeding 1 J per pulse and a pulsed "peak power" exceeding 20 W; or
2. An average or CW output power exceeding 20 W; or

c. An output wavelength exceeding 1,400 nm and having any of the following:

1. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
2. An average or CW output power exceeding 1 W;

2. Non-"tunable" "lasers", as follows:

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

a. Neodymium glass "lasers", as follows:

1. "Q-switched lasers" having any of the following:

a. An output energy exceeding 20 J but not exceeding 50 J per pulse and an average output power exceeding 10 W; or
b. An output energy exceeding 50 J per pulse;

2. Non-"Q-switched lasers" having any of the following:

a. An output energy exceeding 50 J but not exceeding 100 J per pulse and an average output power exceeding 20 W; or
b. An output energy exceeding 100 J per pulse;

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

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

1. Pulse-excited, mode-locked, "Q-switched lasers" having a "pulse duration" of less than 1 ns and having any of the following:

a. A "peak power" exceeding 5 GW;
b. An average output power exceeding 10 W; or
c. A pulsed energy exceeding 0.1 J;

2. Pulse-excited, "Q-switched lasers" having a pulse duration equal to or more than 1ns, and having any of the following:

a. A single-transverse mode output having:
1. A "peak power" exceeding 100 MW;
2. An average output power exceeding 20 W; or
3. A pulsed energy exceeding 2 J; or

b. A multiple-transverse mode output having:

1. A "peak power" exceeding 400 MW;
2. An average output power exceeding 2 kW; or
3. A pulsed energy exceeding 2 J;

3. Pulse-excited, non-"Q-switched lasers", having:

a. A single-transverse mode output having:

1. A "peak power" exceeding 500 kW; or
2. An average output power exceeding 150 W; or

b. A multiple-transverse mode output having:

1. A "peak power" exceeding 1 MW; or
2. An average power exceeding 2 kW;

4. Continuously excited "lasers" having:

a. A single-transverse mode output having:

1. A "peak power" exceeding 500 kW; or
2. An average or CW output power exceeding 150 W; or

b. A multiple-transverse mode output having:

1. A "peak power" exceeding 1 MW; or
2. An average or CW output power exceeding 2 kW;

c. Other non-"tunable" "lasers", having any of the following:

1. A wavelength less than 150 nm and having any of the following:

a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:

a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 30 W; or

b. An average or CW output power exceeding 30 W;

3. A wavelength exceeding 800 nm but not exceeding 1,400 nm, as follows:

a. "Q-switched lasers" having:

1. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 50 W; or

2. An average output power exceeding:

a. 10 W for single-transverse mode "lasers";
b. 30 W for multiple-transverse mode "lasers";

b. Non-"Q-switched lasers" having:

1. An output energy exceeding 2 J per pulse and a pulsed "peak power" exceeding 50 W; or

2. An average or CW output power exceeding 50 W; or

4. A wavelength exceeding 1,400 nm and having any of the following:

a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

d. Dye and other liquid "lasers", having any of the following:

1. A wavelength less than 150 nm and:

a. An output energy exceeding 50 mJ per pulse and a pulsed "peak power" exceeding 1 W; or

b. An average or CW output power exceeding 1 W;

2. A wavelength of 150 nm or more but not exceeding 800 nm and having any of the following:

   a. An output energy exceeding 1.5 J per pulse and a pulsed "peak power" exceeding 20 W;

   b. An average or CW output power exceeding 20 W; or

   c. A pulsed single longitudinal mode oscillator having an average output power exceeding 1 W and a repetition rate exceeding 1 kHz if the "pulse duration" is less than 100 ns;

d. 3. A wavelength exceeding 800 nm but not exceeding 1,400 nm and having any of the following:

   a. An output energy exceeding 0.5 J per pulse and a pulsed "peak power" exceeding 10 W; or
   b. An average or CW output power exceeding 10 W; or

4. A wavelength exceeding 1,400 nm and having any of the following:

   a. An output energy exceeding 100 mJ per pulse and a pulsed "peak power" exceeding 1 W; or
   c. An average or CW output power exceeding 1 W;

5. "Lasers" with an output power of 100 mW or greater.

e. Components, as follows:

1. Mirrors cooled either by active cooling or by heat pipe cooling;

Technical Note
Active cooling is a cooling technique for optical components using flowing fluids within the subsurface (nominally less than 1 mm below the optical surface) of the optical component to remove heat from the optic.

2. Optical mirrors or transmissive or partially transmissive optical or electro-optical components specially designed for use with ~~controlled~~ "lasers" for which review is required;

f. Optical equipment, as follows:

1. Dynamic wavefront (phase) measuring equipment capable of mapping at least 50 positions on a beam wavefront having any of the following:

   a. Frame rates equal to or more than 100 Hz and phase discrimination of at least 5% of the beam's wavelength; or

b. Frame rates equal to or more than 1,000 Hz and phase discrimination of at least 20% of the beam's wavelength;

2. "Laser" diagnostic equipment capable of measuring "SHPL" system angular beam steering errors of equal to or less than 10 µrad;

3. Optical equipment and components specially designed for a phased-array "SHPL" system for coherent beam combination to an accuracy of lambda/10 at the designed wavelength, or 0.1 µm, whichever is the smaller;

4. Projection telescopes specially designed for use with "SHPL" systems.

6. A. 6. MAGNETOMETERS

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

Note *6.A.6. does not ~~control~~require review of instruments specially designed for biomagnetic measurements for medical diagnostics.*

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 any of the following:

1. 0.05 nT rms/square root Hz at frequencies of less than 1 Hz;
2. 1 x 10^{-3} nT rms/square root Hz at frequencies of 1 Hz or more but not exceeding 10 Hz; or
3. 1 x 10^{-4} nT rms/square root Hz at frequencies exceeding 10 Hz;

c. Fibre optic "magnetometers" having a "noise level" (sensitivity) lower (better) than 1 nT rms per square root Hz;

d. "Magnetic gradiometers" using multiple "magnetometers" ~~controlled by~~ for which review is required by 6.A.6.a., 6.A.6.b. or 6.A.6.c.;

e. Fibre optic "intrinsic magnetic gradiometers" having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.3 nT/m rms per square root Hz;

f. "Intrinsic magnetic gradiometers", using "technology" other than fibre-optic "technology", having a magnetic gradient field "noise level" (sensitivity) lower (better) than 0.015 nT/m rms per square root Hz;

g. Magnetic compensation systems for magnetic sensors designed for operation on mobile platforms;

h. "Superconductive" electromagnetic sensors, containing components manufactured from "superconductive" materials and having all of the following:

1. Being designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents (including Josephson effect devices or "superconductive" quantum interference devices (SQUIDS));

2. Being designed for sensing electromagnetic field variations at frequencies of 1 kHz or less; and:

3. Having any of the following characteristics:

a. Incorporating thin-film SQUIDS with a minimum feature size of less than 2µm and with associated input and output coupling circuits;
b. Designed to operate with a magnetic field slew rate exceeding 1×10^6 magnetic flux quanta per second;
c. Designed to function without magnetic shielding in the earth's ambient magnetic field; or
d. Having a temperature coefficient less (smaller) than 0.1 magnetic flux quantum/K.

6. A. 7 GRAVIMETERS

Gravity meters (gravimeters) and gravity gradiometers, as follows:

a. Gravity meters designed or modified for ground use having a static accuracy of less (better) than 10 µgal;

Note 6.A.7.a. does not ~~control~~require review of ground gravity meters of the quartz element (Worden) type.

b. Gravity meters designed for mobile platforms, having all of the following:

1. A static accuracy of less (better) than 0.7 mgal; and
2. An in-service (operational) accuracy of less (better) than 0.7 mgal having a time-to-steady-state registration of less than 2 minutes under any combination of attendant corrective compensations and motional influences;

c. Gravity gradiometers.

6. A. 8. RADAR

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

Note 6.A.8. does not ~~control~~require review of:
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. All airborne radar equipment and specially designed components therefor, not including radars specially designed for meteorological use or Mode 3, Mode C. or Mode S civilian air traffic control equipment specially designed to operate only in the 960-1215 MHz band;

Note: This entry does not require initial review of airborne radar equipment installed as original equipment in civil-certified aircraft operating in Iraq.

b. All ground-based primary radar systems that are capable of aircraft detection and tracking;

c.~~a~~ Operating at frequencies from 40 GHz to 230 GHz and having an average output power exceeding 100 mW;

d.~~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.

e.~~c.~~ Capable of operating simultaneously on more than two carrier frequencies;

f.~~d~~. Capable of operating in synthetic aperture (SAR), inverse synthetic aperture (ISAR) radar mode, or sidelooking airborne (SLAR) radar mode;

g.~~e.~~ Incorporating "electronically steerable phased array antennae";

h.~~f.~~ Capable of heightfinding non-cooperative targets;

Note 6.A.8.h. does not ~~control~~require review of precision approach radar (PAR) equipment conforming to ICAO standards.

i.~~g.~~ Specially designed for airborne (balloon or airframe mounted) operation and having Doppler "signal processing" for the detection of moving targets;

j.~~h.~~ Employing processing of radar signals using any of the follow ing:

1. "Radar spread spectrum" techniques; or
2. "Radar frequency agility" techniques;

k.~~i. Providing ground-based operation with a maximum "instrumented range" exceeding 185 km;~~

~~*Note 6.A.8.i. does not control:*~~

~~*a. Fishing ground surveillance radar;*~~

~~*b. Ground radar equipment specially designed for enroute air traffic control, provided that all the following conditions are met:*~~

~~*1. It has a maximum "instrumented range" of 500 km or less;*~~

~~*2. It is configured so that radar target data can be transmitted only one way from the radar site to one or more civil ATC centres;*~~

~~*3. It contains no provisions for remote control of the radar scan rate from the enroute ATC centre; and*~~

~~*4. It is to be permanently installed.*~~

~~*c. Weather balloon tracking radars.*~~

Being "laser" radar or Light Detection and Ranging (LIDAR) equipment, having any of the following:

1. "Space-qualified"; or
2. Employing coherent heterodyne or homodyne detection techniques and having an angular resolution of less (better) than 20 µr (microradians);

Note 6.A.8.k. does not control require review of LIDAR equipment specially designed for surveying or for meteorological observation.

l. Having "signal processing" sub-systems using "pulse compression," with any of the following:

1. A "pulse compression" ratio exceeding 150; or

3. A pulse width of less than 200 ns; or

m. Having data processing sub-systems with any of the following:

1. "Automatic target tracking" providing, at any antenna rotation, the predicted target position beyond the time of the next antenna beam passage;

Note *6.A.8.m.1. does not ~~control~~require review of 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 *6.A.8.m.4. does not ~~control~~require review of systems, equipment and assemblies used for marine traffic control.*

9. Non-X-ray explosive detection equipment.

6. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

6. B. 1. ACOUSTICS - None

6. B. 2. OPTICAL SENSORS - None

6. B. 3. CAMERAS - None

6. B. 4. OPTICS

Optical equipment, as follows:

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 *6.B.4. does not ~~control~~require review of microscopes.*

6. B. 5. LASERS - None

6. B. 6. MAGNETOMETERS - None

6. B. 7. GRAVIMETERS

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

6. B. 8 RADAR

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

6. C. MATERIALS

6. C. 1. ACOUSTICS - None

6. C. 2. OPTICAL SENSORS

Optical sensor materials, as follows:

a. Elemental tellurium (Te) of purity levels of 99.9995% or more;

b. Single crystals (including epitaxial wafers) of any of the following:

1. Cadmium zinc telluride with zinc content of less than 6% by mole fraction;
2. Cadmium telluride (CdTe) of any purity level; or
3. Mercury cadmium telluride (HgCdTe) of any purity level.

Technical Note
Mole fraction is defined as the ratio of moles of ZnTe to the sum of the moles of CdTe and ZnTe present in the crystal.

6. C. 3. CAMERAS - None

6. C. 4 OPTICS

Optical materials, as follows:

a. Zinc selenide (ZnSe) and zinc sulphide (ZnS) "substrate blanks" produced by the chemical vapour deposition process, having any of the following:

1. A volume greater than 100 cm^3; or
2. A diameter greater than 80 mm having a thickness of 20 mm or more;

b. Boules of the following electro-optic materials:

1. Potassium titanyl arsenate (KTA);
2. Silver gallium selenide ($AgGaSe_2$);
3. Thallium arsenic selenide (Tl_3AsSe_3, also known as TAS);

c. Non-linear optical materials, having all of the following:

1. Third order susceptibility (chi 3) of 10^{-6} m^2/V^2 or more; and
2. A response time of less than 1 ms;

d. "Substrate blanks" of silicon carbide or beryllium beryllium (Be/Be) deposited materials exceeding 300 mm in diameter or major axis length;

e. Glass, including fused silica, phosphate glass, fluorophosphate glass, zirconium fluoride (ZrF_4) and hafnium fluoride (HfF_4), having all of the following:

1. A hydroxyl ion (OH^-) concentration of less than 5 ppm;
2. Integrated metallic purity levels of less than 1 ppm; and
3. High homogeneity (index of refraction variance) less than 5×10^{-6};

f. Synthetically produced diamond material with an absorption of less than 10^{-5} cm^{-1} for wavelengths exceeding 200 nm but not exceeding 14,000 nm.

6. C. 5. LASERS

Synthetic crystalline "laser" host material in unfinished form, as follows:

a. Titanium doped sapphire;
b. Alexandrite.

6. C. 6. MAGNETOMETERS - None

6. C. 7. GRAVIMETERS - None

6. C. 8. RADAR - None.

6. D. SOFTWARE

1. "Software" specially designed for the "development" or "production" of equipment ~~controlled~~ for which review is required by 6.A.2, 6.A.3, 6.A.4, 6.A.5., 6.A.8 or 6.B.8.

2. "Software" specially designed for the "use" of equipment ~~controlled~~ for which review is required by 6.A.2.b., 6.A.8 or 6.B.8.

3. Other "software", as follows:

a. ACOUSTICS

"Software," as follows:

1. "Software" specially designed for acoustic beam forming for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;

2. "Source code" for the "real time processing" of acoustic data for passive reception using towed hydrophone arrays;

3. "Software" specially designed for acoustic beam forming for the "real time processing" of acoustic data for passive reception using bottom or bay cable systems;

4. "Source code" for the "real time processing" of acoustic data for passive reception using bottom or bay cable systems;

. b. OPTICAL SENSORS - None

c. CAMERAS - None

d. OPTICS - None

e. LASERS - None

f. MAGNETOMETERS

"Software", as follows:

1. "Software" specially designed for magnetic compensation systems for magnetic sensors designed to operate on mobile platforms;

2. "Software" specially designed for magnetic anomaly detection on mobile platforms;

g. GRAVIMETERS

"Software" specially designed to correct motional influences of gravity meters or gravity gradiometers;

h RADAR

"Software," as follows:

1. Air Traffic Control "software" application "programmes" hosted on general purpose computers located at Air Traffic Control centres and capable of any of the following:

   a. Processing and displaying more than 150 simultaneous "system tracks"; or
   b. Accepting radar target data from more than four primary radars;

2. "Software" for the design or "production" of radomes which:

   a. Are specially designed to protect the "electronically steerable phased array antennae" ~~controlled~~ for which review is required by 6.A.8.e.; and
   b. Result in an antenna pattern having an 'average side lobe level' more than 40 dB below the peak of the main beam level.

   Technical Note
   'Average side lobe level' in 6.D.3.h.2.b. is measured over the entire array excluding the angular extent of the main beam and the first two side lobes on either side of the main beam.

6. E. TECHNOLOGY

6. E. 1. "Technology" according to the General Technology Note for the "development" of equipment, materials or "software" ~~controlled by~~ for which review is required by 6.A., 6.B., 6.C. or 6.D.

6. E. 2. "Technology" according to the General Technology Note for the "production" of equipment or materials ~~controlled by~~for which review is required by 6.A., 6.B. or 6.C.

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

a. ACOUSTICS - None

b. OPTICAL SENSORS - None

c. CAMERAS - None

d. OPTICS

"Technology," as follows:

1. Optical surface coating and treatment "technology" "required" to achieve uniformity of 99.5% or better for optical coatings 500 mm or more in diameter or major axis length and with a total loss (absorption and scatter) of less than 5×10^{-3};
   N.B. See also 2.E.3.f.

2. Optical fabrication "technology" using single point diamond turning techniques to produce surface finish accuracies of better than 10 nm rms on non-planar surfaces exceeding $0.5 m^2$;

e. LASERS

"Technology" "required" for the "development", "production" or "use" of specially designed diagnostic instruments or targets in test facilities for "SHPL" testing or testing or evaluation of materials irradiated by "SHPL" beams;

f. MAGNETOMETERS

"Technology" "required" for the "development" or "production" of fluxgate "magnetometers" or fluxgate "magnetometer" systems, having any of the following:

1. A "noise level" of less than 0.05 nT rms per square root Hz at frequencies of less than 1 Hz; or

2. A "noise level" of less than 1×10^{-3} nT rms per square root Hz at frequencies of 1 Hz or more.

g. GRAVIMETERS - None

h. RADAR - None

7. A. SYSTEMS, EQUIPMENT AND COMPONENTS

N.B.1 For automatic pilots for underwater vehicles, see Category 8.
For radar, see Category 6.

~~*N.B.2 For inertial navigation equipment for ships or submersibles, see Item 9.e. on the Munitions List.*~~*

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

a. A "bias" "stability" of less (better) than 130 micro g with respect to a fixed calibration value over a period of one year;

b. A "scale factor" "stability" of less (better) than 130 ppm with respect to a fixed calibration value over a period of one year; or

c. Specified to function at linear acceleration levels exceeding 100 g.

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

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

a. A "drift rate" "stability", when measured in a 1 g environment over a period of three months and with respect to a fixed calibration value, of:

1. Less (better) than 0.1° per hour when specified to function at linear acceleration levels below 10 g; or
2. Less (better) than 0.5° per hour when specified to function at linear acceleration levels from 10 g to 100 g inclusive; or

b. Specified to function at linear acceleration levels exceeding 100 g.

7. A. 3. Inertial navigation systems (gimballed or strapdown) and inertial equipment designed for "aircraft", land vehicle or "spacecraft" for attitude, guidance or control having any of the following characteristics, and specially designed components therefor:

a. Navigation error (free inertial) subsequent to normal alignment of 0.8 nautical mile per hour (50% Circular Error Probable (CEP)) or less (better); or

b. Specified to function at linear acceleration levels exceeding 10 g.

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

Note 1 *The parameters of 7.A.3.a. are applicable with any of the following environmental conditions:*

1. *Input random vibration with an overall magnitude of 7.7 g rms in the first half hour and a total test duration of one and one half hour per axis in each of the three perpendicular axes, when the random vibration meets the following:*
   a. *A constant power spectral density (PSD) value of 0.04 g^2/Hz over a frequency interval of 15 to 1,000 Hz; and*
   b. *The PSD attenuates with frequency from 0.04 g^2/Hz to 0.01 g^2/Hz over a frequency interval from 1,000 to 2,000 Hz; or*
2. *A roll and yaw rate of equal to or more than +2.62 radian/s (150 deg/s); or*
3. *According to national standards equivalent to 1. or 2. above.*

Note 2 *7.A.3. does not ~~control~~ require review of inertial navigation systems which are certified for use on "civil aircraft" by civil authorities of a participating state.*

7. A. 4. Gyro-astro compasses, and other devices which derive position or orientation by means of automatically tracking celestial bodies or satellites, with an azimuth accuracy of equal to or less (better) than 5 seconds of arc.

7. A. 5. Global navigation satellite systems (i.e., GPS or GLONASS) receiving equipment having any of the following characteristics, and specially designed components therefor:

a. Employing decryption; or

b. A null-steerable antenna.

7. A. 6. Airborne altimeters operating at frequencies other than 4.2 to 4.4 GHz inclusive, having any of the following characteristics:

a. "Power management"; or

b. Using phase shift key modulation.

7. A. 7. Direction finding equipment operating at frequencies above 30 MHz and having all of the following characteristics, and specially designed components therefor:

a. "Instantaneous bandwidth" of 1 MHz or more;

b. Parallel processing of more than 100 frequency channels; and

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

7. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

7. B. 1. Test, calibration or alignment equipment specially designed for equipment ~~controlled~~ for which review is required by 7.A.

Note 7.B.1. does not ~~control~~require review of test, calibration or alignment equipment for Maintenance Level I or Maintenance Level II.

Technical Notes

1. *Maintenance Level I*
The failure of an inertial navigation unit is detected on the aircraft by indications from the control and display unit (CDU) or by the status message from the corresponding sub-system. By following the manufacturer's manual, the cause of the failure may be localised at the level of the malfunctioning line replaceable unit (LRU). The operator then removes the LRU and replaces it with a spare.
2. *Maintenance Level II*
The defective LRU is sent to the maintenance workshop (the manufacturer's or that of the operator responsible for level II maintenance). At the maintenance workshop, the malfunctioning LRU is tested by various appropriate means to verify and localise the defective shop replaceable assembly (SRA) module responsible for the failure. This SRA is removed and replaced by an operative spare. The defective SRA (or possibly the complete LRU) is then shipped to the manufacturer. Maintenance Level II does not include the removal of ~~controlled~~ accelerometers or gyro sensors for which review is required from the SRA.

7. B. 2. Equipment, as follows, specially designed to characterize mirrors for ring "laser" gyros:

a. Scatterometers having a measurement accuracy of 10 ppm or less (better);

b. Profilometers having a measurement accuracy of 0.5 nm (5 angstrom) or less (better).

7. B. 3. Equipment specially designed for the "production" of equipment ~~controlled~~ for which review is required by 7.A.

Note 7.B.3 includes:
a. Gyro tuning test stations;
b. Gyro dynamic balance stations;
c. Gyro run-in/motor test stations;
d. Gyro evacuation and fill stations;
e. Centrifuge fixtures for gyro bearings;
f. Accelerometer axis align stations.

7. C. MATERIALS - None

7. D. SOFTWARE

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

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

Note *7.D.2. does not ~~control~~ require review of "source code" for the "use" of gimballed AHRS.*

Technical Note
AHRS generally differ from inertial navigation systems (INS) in that an AHRS provides attitude and heading information and normally does not provide the acceleration, velocity and position information associated with an INS.

3. Other "software", as follows:

a. "Software" specially designed or modified to improve the operational performance or reduce the navigational error of systems to the levels specified in 7.A.3. or 7.A.4.;

b. "Source code" for hybrid integrated systems which improves the operational performance or reduces the navigational error of systems to the level specified in 7.A.3. by continuously combining inertial data with any of the following navigation data:

1. Doppler radar velocity;
2. Global navigation satellite systems (i.e., GPS or GLONASS) reference data; or
3. Terrain data from data bases;

c. "Source code" for integrated avionics or mission systems which combine sensor data and employ "expert systems";

d. "Source code" for the "development" of any of the following:

1. Digital flight management systems for "total control of flight";
2. Integrated propulsion and flight control systems;
3. Fly-by-wire or fly-by-light control systems;
4. Fault-tolerant or self-reconfiguring "active flight control systems";
5. Airborne automatic direction finding equipment;
6. Air data systems based on surface static data; or
7. Raster-type head-up displays or three dimensional displays;

e. Computer-aided-design (CAD) "software" specially designed for the "development" of "active flight control systems", helicopter multi-axis fly-by-wire or fly-by-light controllers or helicopter "circulation controlled anti-torque or circulation-controlled direction control systems" whose "technology" is required for review in 7.E.4.b., 7.E.4.c.1. or 7.E.4.c.2.

7. E. TECHNOLOGY

1. "Technology" according to the General Technology Note for the "development" of equipment or "software" ~~controlled by~~requiring review by 7.A., 7.B. or 7.D.

2. "Technology" according to the General Technology Note for the "production" of equipment ~~controlled by~~requiring review by 7.A. or 7.B.

3. "Technology" according to the General Technology Note for the repair, refurbishing or overhaul of equipment ~~controlled by~~requiring review by 7.A.1. to 7.A.4.

Note 7.E.3. does not ~~control~~require review of maintenance "technology" directly associated with calibration, removal or replacement of damaged or unserviceable LRUs and SRAs of a "civil aircraft" as described in Maintenance Level I or Maintenance Level II.
N.B. See Technical Notes to 7.B.1.

7. E. 4. Other "technology", as follows:

a. "Technology" for the "development" or "production" of:

1. Airborne automatic direction finding equipment operating at frequencies exceeding 5 MHz;
2. Air data systems based on surface static data only, i.e., which dispense with conventional air data probes;
3. Raster-type head-up displays or three dimensional displays for "aircraft";
4. Inertial navigation systems or gyro-astro compasses containing accelerometers or gyros ~~controlled by~~requiring review by 7.A.1. or 7.A.2.;
5. Electric actuators (i.e., electromechanical, electrohydrostatic and integrated actuator package) specially designed for "primary flight control";
6. "Flight control optical sensor array" specially designed for implementing "active flight control systems";

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;

   <u>Note</u> 7.E.4.b.3. does not ~~control~~require review of " 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 "total control of flight";

   <u>Note</u> 7.E.4.b.5. does not ~~control~~require review of:
   1. *"Development" "technology" for integration of digital flight control, navigation and propulsion control data into a digital flight management system for "flight path optimisation";*
   2. *"Development" "technology" for "aircraft" flight instrument systems integrated solely for VOR, DME, ILS or MLS navigation or approaches.*

6. Full authority digital flight control or multisensor mission management systems employing "expert systems";

   <u>N.B.</u> For "technology" for Full Authority Digital Engine Control ("FADEC"), see 9.E.3.a.9.

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.

8. A. SYSTEMS, EQUIPMENT AND COMPONENTS

8. A. 1. Submersible vehicles and surface vessels, as follows:

N.B. For the ~~control~~review status of equipment for submersible vehicles, see:
Category 5, Part 2 "Information Security" for encrypted communication equipment;
Category 6 for sensors;
Categories 7 and 8 for navigation equipment;
Category 8.A. for underwater equipment.

a. Manned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m;

b. Manned, untethered submersible vehicles, having any of the following:

1. Designed to operate autonomously and having a lifting capacity of all the following:

   a. 10% or more of their weight in air; and
   b. 15 kN or more;

2. Designed to operate at depths exceeding 1,000 m; or

3. Having all of the following:

   a. Designed to carry a crew of 4 or more;
   b. Designed to operate autonomously for 10 hours or more;
   c. Having a range of 25 nautical miles or more; and
   d. Having a length of 21 m or less;

Technical Notes

1. *For the purposes of 8.A.1.b., operate autonomously means fully submerged, without snorkel, all systems working and cruising at minimum speed at which the submersible can safely control its depth dynamically by using its depth planes only, with no need for a support vessel or support base on the surface, sea-bed or shore, and containing a propulsion system for submerged or surface use.*
2. *For the purposes of 8.A.1.b., range means half the maximum distance a submersible vehicle can cover.*

c. Unmanned, tethered submersible vehicles designed to operate at depths exceeding 1,000 m, having any of the following:

1. Designed for self-propelled manoeuvre using propulsion motors or thrusters ~~controlled~~ requiring review by 8.A.2.a.2.; or

2. Having a fibre optic data link;

d. Unmanned, untethered submersible vehicles, having any of the following:

1. Designed for deciding a course relative to any geographical reference without real-time human assistance;

2. 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 any of the following:

1. Dynamic positioning systems capable of position keeping within 20 m of a given point provided by the navigation system; or

2. Seafloor navigation and navigation integration systems for depths exceeding 1,000 m with positioning accuracies to within 10 m of a predetermined point;

f. Surface-effect vehicles (fully skirted variety) having all of the following characteristics:

1. a maximum design speed, fully loaded, exceeding 30 knots in a significant wave height of 1.25 m (Sea State 3) or more;

2. a cushion pressure exceeding 3,830 Pa; and

3. a light-ship-to-full-load displacement ratio of less than 0.70;

g. Surface-effect vehicles (rigid sidewalls) with a maximum design speed, fully loaded, exceeding 40 knots in a significant wave height of 3.25 m (Sea State 5) or more;

h. Hydrofoil vessels with active systems for automatically controlling foil systems, with a maximum design speed, fully loaded, of 40 knots or more in a significant wave height of 3.25 m (Sea State 5) or more;

i. Small waterplane area vessels having any of the following:

1. A full load displacement exceeding 500 tonnes with a maximum design speed, fully loaded, exceeding 35 knots in a significant wave height of 3.25 m (Sea State 5) or more; or

2. A full load displacement exceeding 1,500 tonnes with a maximum design speed, fully loaded, exceeding 25 knots in a significant wave height of 4 m (Sea State 6) or more.

Technical Note
A small waterplane area vessel is defined by the following formula: waterplane area at an operational design draft less than 2x (displaced volume at the operational design draft)$^{2/3}$.

8. A. 2. Systems and equipment, as follows:

N.B. *For underwater communications systems, see Category 5, Part 1 - Telecommunications.*

a. Systems and equipment, specially designed or modified for submersible vehicles, designed to operate at depths exceeding 1,000 m, as follows:

1. Pressure housings or pressure hulls with a maximum inside chamber diameter exceeding 1.5 m;

2. Direct current propulsion motors or thrusters;

3. Umbilical cables, and connectors therefor, using optical fibre and having synthetic strength members;

b. Systems specially designed or modified for the automated control of the motion of submersible vehicles ~~controlled~~ requiring review by 8.A.1. using navigation data and having closed loop servo-controls:

1. Enabling a vehicle to move within 10 m of a predetermined point in the water column;

2. Maintaining the position of the vehicle within 10 m of a predetermined point in the water column; or

3. Maintaining the position of the vehicle within 10 m while following a cable on or under the seabed;

c. Fibre optic hull penetrators or connectors;

d. Underwater vision systems, as follows:

1. Television systems and television cameras, as follows:

a. Television systems (comprising camera, monitoring and signal transmission equipment) having a limiting resolution when measured in air of more than 800 lines and specially designed or modified for remote operation with a submersible vehicle;

b. Underwater television cameras having a limiting resolution when measured in air of more than 1,100 lines;

c. Low light level television cameras specially designed or modified for underwater use containing all of the following:

1. Image intensifier tubes ~~controlled~~ requiring review by 6.A.2.a.2.a.; and
2. More than 150,000 "active pixels" per solid state area array;

Technical Note
Limiting resolution in television is a measure of horizontal resolution usually expressed in terms of the maximum number of lines per picture height discriminated on a test chart, using IEEE Standard 208/1960 or any equivalent standard.

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;

e. Photographic still cameras specially designed or modified for underwater use below 150 m having a film format of 35 mm or larger, and having any of the following:

1. Annotation of the film with data provided by a source external to the camera;

2. Automatic back focal distance correction; or

3. Automatic compensation control specially designed to permit an underwater camera housing to be usable at depths exceeding 1,000 m;

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 and a flash rate of more than 5 flashes per second;

2. Argon arc light systems specially designed for use below 1,000 m;

h. "Robots" specially designed for underwater use, ~~controlled by~~requiring review by using a dedicated "stored programme controlled" computer, having any of the following:

1. Systems that control the "robot" using information from sensors which measure force or torque applied to an external object, distance to an

external object, or tactile sense between the "robot" and an external object; or

2. The ability to exert a force of 250 N or more or a torque of 250 Nm or more and using titanium based alloys or "fibrous or filamentary" "composite" materials in their structural members;

i. Remotely controlled articulated manipulators specially designed or modified for use with submersible vehicles, having any of the following:

1. Systems which control the manipulator using the information from sensors which measure the torque or force applied to an external object, or tactile sense between the manipulator and an external object; or

2. Controlled by proportional master-slave techniques or by using a dedicated "stored programme controlled" computer, and having 5 degrees of freedom of movement or more;

Note *Only functions having proportional control using positional feedback or by using a dedicated "stored programme controlled" computer are counted when determining the number of degrees of freedom of movement.*

j. Air independent power systemsengines and fuel cells, specially designed for underwater use. Underwater fuel cells are packaged in a pressure-tight containment vessel.~~, as follows:~~

~~1. Brayton or Rankine cycle engine air independent power systems having any of the following:~~

~~a. Chemical scrubber or absorber systems specially designed to remove carbon dioxide, carbon monoxide and particulates from recirculated engine exhaust;~~

~~b. Systems specially designed to use a monoatomic gas;~~

~~c. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz, or special mounting devices for shock mitigation; or~~

~~d. Systems specially designed:~~

~~1. To pressurise the products of reaction or for fuel reformation;~~

~~2. To store the products of the reaction; and~~

~~3. To discharge the products of the reaction against a pressure of 100 kPa or more;~~

~~8. A. 2. j. 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;8. A. 2. j. 3. Fuel cell air independent power systems with an output exceeding 2 kW having any of the following:~~

~~a. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special~~ mounting devices for shock mitigation; or

~~b. Systems specially designed:~~

~~1. To pressurise the products of reaction or for fuel reformation;~~

~~2. To store the products of the reaction; and~~

~~3. To discharge the products of the reaction against a pressure of 100 kPa or more;8. A. 2. j. 4. Stirling cycle engine air independent power systems, having all of the following:~~

~~a. Devices or enclosures specially designed for underwater noise reduction in frequencies below 10 kHz or special mounting devices for shock mitigation; and~~

~~b. Specially designed exhaust systems which discharge the products of combustion against a pressure of 100 kPa or more;~~ k. Skirts, seals and fingers, having any of the following:

1. Designed for cushion pressures of 3,830 Pa or more, operating in a significant wave height of 1.25 m (Sea State 3) or more and specially designed for surface effect vehicles (fully skirted variety) ~~controlled~~ requiring review by 8.A.1.f.; or

2. Designed for cushion pressures of 6,224 Pa or more, operating in a significant wave height of 3.25 m (Sea State 5) or more and specially designed for surface effect vehicles (rigid sidewalls) ~~controlled~~ requiring review by 8.A.1.g.;

l. Lift fans rated at more than 400 kW specially designed for surface effect vehicles ~~controlled by~~requiring review by 8.A.1.f. or 8.A.1.g.;

m. Fully submerged subcavitating or supercavitating hydrofoils specially designed for vessels ~~controlled by~~requiring review by 8.A.1.h.;

n. Active systems specially designed or modified to control automatically the sea-induced motion of vehicles or vessels ~~controlled by~~requiring review by 8.A.1.f., 8.A.1.g., 8.A.1.h. or 8.A.1.i.;

o. Propellers, power transmission systems, power generation systems and noise reduction systems, as follows:

1. Water-screw propeller or power transmission systems, as follows, specially designed for surface effect vehicles (fully skirted or rigid sidewall variety), hydrofoils or small waterplane area vessels ~~controlled by~~requiring review by 8.A.1.f., 8.A.1.g., .8.A.1.h. or 8.A.1.i.:

   a. Supercavitating, super-ventilated, partially-submerged or surface piercing propellers rated at more than 7.5 MW;
   b. Contrarotating propeller systems rated at more than 15 MW;
   c. Systems employing pre-swirl or post-swirl techniques for smoothing the flow into a propeller;
   d. Light-weight, high capacity (K factor exceeding 300) reduction gearing;
   e. Power transmission shaft systems, incorporating "composite" material components, capable of transmitting more than 1 MW;

2. Water-screw propeller, power generation systems or transmission systems designed for use on vessels, as follows:

   a. Controllable-pitch propellers and hub assemblies rated at more than 30 MW;
   b. Internally liquid-cooled electric propulsion engines with a power output exceeding 2.5 MW;
   c. "Superconductive" propulsion engines, or permanent magnet electric propulsion engines, with a power output exceeding 0.1 MW;
   d. Power transmission shaft systems, incorporating "composite" material components, capable of transmitting more than 2 MW;
   e. Ventilated or base-ventilated propeller systems rated at more than 2.5 MW;

3. Noise reduction systems designed for use on vessels of 1,000 tonnes displacement or more, as follows:

   a. Systems that attenuate underwater noise at frequencies below 500 Hz and consist of compound acoustic mounts for the acoustic isolation of diesel engines, diesel generator sets, gas turbines, gas turbine generator sets, propulsion motors or propulsion reduction gears, specially designed for sound or vibration isolation, having an intermediate mass exceeding 30% of the equipment to be mounted;
   b. Active noise reduction or cancellation systems, or magnetic bearings, specially designed for power transmission systems, and incorporating electronic control systems capable of actively reducing equipment vibration by the generation of anti-noise or anti-vibration signals directly to the source;

p. Pumpjet propulsion systems having a power output exceeding 2.5 MW using divergent nozzle and flow conditioning vane techniques to improve propulsive efficiency or reduce propulsion-generated underwater-radiated noise;

q. Self-contained, closed or semi-closed circuit (rebreathing) diving and underwater swimming apparatus.

Note *8.A.2.q. does not ~~contro~~require review ofl an individual apparatus for personal use when accompanying its user.*

8. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

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

8. C. MATERIALS

8. C. 1. Syntactic foam designed for underwater use, having all of the following:

a. Designed for marine depths exceeding 1,000 m; and
b. A density less than 561 kg/m^3.

Technical Note
Syntactic foam consists of hollow spheres of plastic or glass embedded in a resin matrix.

8. D. SOFTWARE

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

8. D. 2. Specific "software" specially designed or modified for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction.

8. E. TECHNOLOGY

8. E. 1. "Technology" according to the General Technology Note for the "development" or "production" of equipment or materials ~~controlled by~~requiring review by 8.A., 8.B. or 8.C.

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

a. "Technology" for the "development", "production", repair, overhaul or refurbishing (re-machining) of propellers specially designed for underwater noise reduction;

b. "Technology" for the overhaul or refurbishing of equipment ~~controlled by~~requiring review by 8.A.1., 8.A.2.b., 8.A.2.j., 8.A.2.o., or 8.A.2.p.

9. A. SYSTEMS, EQUIPMENT AND COMPONENTS~~N.B. For propulsion systems designed or rated against neutron or transient ionizing radiation, see the Munitions List.~~*

9. A. 1. Aero gas turbine engines incorporating any of the "technologies" ~~controlled by~~requiring review by 9.E.3.a., as follows:

a. Not certified for the specific "civil aircraft" for which they are intended;

Note *For the purpose of the "civil aircraft" certification process, a number of up to 16 civil certified engines, assemblies or components including spares, is considered appropriate.*

b. Not certified for civil use by the aviation authorities in a participating state;

c. Designed to cruise at speeds exceeding Mach 1.2 for more than thirty minutes.

9. A. 2. Marine gas turbine engines with an ISO standard continuous power rating of 24,245 kW or more and a specific fuel consumption not exceeding 0.219 kg/kWh in the power range from 35 to 100%, and specially designed assemblies and components therefor.

Note *The term 'marine gas turbine engines' includes those industrial, or aero-derivative, gas turbine engines adapted for a ship's electric power generation or propulsion.*

9. A. 3. Specially designed assemblies and components, incorporating any of the "technologies" ~~controlled by~~requiring review by 9.E.3.a., for the following gas turbine engine propulsion systems:

a. ~~Controlled by~~Requiring review by 9.A.1.;

b. Whose design or production origins are either non-participating states or unknown to the manufacturer.

9. A. 4. Space launch vehicles and "spacecraft".

Note *9.A.4. does not ~~control~~require review of payloads.*

N.B. *For the ~~control~~review status of products contained in "spacecraft" payloads, see the appropriate Categories.*

9. A. 5. Liquid rocket propulsion systems containing any of the systems or components ~~controlled by~~requiring review by 9.A.6.

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

9. A. 6. Systems and components specially designed for liquid rocket propulsion systems, as follows:

a. Cryogenic refrigerators, flightweight dewars, cryogenic heat pipes or cryogenic systems specially designed for use in space vehicles and capable of restricting cryogenic fluid losses to less than 30% per year;

b. Cryogenic containers or closed-cycle refrigeration systems capable of providing temperatures of 100 K (-173°C) or less for "aircraft" capable of sustained flight at speeds exceeding Mach 3, launch vehicles or "spacecraft";

c. Slush hydrogen storage or transfer systems;

d. High pressure (exceeding 17.5 MPa) turbo pumps, pump components or their associated gas generator or expander cycle turbine drive systems;

e. High-pressure (exceeding 10.6 MPa) thrust chambers and nozzles therefor;

f. Propellant storage systems using the principle of capillary containment or positive expulsion (i.e., with flexible bladders);

g. Liquid propellant injectors, with individual orifices of 0.381 mm or smaller in diameter (an area of 1.14×10^{-3} cm^2 or smaller for non-circular orifices) specially designed for liquid rocket engines;

h. One-piece carbon-carbon thrust chambers or one-piece carbon-carbon exit cones with densities exceeding 1.4 g/cm^3 and tensile strengths exceeding 48 MPa.

9. A. 7. Solid rocket propulsion systems with any of the following:

a. Total impulse capacity exceeding 1.1 MNs;

b. Specific impulse of 2.4 kNs/kg or more when the nozzle flow is expanded to ambient sea level conditions for an adjusted chamber pressure of 7 MPa;

c. Stage mass fractions exceeding 88% and propellant solid loadings exceeding 86%;

d. Any of the components ~~controlled by~~requiring review by 9.A.8.; or

e. Insulation and propellant bonding systems using direct-bonded motor designs to provide a strong mechanical bond or a barrier to chemical migration between the solid propellant and case insulation material.

Technical Note
For the purposes of 9.A.7.e., a strong mechanical bond means bond strength equal to or more than propellant strength.

9. A. 8. Components, as follows, specially designed for solid rocket propulsion systems:

a. Insulation and propellant bonding systems using liners to provide a strong mechanical bond or a barrier to chemical migration between the solid propellant and case insulation material;

Technical Note
For the purposes of 9.A.8.a., a strong mechanical bond means bond strength equal to or more than propellant strength.

b. Filament-wound "composite" motor cases exceeding 0.61 m in diameter or having structural efficiency ratios (PV/W) exceeding 25 km.

Technical Note
The structural efficiency ratio (PV/W) is the burst pressure (P) multiplied by the vessel volume (V) divided by the total pressure vessel weight (W).

c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0.075 mm/s;

d. Movable nozzle or secondary fluid injection thrust vector control systems capable of any of the following:

1. Omni-axial movement exceeding ± 5°;
2. Angular vector rotations of 20°/s or more; or
3. Angular vector accelerations of 40°/s^2 or more.

9. A. 9. Hybrid rocket propulsion systems with:

a. Total impulse capacity exceeding 1.1 MNs; or

b. Thrust levels exceeding 220 kN in vacuum exit conditions.

9. A. 10. Specially designed components, systems and structures for launch vehicles, launch vehicle propulsion systems or "spacecraft", as follows:

a. Components and structures each exceeding 10 kg, specially designed for launch vehicles manufactured using metal "matrix," "composite," organic "composite," ceramic "matrix" or intermetallic reinforced materials ~~controlled by~~requiring review by 1.C.7. or 1.C.10.;

Note *The weight cut-off is not relevant for nose cones.*

b. Components and structures specially designed for launch vehicle propulsion systems ~~controlled by~~requiring review by 9.A.5 to 9.A.9. manufactured using metal matrix, composite, organic composite, ceramic matrix or intermetallic reinforced materials ~~controlled by~~requiring review by 1.C.7. or 1.C.10.;

c. Structural components and isolation systems specially designed to control actively the dynamic response or distortion of "spacecraft" structures;

d. Pulsed liquid rocket engines with thrust-to-weight ratios equal to or more than 1 kN/kg and a response time (the time required to achieve 90% of total rated thrust from start-up) of less than 30 ms.

9. A. 11. Ramjet, scramjet or combined cycle engines and specially designed components therefor.

9. A. 12. Non-civil-certified aircraft; all aero gas turbine engines; unmanned aerial vehicles; and parts and components therefor:

a. Non-civil-certified aircraft and specially designed parts and components therefor. This does not include parts and components solely designed to accommodate a carrying of passengers including seats, food services, environmental conditioning, lighting systems, and passenger safety devices;

Note: Civil certified aircraft consist of aircraft that have been certified for general civil use by the civil aviation authorities of the original equipment manufacturer's government.

b. All gas turbine engines except those designed for stationary power generation applications, and specially designed parts and components therefor;

c. Unmanned aerial vehicles and parts and components therefor with any of the following characteristics:

1. Capable of autonomous operation;
2. Capable of operating beyond line-of-sight;
3. Incorporating a satellite navigation receiver (e.g. GPS);
4. A gross take-off weight greater than 25 kg;

d. Parts and components for civil-certified aircraft (not including engines).

Note 1: This does not include parts and components for normal maintenance of non-Iraqi-owned or –leased civil-certified aircraft that were originally qualified or certified by the original equipment manufacturer of the aircraft.

Note 2: For Iraqi-owned or –leased civil aircraft, review of parts and components for normal maintenance is not required if the maintenance is performed in a country other than Iraq.

Note 3: For Iraqi-owned or –leased aircraft, parts and components are subject to review except for equivalent one-for-one replacement of parts and components that *have been certified or qualified by the original equipment manufacturer for use on the aircraft*.

9. A. 13. Heavy military-useful transport:

a. Low-bed trailers/loaders with a payload capacity of 20 MT or greater; bed width of 2.5 meters or more with any extenders fully deployed; kingpin of 2.5 inches or greater; 3 or more axles; and tire size of 1200x20 or greater. Tractor or cab may or may not be attached.

b. Trucks with any military attributes (e.g., armor plating, electromagnetic pulse hardened, multiple fuel capability, independent steering) or trucks with: all-wheel drive capability, payload of 15 tons or greater, reinforced chassis, horsepower of 300 or more, central tire inflation, run flat capability tires and/or semi-pneumatic, or independent leveling/stabilization. Trucks capable of attachments such as hoists, cranes, drills, oil workover capabilities would be covered as items for review.

Note 1: Multiple fuel capability indicates the ability of the same engine to use different combustible fuels, e.g.,gasoline, diesel, alcohol.

Note 2: Reinforced chassis could include inter alia extra members and/or heavier gauge metal than standard, additional leaves and/or springs, additional engine and transmission protection, heavier grade transmission (including axles), and equipment for improved ground clearance

9. B. TEST, INSPECTION AND PRODUCTION EQUIPMENT

9. B. 1. Specially designed equipment, tooling and fixtures, as follows, for manufacturing gas turbine blades, vanes or tip shroud castings:

a. Directional solidification or single crystal casting equipment;

b. Ceramic cores or shells.

9. B. 2. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for the "development" of gas turbine engines, assemblies or components incorporating "technologies" ~~controlled by~~requiring review by 9.E.3.a.

9. B. 3. Equipment specially designed for the "production" or test of gas turbine brush seals designed to operate at tip speeds exceeding 335 m/s, and temperatures in excess of 773 K (500°C), and specially designed components or accessories therefor.

9. B. 4. Tools, dies or fixtures for the solid state joining of "superalloy", titanium or intermetallic airfoil-to-disk combinations described in 9.E.3.a.3. or 9.E.3.a.6. for gas turbines.

9. B. 5. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for use with any of the following wind tunnels or devices:

a. Wind tunnels designed for speeds of Mach 1.2 or more, except those specially designed for educational purposes and having a test section size (measured laterally) of less than 250 mm;

Technical Note
Test section size: the diameter of the circle, or the side of the square, or the longest side of the rectangle, at the largest test section location.

b. Devices for simulating flow-environments at speeds exceeding Mach 5, including hot-shot tunnels, plasma arc tunnels, shock tubes, shock tunnels, gas tunnels and light gas guns; or

c. Wind tunnels or devices, other than two-dimensional sections, capable of simulating Reynolds number flows exceeding 25 x 10^6.

9. B. 6. Acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 µPa) with a rated output of 4 kW or more at a test cell temperature exceeding 1,273 K (1,000°C), and specially designed quartz heaters therefor.

9. B. 7. Equipment specially designed for inspecting the integrity of rocket motors using non-destructive test (NDT) techniques other than planar X-ray or basic physical or chemical analysis.

9. B. 8. Transducers specially designed for the direct measurement of the wall skin friction of the test flow with a stagnation temperature exceeding 833 K (560°C).

9. B. 9. Tooling specially designed for producing turbine engine powder metallurgy rotor components capable of operating at stress levels of 60% of ultimate tensile strength (UTS) or more and metal temperatures of 873 K (600°C) or more.

9 B. 10. Vibration test equipment capable of simulating flight conditions, and specially designed parts and components therefor.

9. C. MATERIALS - None

9. D. SOFTWARE

9. D. 1. "Software" specially designed or modified for the "development" of equipment or "technology" ~~controlled by~~requiring review by 9.A., 9.B. or 9.E.3.

9. D. 2. "Software" specially designed or modified for the "production" of equipment ~~controlled by~~requiring review by 9.A. or 9.B.

9. D. 3. "Software" specially designed or modified for the "use" of full authority digital electronic engine controls (FADEC) for propulsion systems ~~controlled by~~requiring review by 9.A. or equipment ~~controlled by~~requiring review by 9.B., as follows:

a. "Software" in digital electronic controls for propulsion systems, aerospace test facilities or air breathing aero-engine test facilities;

b. Fault-tolerant "software" used in "FADEC" systems for propulsion systems and associated test facilities.

9. D. 4. Other "software", as follows:

a. 2D or 3D viscous "software" validated with wind tunnel or flight test data required for detailed engine flow modelling;

b. "Software" for testing aero gas turbine engines, assemblies or components, specially designed to collect, reduce and analyse data in real time, and capable of feedback control, including the dynamic adjustment of test articles or test conditions, as the test is in progress;

c. "Software" specially designed to control directional solidification or single crystal casting;

d. "Software" in "source code," "object code" or machine code required for the "use" of active compensating systems for rotor blade tip clearance control.

Note *9.D.4.d. does not ~~control~~ require review of "software" embedded in ~~uncontrolled~~ equipment which otherwise does not require review or required for maintenance activities associated with the calibration or repair or updates to the active compensating clearance control system.*

9. D. 5. Software for "development," "production," or "use" of vibration test equipment capable of simulating flight conditions, and specially designed parts and components therefor.

9. E. TECHNOLOGY

9. E. 1. "Technology" according to the General Technology Note for the "development" of equipment or "software" ~~controlled by~~requiring review by 9.A.1.c., 9.A.4. to 9.A.~~11.~~13., 9.B. or 9.D.

9. E. 2. "Technology" according to the General Technology Note for the "production" of equipment ~~controlled by~~requiring review by 9.A.1.c., 9.A.4. to 9.A.~~11.~~13., or 9.B.

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

Note "Development" or "production" "technology" ~~controlled by~~requiring review by 9.E. for gas turbine engines ~~remains controlled~~ continues to require review even when used as "use" "technology" for repair, rebuild and overhaul. ~~Excluded from control are: technical data, drawings or documentation for maintenance activities directly associated with calibration, removal or replacement of damaged or unserviceable line replaceable units, including replacement of whole engines or engine modules.~~

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

a. "Technology" "required" for the "development" or "production" of any of the following gas turbine engine components or systems:

1. Gas turbine blades, vanes or tip shrouds made from directionally solidified (DS) or single crystal (SC) alloys having (in the 001 Miller Index Direction) a stress-rupture life exceeding 400 hours at 1,273 K (1,000°C) at a stress of 200 MPa, based on the average property values;

2. Multiple domed combustors operating at average burner outlet temperatures exceeding 1,813 K (1,540°C) or combustors incorporating thermally decoupled combustion liners, non-metallic liners or non-metallic shells;

3. Components manufactured from any of the following:

a. Organic "composite" materials designed to operate above 588 K (315°C);
b. Metal "matrix" "composite", ceramic "matrix", intermetallic or intermetallic reinforced materials ~~controlled by~~requiring review by 1.C.7.; or
c. "Composite" material ~~controlled by~~requiring review by 1.C.10. and manufactured with resins ~~controlled by~~requiring review by 1.C.8.

4. Uncooled turbine blades, vanes, tip-shrouds or other components designed to operate at gas path temperatures of 1,323 K (1,050°C) or more;

5. Cooled turbine blades, vanes or tip-shrouds, other than those described in 9.E.3.a.1., exposed to gas path temperatures of 1,643 K (1,370°C) or more;

6. Airfoil-to-disk blade combinations using solid state joining;

7. Gas turbine engine components using "diffusion bonding" "technology" ~~controlled by~~requiring review by 2.E.3.b.;

8. Damage tolerant gas turbine engine rotating components using powder metallurgy materials ~~controlled by~~requiring review by 1.C.2.b.;

9. "FADEC" for gas turbine and combined cycle engines and their related diagnostic components, sensors and specially designed components;

10. Adjustable flow path geometry and associated control systems for:

    a. Gas generator turbines;
    b. Fan or power turbines;
    c. Propelling nozzles; or

    Note 1 *Adjustable flow path geometry and associated control systems in 9.E.3.a.10. do not include inlet guide vanes, variable pitch fans, variable stators or bleed valves for compressors.*

    Note 2 *9.E.3.a.10. does not ~~control~~ require review of "development" or "production" "technology" for adjustable flow path geometry for reverse thrust.*

11. Wide chord hollow fan blades without part-span support;

b. "Technology" "required" for the "development" or "production" of any of the following:

1. Wind tunnel aero-models equipped with non-intrusive sensors capable of transmitting data from the sensors to the data acquisition system; or

2. "Composite" propeller blades or propfans capable of absorbing more than 2,000 kW at flight speeds exceeding Mach 0.55;

c. "Technology" "required" for the "development" or "production" of gas turbine engine components using "laser", water jet, ECM or EDM hole drilling processes to produce holes having any of the following sets of characteristics:

1. All of the following:

    a. Depths more than four times their diameter;
    b. Diameters less than 0.76 mm; and
    c. Incidence angles equal to or less than 25°; or

2. All of the following:

   a. Depths more than five times their diameter;
   b. Diameters less than 0.4 mm; and
   c. Incidence angles of more than 25°;

Technical Note
For the purposes of 9.E.3.c., incidence angle is measured from a plane tangential to the airfoil surface at the point where the hole axis enters the airfoil surface.

d. "Technology" "required" for the "development" or "production" of helicopter power transfer systems or tilt rotor or tilt wing "aircraft" power transfer systems;

e. "Technology" for the "development" or "production" of reciprocating diesel engine ground vehicle propulsion systems having all of the following:

   1. A box volume of 1.2 m^3 or less;

   2. An overall power output of more than 750 kW based on 80/1269/EEC, ISO 2534 or national equivalents; and

   3. A power density of more than 700 kW/m^3 of box volume;

   Technical Note
   Box volume: the product of three perpendicular dimensions is measured in the following way:
   Length: The length of the crankshaft from front flange to flywheel face;
   Width: The widest of the following:
   a. The outside dimension from valve cover to valve cover;
   b. The dimensions of the outside edges of the cylinder heads; or
   c. The diameter of the flywheel housing;
   Height: The largest of the following:
   a. The dimension of the crankshaft centre-line to the top plane of the valve cover (or cylinder head) plus twice the stroke; or
   b. The diameter of the flywheel housing.

f. "Technology" "required" for the "production" of specially designed components, as follows, for high output diesel engines:

   1. "Technology" "required" for the "production" of engine systems having all of the following components employing ceramics materials ~~controlled by~~requiring review by 1.C.7:

      a. Cylinder liners;

b. Pistons;

c. Cylinder heads; and

d. One or more other components (including exhaust ports, turbochargers, valve guides, valve assemblies or insulated fuel injectors);

2. "Technology" "required" for the "production" of turbocharger systems, with single-stage compressors having all of the following:

a. Operating at pressure ratios of 4:1 or higher;

b. A mass flow in the range from 30 to 130 kg per minute; and

c. Variable flow area capability within the compressor or turbine sections;

3. "Technology" "required" for the "production" of fuel injection systems with a specially designed multifuel (e.g., diesel or jet fuel) capability covering a viscosity range from diesel fuel (2.5 cSt at 310.8 K (37.8°C)) down to gasoline fuel (0.5 cSt at 310.8 K (37.8°C)), having both of the following:

a. Injection amount in excess of 230 mm^3 per injection per cylinder; and

b. Specially designed electronic control features for switching governor characteristics automatically depending on fuel property to provide the same torque characteristics by using the appropriate sensors;

g. "Technology" "required" for the "development" or "production" of high output diesel engines for solid, gas phase or liquid film (or combinations thereof) cylinder wall lubrication, permitting operation to temperatures exceeding 723 K (450°C), measured on the cylinder wall at the top limit of travel of the top ring of the piston.

Technical Note

High output diesel engines: diesel engines with a specified brake mean effective pressure of 1.8 MPa or more at a speed of 2,300 r.p.m., provided the rated speed is 2,300 r.p.m. or more.

9 E. 4. Technology for the “development”, “production”, or “use” of vibration test equipment capable of simulating flight conditions, and specially designed parts and components therefor.

DEFINITIONS OF TERMS USED IN THE CONVENTIONAL SECTION~~SE LISTS~~

GOODS REVIEW LIST
CONVENTIONAL SECTION
DEFINITIONS

This document contains the definitions of the terms used in the Conventional Section, ~~se Lists~~ in alphabetical order.

<u>Note 1</u> *Definitions apply throughout the ~~Lists and their Annexes~~Conventional Section. The references are purely advisory and have no effect on the universal application of defined terms throughout the Conventional Section. ~~se Lists and their Annexes~~Sections.*

<u>Note 2</u> *Words and terms contained in the List of Definitions only take the defined meaning where this is indicated by their being enclosed in quotations marks (" "). Elsewhere, words and terms take their commonly accepted (dictionary) meanings, unless a local definition for a particular review specification is given. ~~(See also 'Statements of Understanding and Validity Notes – Definition of Terms used in these Lists').~~*

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

Cat 7
"Active flight control systems"
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.

Cat 6
Cat 8
"Active pixel"
A minimum (single) element of the solid state array which has a photoelectric transfer function when exposed to light (electromagnetic) radiation.

Cat 1
~~ML 7~~
"Adapted for use in war"
Any modification or selection (such as altering purity, shelf life, virulence, dissemination characteristics, or resistance to UV radiation) designed to increase the effectiveness in producing casualties in humans or animals, degrading equipment or damaging crops or the environment.

Cat 2
"Adaptive control"
A control system that adjusts the response from conditions detected during the operation (Reference: ISO 2806-1980).

ML8. Cat 1
"Additives"
Substances used in explosive formulations to improve their properties.

Cat 1
Cat 7 & 9
"Aircraft"
A fixed wing, swivel wing, rotary wing (helicopter), tilt rotor or tilt-~~ML 8, 9 & 10~~wing airborne vehicle.

Cat 2
"All compensations available"
"All compensations available" means after all feasible measures available to the manufacturer to minimise all systematic positioning errors for the particular machine-tool model are considered.

Cat 3
Cat 5 P1
"Allocated by the ITU"
The allocation of frequency bands according to the ITU Radio Regulations (Edition 1998) for primary, permitted and secondary services.
N.B. Additional and alternative allocations are not included.

Cat 2
"Angular position deviation"
The maximum difference between angular position and the actual, very accurately measured angular position after the workpiece mount of the table has been turned out of its initial position. (Reference: VDI/VDE 2617, Draft: 'Rotary tables on coordinate measuring machines').

Cat 5 "Asymmetric algorithm "

A cryptographic algorithm using different, mathematically-related keys for encryption and decryption.

Technical Note

A common use of "asymmetric algorithms" is key management.

Cat 5 "Asynchronous transfer mode" ("ATM")

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.

Cat 5 "ATM"

"ATM" is equivalent to "Asynchronous transfer mode".

Cat 6 "Automatic target tracking"

A processing technique that automatically determines and provides as output an extrapolated value of the most probable position of the target in real time.

Cat 3 "Basic gate propagation delay time"

The propagation delay time value corresponding to the basic gate used in a "monolithic integrated circuit". For a 'family' of "monolithic integrated circuits", this may be specified either as the propagation delay time per typical gate within the given 'family' or as the typical propagation delay time per gate within the given 'family'.

Technical Notes

1. *"Basic gate propagation delay time" is not to be confused with the input/output delay time of a complex "monolithic integrated circuit".*
2. *'Family' consists of all integrated circuits to which all of the following are applied as their manufacturing methodology and specifications except their respective functions:*
   a. *The common hardware and software architecture;*
   b. *The common design and process technology; and*
   c. *The common basic characteristics.*

GTN "Basic scientific research"

Experimental or theoretical work undertaken principally to acquire new knowledge of the fundamental principles of phenomena or observable facts, not primarily directed towards a specific practical aim or objective.

Cat 7 "Bias" (accelerometer)

An accelerometer output when no acceleration is applied.

ML 7 Cat 1 "Biocatalysts"

Enzymes for specific chemical or biochemical reactions or other biological compounds which bind to and accelerate the degradation of CW agents.

Technical Note

'Enzymes' means "biocatalysts" for specific chemical or biochemical reactions.

~~ML 7~~Cat 1 "Biopolymers"

Biological macromolecules as follows:

a. Enzymes for specific chemical or biochemical reactions;
b. Antibodies, monoclonal, polyclonal or anti-idiotypic;
c. Specially designed or specially processed receptors;

Technical Notes

1. *'Anti-idiotypic antibodies' means antibodies which bind to the specific antigen binding sites of other antibodies;*
2. *'Monoclonal antibodies' means proteins which bind to one antigenic site and are produced by a single clone of cells;*
3. *'Polyclonal antibodies' means a mixture of proteins which bind to the specific antigen and are produced by more than one clone of cells;*
4. *'Receptors' means biological macromolecular structures capable of binding ligands, the binding of which affects physiological functions.*

Cat 2 "Camming" (axial displacement)

Axial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle faceplate, at a point next to the circumference of the spindle faceplate (Reference: ISO 230/1 1986, paragraph 5.63).

Cat 1 "Carbon fibre preforms"

An ordered arrangement of uncoated or coated fibres intended to constitute a framework of a part before the "matrix" is introduced to form a "composite".

Cat 4 "CE"

"CE" is equivalent to "computing element".

Cat 6 "Chemical Laser"

A "laser" in which the excited species is produced by the output energy from a chemical reaction.

"Circuit element"

A single active or passive functional part of an electronic circuit, such as one diode, one transistor, one resistor, one capacitor, etc.

Cat 7 "Circulation-controlled anti-torque or circulation-controlled direction control systems"

Control systems using air blown over aerodynamic surfaces to increase or control the forces generated by the surfaces.

Cat 1
Cat 7
Cat 9 "Civil aircraft"

Those "aircraft" listed by designation in published airworthiness certification lists by the civil aviation authorities to fly commercial civil

~~ML 10~~ internal and external routes or for legitimate civil, private or business use.

Cat 1 "Commingled"
Filament to filament blending of thermoplastic fibres and reinforcement fibres in order to produce a fibre reinforcement "matrix" mix in total fibre form.

Cat 1 "Comminution"
A process to reduce a material to particles by crushing or grinding.

Cat 5 "Common channel signalling"
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.

Cat 4 "Communications channel controller"
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.

Cat 1, Cat 2, Cat 6, Cat 8 & 9 "Composite"
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.

Cat 3, Cat 4 "Composite theoretical performance" ("CTP")
A measure of computational performance given in millions of theoretical operations per second (Mtops), calculated using the aggregation of "computing elements"
N.B. *See Category 4, Technical Note.*

Cat 2 "Compound rotary table"
A table allowing the workpiece to rotate and tilt about two non-parallel axes, which can be coordinated simultaneously for "contouring control".

Cat 4 "Computing element" ("CE")
The smallest computational unit that produces an arithmetic or logic result.

Cat 2 "Contouring control"
Two or more "numerically controlled" motions operating in accordance with instructions that specify the next required position and the required feed rates to that position. These feed rates are varied in relation to each other so that a desired contour is generated (Ref. ISO/DIS 2806 - 1980).

Cat 1, Cat 3, Cat 6 "Critical temperature"
(sometimes referred to as the transition temperature) of a specific "superconductive" material is the temperature at which the material loses all resistance to the flow of direct electrical current.

Cat 5 "Cryptography"

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.

Technical Note

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

Cat 3
Cat 4 "CTP"

"CTP" is equivalent to "Composite theoretical performance".

Cat 5 "Data signalling rate"

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.

Note *When determining the "data signalling rate", servicing and administrative channels shall be excluded.*

Technical Note

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

Cat 6 "Deformable Mirrors"

Mirrors:

a. Having 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. Having multiple optical reflecting elements that can be individually and dynamically repositioned by the application of torques or forces to compensate for distortions in the optical waveform incident upon the mirror.

"Deformable mirrors" are also known as adaptive optic mirrors.

GTN ~~Both Lists~~ "Development"

Is related to all stages prior to serial production, such as: design, design research, design analyses, design concepts, assembly and testing of prototypes, pilot production schemes, design data, process of transforming design data into a product, configuration design, integration design, layouts.

Cat 1
Cat 2
Cat 9 "Diffusion bonding"

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.

Cat 4 "Digital computer"
Cat 5

Equipment which can, in the form of one or more discrete variables, perform all of the following:

a. Accept data;
b. Store data or instructions in fixed or alterable (writable) storage devices;
c. Process data by means of a stored sequence of instructions which is modifiable; and
d. Provide output of data.

Technical Note
Modifications of a stored sequence of instructions include replacement of fixed storage devices, but not a physical change in wiring or interconnections.

Cat 5 "Digital transfer rate"

The total bit rate of the information that is directly transferred on any type of medium. (See also "total digital transfer rate").

Cat 2 "Direct-acting hydraulic pressing"

A deformation process which uses a fluid-filled flexible bladder in direct contact with the workpiece.

"Discrete component"

A separately packaged "circuit element" with its own external connections.

Cat 7 "Drift rate" (gyro)

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.

Cat 5 "Dynamic adaptive routing"

Automatic rerouting of traffic based on sensing and analysis of current actual network conditions.

Note *This does not include cases of routing decisions taken on predefined information.*

Cat 3 "Dynamic signal analysers"

"Signal analysers" which use digital sampling and tranformation techniques to form a Fourier spectrum display of the given waveform including amplitude and phase information.

Cat 1 "Effective gram"

"Effective gram" for plutonium isotope is defined as the isotope weight in grams.

Cat 5
Cat 6
"Electronically steerable phased array antenna"
An antenna which forms a beam by means of phase coupling, (i.e., the beam direction is controlled by the complex excitation coefficients of the radiating elements) and the direction of that beam can be varied (both in transmission and reception) in azimuth or in elevation, or both, by application of an electrical signal.

Cat 3
Cat 4
Cat 5
"Electronic assembly"
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.

Cat 2
~~ML 17~~
"End-effectors"
Grippers, active tooling units and any other tooling that is attached to the baseplate on the end of a "robot" manipulator arm.

Technical Note
'Active tooling units' are devices for applying motive power, process energy or sensing to a workpiece.

Cat 6
"Equivalent Density"
The mass of an optic per unit optical area projected onto the optical surface.

Cat 4
Cat 7
"Expert systems"
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).

~~ML 7~~ Cat 1
"Expression Vectors"
Carriers (e.g., plasmid or virus) used to introduce genetic material into host cells.

Cat 7
Cat 9
"FADEC"
Full Authority Digital Engine Control (FADEC) - an electronic control system for gas turbine or combined cycle engines utilising a digital computer to control the variables required to regulate engine thrust or shaft power output throughout the engine operating range from the beginning of fuel metering to fuel shutoff.

Cat 4
"Fault tolerance"
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.

Cat 1 "Fibrous or filamentary materials"
Cat 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.

Cat 3 "Film type integrated circuit"

An array of "circuit elements" and metallic interconnections formed by deposition of a thick or thin film on an insulating "substrate".

~~ML 15~~Cat 6 "First generation image intensifier tubes"

Electrostatically focused tubes, employing input and output fibre optic or glass face plates, multi-alkali photocathodes (S-20 or S-25), but not microchannel plate amplifiers.

Cat 5 "Fixed"

The coding or compression algorithm cannot accept externally supplied parameters (eg., cryptographic or key variables) and cannot be modified by the user.

Cat 7 "Flight control optical sensor array"

A network of distributed optical sensors, using "laser" beams, to provide real-time flight control data for on-board processing.

Cat 7 "Flight path optimization"

A procedure that minimizes deviations from a four-dimensional (space and time) desired trajectory based on maximizing performance or effectiveness for mission tasks.

Cat 6 "Focal plane array"

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.

<u>Note</u> *This definition does not include a stack of single detector elements or any two, three or four element detectors provided time delay and integration is not performed within the element.*

Cat 3 "Fractional bandwidth"

The "instantaneous bandwidth" divided by the centre frequency, expressed as a percentage.

Cat 5 "Frequency hopping "

A form of "spread spectrum" in which the transmission frequency of a single communication channel is made to change by a random or pseudo-random sequence of discrete steps.

Cat 3 Cat 5 "Frequency switching time"
The maximum time (i.e., delay) taken by a signal, when switched from one selected output frequency to another selected output frequency, to reach any of the following:
a. A frequency within 100 Hz of the final frequency; or
b. An output level within 1 dB of the final output level.

Cat 3 "Frequency synthesiser"
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.

Cat 1 "Gas atomisation"
A process to reduce a molten stream of metal alloy to droplets of 500 µm diameter or less by a high pressure gas stream.

Cat 6 "Geographically dispersed"
Sensors are considered "geographically dispersed" when each location is distant from any other more than 1,500 m in any direction. Mobile sensors are always considered "geographically dispersed".

Cat 4 "Global interrupt latency time"
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.

Cat 2 "Hot isostatic densification"
A process of pressurising a casting at temperatures exceeding 375 K (102°C) in a closed cavity through various media (gas, liquid, solid particles, etc.) to create equal force in all directions to reduce or eliminate internal voids in the casting.

Cat 4 "Hybrid computer"
Equipment which can perform all of the following:
a. Accept data;
b. Process data, in both analogue and digital representations; and
c. Provide output of data.

Cat 3 "Hybrid integrated circuit"
Any combination of integrated circuit(s), or integrated circuit with "circuit elements" or "discrete components" connected together to perform (a) specific function(s), and having all of the following characteristics:
a. Containing at least one unencapsulated device;
b. Connected together using typical IC production methods;
c. Replaceable as an entity; and
d. Not normally capable of being disassembled.

Cat 4 "Image enhancement"
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.

Cat 5 "Information security"
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.

Technical Note
'Cryptanalysis': the analysis of a cryptographic system or its inputs and outputs to derive confidential variables or sensitive data, including clear text. (ISO 7498-2-1988 (E), paragraph 3.3.18).

Cat 3
Cat 5P1 "Instantaneous bandwidth"
The bandwidth over which output power remains constant within 3 dB without adjustment of other operating parameters.

Cat 6 "Instrumented range"
The specified unambiguous display range of a radar.

Cat 6 "Interconnected radar sensors"
Two or more radar sensors are interconnected when they mutually exchange data in real time.

GTN
~~GSN~~ "In the public domain"
This means "technology" or "software" which has been made available without restrictions upon its further dissemination.

Note *Copyright restrictions do not remove "technology" or "software" from being "in the public domain".*

Cat 6 "Intrinsic magnetic gradiometer"
A single magnetic field gradient sensing element and associated electronics the output of which is a measure of magnetic field gradient.

Cat 2 "Isostatic presses"
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.

Cat 2, 3,5
6 & 9 "Laser"
An assembly of components which produce both spatially and

~~ML5, 9 & 23~~ temporally coherent light that is amplified by stimulated emission of radiation.

Cat 2 "Linearity"

(Usually measured in terms of non-linearity) is the maximum deviation of the actual characteristic (average of upscale and downscale readings), positive or negative, from a straight line so positioned as to equalise and minimise the maximum deviations.

Cat 4 "Local area network"

A data communication system having all of the following characteristics:

a. Allows an arbitrary number of independent data devices to communicate directly with each other; and
b. Is confined to a geographical area of moderate size (e.g., office building, plant, campus, warehouse).
c.

Technical Note

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

Cat 6 "Magnetic gradiometers"

Are designed to detect the spatial variation of magnetic fields from sources external to the instrument. They consist of multiple "magnetometers" and associated electronics the output of which is a measure of magnetic field gradient. (See also "Intrinsic Magnetic Gradiometer")

Cat 6 "Magnetometers"

Are designed to detect magnetic fields from sources external to the instrument. They consist of a single magnetic field sensing element and associated electronics the output of which is a measure of the magnetic field.

Cat 4 "Main storage"

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.

Cat 1
Cat 2
Cat 8 & 9 "Matrix"

A substantially continuous phase that fills the space between particles, whiskers or fibres.

Cat 2 "Measurement uncertainty"

The characteristic parameter which specifies in what range around the output value the correct value of the measurable variable lies with a confidence level of 95%. It includes the uncorrected systematic deviations, the uncorrected backlash and the random deviations
(Reference: ISO 10360-2, or VDI/VDE 2617).

Cat 1 "Mechanical alloying"
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.

Cat 1 "Melt extraction"
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.

Cat 1 "Melt spinning"
A process to "solidify rapidly" a molten metal stream impinging upon a rotating chilled block, forming a flake, ribbon or rod-like product.

Cat 3 "Microcomputer microcircuit"
A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing general purpose instructions from an internal storage, on data contained in the internal storage.

Technical Note
The internal storage may be augmented by an external storage.

Cat 3 "Microprocessor microcircuit"
A "monolithic integrated circuit" or "multichip integrated circuit" containing an arithmetic logic unit (ALU) capable of executing a series of general purpose instructions from an external storage.

Technical Note
The "microprocessor microcircuit" normally does not contain integral user-accessible storage, although storage present on-the-chip may be used in performing its logic function.

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

"Microprogramme"
A sequence of elementary instructions maintained in a special storage, the execution of which is initiated by the introduction of its reference instruction register.

~~ML 8~~Cat 1 "Military explosives"
Solid, liquid or gaseous substances or mixtures of substances which, in their application as primary, booster, or main charges in warheads, demolition and other military applications, are required to detonate.

~~ML 4~~Cat 1 "Military pyrotechnic(s)"
~~ML 8~~
Mixtures of solid or liquid fuels and oxidizers which, when ignited, undergo an energetic chemical reaction at a controlled rate intended to

produce specific time delays, or quantities of heat, noise, smoke, visible light or infrared radiation. Pyrophorics are a subclass of pyrotechnics, which contain no oxidizers but ignite spontaneously on contact with air.

Cat 3 "Monolithic integrated circuit"

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; <u>and</u>
c. Perform the function(s) of a circuit.

Cat 6 "Monospectral imaging sensors"

Are capable of acquisition of imaging data from one discrete spectral band.

Cat 3 "Multichip integrated circuit"

Two or more "monolithic integrated circuits" bonded to a common "substrate".

Cat 4 "Multi-data-stream processing"

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; <u>or</u>
d. Structured arrays of processing elements, including systolic arrays.

Cat 5 "Multilevel security"

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.

<u>Technical Note</u>

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

Cat 6 "Multispectral imaging sensors"

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.

Cat 4 "Network access controller"

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.

Cat 4 "Neural computer"

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.

Cat 6 "Noise level"

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., (nanotesla)^2/Hz) and (f_2-f_1) defines the bandwidth of interest.

~~ML 17~~Cat 1 "Nuclear reactor"

Includes the items within or attached directly to the reactor vessel, the equipment which controls the level of power in the core, and the components which normally contain or come into direct contact with or control the primary coolant of the reactor core.

Cat 2 "Numerical control"

The automatic control of a process performed by a device that makes use of numeric data usually introduced as the operation is in progress (Ref. ISO 2382).

Cat 4 "Object code"
Cat 9 "Object code": An equipment executable form of a convenient expression of one or more processes ("source code" (or source language)) which has been converted by a programming system.

Cat 5 "Optical amplification"

In optical communications, 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.

Cat 4 "Optical computer"

A computer designed or modified to use light to represent data and whose computational logic elements are based on directly coupled optical devices.

Cat 3 "Optical integrated circuit"

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).

Cat 5 "Optical switching"
The routing of or switching of signals in optical form without conversion to electrical signals.

Cat 3 "Overall current density"
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.).

Cat 6 "Peak power"
Energy per pulse in joules divided by the pulse duration in seconds.

Cat 5 "Personalised smart card"
A smart card containing a microcircuit which has been programmed for a specific application and cannot be reprogrammed for any other application by the user.

Cat 7 "Power management"
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.

~~ML 8~~Cat 1 "Precursors"
Speciality chemicals used in the manufacture of military explosives.

Cat 1 "Previously separated"
The application of any process intended to increase the concentration of the controlled isotope.

Cat 7 "Primary flight control"
"Aircraft" stability or manoeuvering control using force/moment generators, i.e. aerodynamic control surfaces or propulsive thrust vectoring.

Cat 4 "Principal element"
An element is a "principal element" when its replacement value is more than 35% of the total value of the system of which it is an element. Element value is the price paid for the element by the manufacturer of the system, or by the system integrator. Total value is the normal international selling price to unrelated parties at the point of manufacture or consolidation of shipment.

GTN "Production"
Means all production stages, such as: product engineering, manufacture, integration, assembly (mounting), inspection, testing, quality assurance.

Cat 2 "Programme"
Cat 4 A sequence of instructions to carry out a process in, or convertible

Cat 5 & 6 into, a form executable by an electronic computer.

Cat 6 "Pulse compression"
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.

Cat 6 "Pulse duration"
Duration of a "laser" pulse measured at Full Width Half Intensity (FWHI) levels.

Cat 6 "Q-switched laser"
A "laser" in which the energy is stored in the population inversion or in the optical resonator and subsequently emitted in a pulse.

Cat 6 "Radar frequency agility"
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.

Cat 6 "Radar spread spectrum"
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.

Cat 3 "Real-time bandwidth"
For "dynamic signal analysers", 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.

Cat 2, 4
Cat 6 & 7 "Real time processing"
The processing of data by a computer system providing a required level of service, as a function of available resources, within a guaranteed response time, regardless of the load of the system, when stimulated by an external event.

Cat 5
Cat 6
Cat 9
GTN "Required"
As applied to "technology", refers to only that portion of "technology" which is peculiarly responsible for achieving or exceeding the controlled performance levels, characteristics or functions specified as causing an item to require review. Such "required" "technology" may be shared by different products.

Cat 2 "Resolution"
The least increment of a measuring device; on digital instruments, the least significant bit. (Reference: ANSI B-89.1.12)

~~ML 7~~Cat 1 "Riot control agents"

Substances which produce temporary irritating or disabling physical effects which disappear within minutes of removal from exposure. There is no significant risk of permanent injury and medical treatment is rarely required.

Cat 2
Cat 8
~~ML 17~~

"Robot"

A manipulation mechanism, which may be of the continuous path or of the point-to-point variety, may use sensors, and has all the following characteristics:

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

Note *The above definition does not include the following devices:*

1. *Manipulation mechanisms which are only manually/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.*

Cat 1 "Rotary atomisation"
A process to reduce a stream or pool of molten metal to droplets to a diameter of 500 µm or less by centrifugal force.

Cat 2 "Run out" (out-of-true running)
Radial displacement in one revolution of the main spindle measured in a plane perpendicular to the spindle axis at a point on the external or internal revolving surface to be tested (Reference: ISO 230/1-1986, paragraph 5.61).

Cat 7 "Scale factor" (gyro or accelerometer)
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.

Cat 3 "Settling time"
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.

Cat 6 "SHPL"
"SHPL" is equivalent to "Super High Power Laser".

Cat 3 "Signal analysers"
Apparatus capable of measuring and displaying basic properties of the single-frequency components of multi-frequency signals.

Cat 3 "Signal processing"
Cat 4 The processing of externally derived information-
Cat 5 bearing signals by algorithms such as time
Cat 6 compression, filtering, extraction, selection, correlation, convolution or transformations between domains (e.g., fast Fourier transform or Walsh transform).

~~Both~~ "Software"
~~Lists~~ A collection of one or more "programmes" or "microprogrammes" fixed in any tangible medium of expression.

"Solidify rapidly"
A process involving the solidification of molten material at cooling rates exceeding 1,000 K/sec.

Cat 4 "Source code"
Cat 5 A convenient expression of one or more processes which may be
Cat 6 turned by a programming system into equipment executable
Cat 7 form ("object code" (or object language)).
Cat 9

Cat 7 "Spacecraft"
Cat 9 Active and passive satellites and space probes.

Cat 3
Cat 6
~~ML 23~~Cat 9

"Space qualified"

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.

Cat 1

"Splat quenching"

A process to "solidify rapidly" a molten metal stream impinging upon a chilled block, forming a flake-like product.

Cat 5

"Spread spectrum"

The technique whereby energy in a relatively narrow-band communication channel is spread over a much wider energy spectrum.

Cat 6

"Spread spectrum" radar - see "Radar spread spectrum"

Cat 7

"Stability"

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.

Cat 2
Cat 3
Cat 5

"Stored programme controlled"

A control using instructions stored in an electronic storage which a processor can execute in order to direct the performance of predetermined functions.

Technical Note
Equipment may be "stored programme controlled" whether the electronic storage is internal or external to the equipment.

Cat 3

"Substrate"

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.

Cat 6

"Substrate blanks"

Monolithic compounds with dimensions suitable for the production of optical elements such as mirrors or optical windows.

Cat 2
Cat 9

"Superalloy"

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.

Cat 1
Cat 3
Cat 6
Cat 8

"Superconductive"

Refers to materials,(i.e., metals, alloys or compounds) which can lose all electrical resistance (i.e., which can attain infinite electrical conductivity and carry very large electrical currents without Joule heating).

~~ML 18 & 20~~

Technical Note
The "superconductive" state of a material is individually characterised by a "critical temperature", a critical magnetic field, which is a function of

temperature, and a critical current density which is, however, a function of both magnetic field and temperature.

Cat 6 "Super High Power Laser" ("SHPL")
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.

Cat 1
Cat 2 "Superplastic forming"
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.

Cat 5 " Symmetric algorithm "
A cryptographic algorithm using an identical key for both encryption and decryption.

Technical Note
A common use of "symmetric algorithms" is confidentiality of data.

Cat 6 "System tracks"
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.

Cat 4 "Systolic array computer"
A computer where the flow and modification of the data is dynamically controllable at the logic gate level by the user.

~~ML 7~~Cat 1 "Tear gases"
Gases which produce temporary irritating or disabling effects which disappear within minutes of removal from exposure.

GTN~~& Both Lists~~ "Technology"
Specific information necessary for the "development", "production" or "use" of a product. The information takes the form of technical data or technical assistance. "Technology" for which review is required is defined in the General Technology Note and in the Conventional Section of the List.

Technical Notes
1. *'Technical data' may take forms such as blueprints, plans, diagrams, models, formulae, tables, engineering designs and specifications, manuals and instructions written or recorded on other media or devices such as disk, tape, read-only memories.*

2. 'Technical assistance' may take forms such as instruction, skills, training, working knowledge, consulting services. 'Technical assistance' may involve transfer of 'technical data'.

Cat 4 "Terminal interface equipment"
Equipment at which information enters or leaves the telecommunication system, e.g., telephone, data device, computer, facsimile device.

Cat 4 "Three dimensional Vector Rate"
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).

Cat 2 "Tilting spindle"
A tool-holding spindle which alters, during the machining process, the angular position of its centre line with respect to any other axis.

Cat 6 "Time constant"
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).

Cat 7 "Total control of flight"
Automated control of "aircraft" state variables and flight path to meet mission objectives responding to real time changes in data regarding objectives, hazards or other "aircraft".

Cat 5 "Total digital transfer rate"
The number of bits, including line coding, overhead and so forth per unit time passing between corresponding equipment in a digital transmission system. (See also "digital transfer rate")

Cat 6 "Transfer laser"
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.

Cat 6 "Tunable"
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".

GTN "Use"
Cat 1, 2, 3 Operation, installation (including on-site
Cat 4, 5, 6 installation), maintenance (checking), repair,
Cat 7, 8, 9 overhaul and refurbishing.

Cat 4 "User-accessible programmability"

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Cat 5	The facility allowing a user to insert, modify or replace "programmes" by means other than:
Cat 6	a. A physical change in wiring or interconnections; or b. The setting of function controls including entry of parameters.

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Cat 1 "Vacuum atomisation"
A process to reduce a molten stream of metal to droplets of a diameter of 500 µm or less by the rapid evolution of a dissolved gas upon exposure to a vacuum.

Cat 7 "Variable geometry airfoils"
Use trailing edge flaps or tabs, or leading edge slats or pivoted nose droop, the position of which can be controlled in flight.

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Fiber straining equipment	Conventional Section: p. 147, 1.B.1.d; Missile Section: p. 44, 7.1.3.1
Fiber surface treatment equipment	Missile Section: p. 44, 7.1.3.4
Fibrous or filamentary materials	Conventional Section: p. 266, 8.A.2.h.2; p. 145, 1.A.2.b and p. 157, 1.C.10; Missile Section: p. 45, 8.1; Nuclear Section: p. 61, 8.1-8.3
Fibrous or filamentary material production equipment	Conventional Section: p. 147, 1.B.1; Missile Section: p. 44, 7.1.3; Nuclear Section: p. 62, 8.4
Fibrous or filamentary material development, production, or use technology	Conventional Section: p. 147, 1.B.1; Missile Section: p. 43, 7
Fibrous/filamentary winding machines characteristics	Nuclear Sectio
Field programmable gate arrays (FPGA)	Conventional Section: p. 192, 3.A.1.a.7 Note
Field Programmable Interconnects (FPICs)	Conventional Section: p. 192, 3.A.1.a.7 Note
Field programmable logic arrays (FPLA)	Conventional Section: p. 192, 3.A.1.a.7 Note

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Fluorine	**Chemical Section: p. 9, A.49**
Fluorine production (electrolytic cells)	**Nuclear Section: p. 99, 46**
Fluorocarbon electronic cooling fluids	**Conventional Section: p. 154, 1.C.6.d**
Fluoroelastomer compounds, technology relating to	**Conventional S**
Fluorophosphate glass	**Conventional Section: p. 252, 6.C.4.e**
Fluoropolymer sheets	**Chemical Section: p. 17, 10.4.1.6**
Flurocarbon electronic cooling fluids	**Conventional Section: p. 154, 1.C.6.a**
Fluxgate magnetometer technology	**Conventional Section: p. 254, 6.E.3.f**
Fly cutting machines	**Conventional Section: p. 165, 2.B.1.b.4**
Fly-by-light flight control system software	**Conventional Section: p. 259, 7.D.3; Missile Section: p. 39, 5.1, 5.1.1**
Fly-by-wire flight control system software	**Conventional Section: p. 259, 7.D.3; Missile Section: p. 39, 5.1, 5.1.1**
Fly-by-wire systems for missiles	**Missile Section: p. 42, 6.1**
Fly-by-wire control system technology	**Conventional Section: p. 260, 7.E.4; Missile Section: p. 42, 6, 6.1**
Foam, syntactic	**Conventional Section: p. 268, 8.C. 1**
Foam, syntactic for underwater use	**Conventional Section: p. 268, 8.C.1**
Foam mirror structures, lightweight	**Conventional Section: p. 237, 6.A.4.a.3**
Focal plane arrays, direct view	**Conventional Section: p. 234, 6.A.2.c.2**
Focal plane arrays, linear & 2D	**Conventional Section: p. 234, 6.A.2.c.2**
Focal plane arrays, space qualified.	**Conventional Section: p. 234, 6.A.2.c.2**
Foggers, aerosol dissemination	**Biological Section: p. 24, 7.3**
Fonofos	**Chemical Section: p. 3, A.01**
Foot & mouth disease virus	**Biological Section: p. 26, 1.2.12**
Forgings	**Nuclear Section: p. 60, 2**

Hexanitrohexaazaisowurtzitane (CL-20; HNIW) Conventional S

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Launch vehicle components/structures	**Missile Section: p. 47, 8.3**
Lenses for radiation hardened TV cameras	**Nuclear Section: p. 106, 51.5(b)**
LEU (See Low Enriched Uranium)	**Nuclear Section: p. 59**
Leveling/stabilization (for trucks)	**Conventional Section: p. 274, 9.A.13.b**
Lewisite 1	**Chemical Section: p. 12, B.05**
Lewisite 2	**Chemical Section: p. 12, B.05**
Lewisite 3	**Chemical Section: p. 12, B.05**
Lidar equipment (Laser radar)	**Conventional Section: p. 249, 6.A.8.k; Missile Section: p. 42, 6.2.2.1**
Lift fans, for surface effect vessels	**Conventional Section: p. 266, 8.A.2.l**
Light gas guns (Multistage) systems	**Nuclear Section: p. 125, 66**
Light systems, underwater	**Conventional Section: p. 265, 8.A.2.g**
Light-weight reduction gearing, marine transmissions	**Conventional Section: p. 267, 8.A.2.o.1.d**
Lightweight composite or foam mirror structures	**Conventional Section: p. 237, 6.A.4.a.3**
Lightweight monolithic mirrors	**Conventional Section: p. 237, 6.A.4.a.2**
Lightweight turbofan/turbojet engines	**Missile Section: p. 31, 2.2**
Linear voltage displacement transformer (LVDT) based instruments	**Conventional Section: p. 168, 2.B.6.b.1.b; Nuclear Section: p. 118, 54.2(a)**
Linear position feedback units or sensors	**Conventional Section: p. 170, 2.B.8.a; Nuclear Section: p. 111, 52.6(b)**
Linear measuring equipment/instruments	**Conventional Section: p. 168, 2.B.6.b.1; Nuclear Section: p. 118, 54.2**
Linear measuring systems, non-contact type	**Conventional S**
Linear focal plane arrays	**Conventional Section: p. 233, 6.A.2.a.3**

Location & object detection systems, acoustic	**Conventional Section: p. 228, 6.A.1.a.1.b**
Logic arrays, field programmable (FPLA)	**Convention al Section: p. 192, 3.A.1.a.7**
Logic processors and assemblies	**Conventional Section: p. 208, 4.A.3.d**
Louping ill virus	**Biological Section: p. 26, 1.2.21**
Low-bed (low-boy, low-loader) trailers	**Conventional Section: p. 273, 9.A.13**
Low Enriched Uranium	**Nuclear Section: p. 59**
Lubricating materials	**Conventional Section: p. 153, 1.C.6; p. 153, 1.C.6.b**
LVDT (Linear voltage displacement transformer) based instruments	**Conventional Section: p. 168, 2.B.6.b.1.b; Nuclear Section: p. 118, 54.2a**
Lymphocytic choriomeningitis virus	**Biological Section: p. 26, 1.2.22**
Lyophilisation equipment	**Biological Section: p. 22, 4.5**
Lyssa virus (Rabies virus)	**Biological Section: p. 26, 1.2.23**

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Machine header piping	**Nuclear Section: p. 71**
Machine header piping systems	**Nuclear Section: p. 71**
Machine tool definitions	**Nuclear Section: pp. 113-117, 52.8**
Machine tools, E-beam	**Conventional Section: p. 166, 2.B.1.e.1.b; Nuclear Section: p. 110, 52.2**
Machine tools, laser	**Conventional Section: p. 166, 2.B.1.e.1.c; Nuclear Secti on: p. 110, 52.2**
Machine tools, numerically controlled	**Conventional Section: p. 164, 2.B.1; Nuclear Section: p. 110, 52.2**
Machine tools, water/other liquid jet	**Conventional Section: p. 166, 2.B.1.e.1.a; Nuclear Section: p. 110, 52.2**

Machine tool components and assemblies for equipment

Microwave frequency extenders, mixers/converters	**Conventional Section: p. 195, 3.A.1.b.7**
Microwave integrated circuit test equipment	**Conventional Section: p. 202, 3.B.2.c**
Microwave integrated circuits	**Conventional Section: p. 194, 3.A.1.b.2**
Microwave modules	**Conventional Section: p. 194, 3.A.1.b.2**
Microwave power amplifiers	**Conventional Section: p.195, 3.A.1.b.8**
Microwave power sources and antennae	**Nuclear Section: p. 87, 29.1**
Microwave transistors	**Conventional Section: p. 194, 3.A.1.b.3**
Microwave test receivers	**Conventional Section: p. 194, 3.A.2.f**
Microwave wave components	**Conventional S ection: p. 193, 3.A.1.b**
Millimeter wave components	**Conventional Section: p. 193, 3.A.1.b**
Milling equipment, powders	**Biological Section: p. 22, 4.6**
Milling machines, (CNC) with two or more coordinated axes	**Conventional Section: p. 165, 2.B.1.b; Nuclear Section: p. 109, 52.1**
Mills, fluid energy	**Missile Section: p. 38, 4.2.3**
Mirror assemblies/segments, space assembly	**Conventional Section: p. 237, 6.A.4.c.3**
Mirror characterization equipment, reflectometers	**Missile Section: p. 40, 5.4.3**
Mirror control equipment, phased array/segment	**Conventional Section: p. 238, 6.A.4.d.4**
Mirror structures, lightweight foam or composite type	**Conventional Section: p. 237, 6.A.4.a.3**
Mirror, equipment to characterize	**Conventional Section: p. 258, 7.B. 2**
Mirrors, actively cooled or heat pipe cooled	**Conventional Section: p. 246 6.A.5.e.1**
Mirrors, beam steering	**Conventional Section: p. 237 6.A.4.a 4**

Nickel metal (made from powder metals/alloys/powders)	Conventional Section: p. 150, 1.C.2.b.1; Nuclear Section: p. 64, 17
Nickel metal powders	Conventional Section: p. 150, 1.C.2.b.1; Nuclear Section: p. 64, 17
Nickel powder	Conventional Section: p. 150, 1.C.2.c.1.a; Nuclear Section: p. 64, 17
Nickel powder or porous nickel metal	Conventional Section: p. 150, 1.C.2.c.1.a; Nuclear Section: p. 64, 17
Niobium alloys	Conventional Section: p. 150, 1.C.2.b.2; Nuclear Section: p. 130 77.1(g)
Niobium alloy/powder or particulate form	Conventional Section: p. 150, 1.C.2.c.1.b; Nuclear Section: p. 130, 77.1(g)
Nipah virus	Biological Section: p. 26, 1.2.29
Nitramines	Missile Section: p. 33, 3.3.2
Nitrate esters	Missile Section: p. 36, 3.4.4
Nitratomethyl methyl oxetane (NIMMO)	Missile Section: p. 35, 3.3.6.6
Nitratoplasticizer	Missile Section: p. 36, 3.4.4
Nitrided niobium-titanium -tungsten alloy crucibles	Nuclear Section: p. 130, 77.1(g)
3-nitro-1,2,4,-triazol -5-one (NTO or ONTA)	Conventional Section: p. 160, 1.C.12.k
2-Nitrodiphenylamine (2-NDPA)	Missile Section: p. 37, 3.4.5.1
Nitrogen dioxide (dinitrogen tetroxide)	Missile Section: p. 34, 3.3.5.2
Nitrogen stabilized duplex stainless steel (N-DSS)	Missile Section: p. 46, 8.1.6
Nitrogen mustards and their protonated salts	Chemical Secti
Nitroguanidine (NQ)	Conventional Section: p. 159, 1.C.11.d
NMR	Nuclear Section: p. 88
NMT (Nordic Mobile Telephone)	Conventional Section: p. 219, 5.A.1.b.3.Note

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Octogen(e)	Conventional Section: p. 159, 1.C.12.a
Oil well cartridges	(See charges and devices, Conventional Section: p. 159 1.C.12; p. 161, 1.C.13)
Oil workover capability	Conventional Section: p. 274, 9.A.13.b
ONTA (3-nitro-1,2,4,-triazol-5-one)	Conventional Section: p. 160, 1.C.12.k
Operating systems for real time processing equipment, software	Conventional section: p.210, 4.D.3.d.
Operating system software, development tools & compilers	Conventional Section: p. 210, 4.D.3.a.
Operating system software, multi-data-stream processing equipment	Conventional Section: p. 210, 4.D.3.a.
Optic fiber	Conventional Section: p. 262, 8.A.1.c.2; p. 263, 8.A.1.d.3; p. 264, 8.A.2.a.3; p. 264, 8.A.2.c;
Optical components, space-qualified	Conventional Section: p. 237, 6.A.4.c.
Optical components, zinc selenide or zinc sulphide	Conventional S
Optical components for lasers	Conventional Section: p. 246, 6.A.5.f.
Optical control equipment	Conventional Section: p. 237, 6.A.4.d.
Optical detectors & sensors	Conventional section: p. 231, 6.A.2.a.; p. 260, 7.E.4.e.6
Optical element manufacturing equipment	Conventional Section: p. 202, 3.B.2.d.
Optical elements, aspheric	Conventional Section: p. 238, 6.A.4.e.
Optical equipment	Conventional Section: p. 239, 6.A.5; p. 246, 6.A.5.f; p. 250, 6.B.4
Optical equipment and components, phased-array, SHPL	Conventional S
Optical equipment other than optical surface scattering measurement equipment	Conventional Section: p. 250, 6.B.4.b.
Optical fabrication technologies	Conventional Section: p. 250, 6.E.3.d.2.
Optical fiber and accessories, communications	Conventional Section: p. 220, 5.A.1.c.

Oxygen Iodine (O1-I) laser	**Conventional Section: p. 244, 6.A.5.a.5.c.1.**

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Pack cementation	**Conventional Section: p. 176, 2.E.3.f. table 1.C**
Paralytic shellfish poison (Saxitoxin)	**Biological Section: p. 27, 1.3.12**
Passive sensors, direction finding systems	**Missile Section: p. 42, 6.2.2.2**
Passive acoustic systems (passive sonar)	**Conventional Section: p. 229, 6.A.1.a.1.d**
Pathogens, genetically modified microorganisms	**Biological Section: p. 28, 1.6**
PBAA (Polybutadiene-acrylic acid)	**Missile Section: p. 34, 3.3.6.4**
PBAN (Polybutadiene-acrylic acid-acrylonitrile)	**Missile Section: p. 34, 3.3.6.5**
PDC (Personal Digital Cellular)	**Conventional Section: p. 219, 5.A.1.b.3note**
Polyarylene ether ketones	**Conventional Section: p. 156, 1.C.8.c**
PEEK (Polyether ether ketone)	**Conventional section: p. 156, 1.C.8.c.**
PEK (Polyether ketone)	**Conventional section: p. 156, 1.C.8.c.3**
PEKEKK (Polyether ketone ether ketone ketone)	**Conventional section: p. 156, 1.C.8.c.4**
PEKK (Polyether ketone ketone)	**Conventional section: p. 156, 1.C.8.c.**
Pellicular structures surface coated	**Nuclear Section: p. 80, 27.6**
Pentaerythritoltetranitrate (PETN)	**Nuclear Section: p. 127, 129**
1,1,3,3,3-Pentafluoro-2-(trifluoromethyl)-1-propene (PFIB)	**Chemical Section: p. 16, B.18**
Perchlorates	**Missile Section: p. 33, 3.3.3**
Perfluoroaliphatic-ethers, monomeric or polymeric	**Conventional section: p. 154, 1.C.6.d.1.a.**
Perfluoroalkanes	**Conventional section: p. 154, 1.C.6.d.1.d.**
Perfluoroalkylamines	**Conventional Section: p. 154, 1.C.6.d.1.b**

Perfluorocycloalkanes	**Conventional section: p. 154, 1.C.6.d.1.c.**
Perfluoropolyalkylether-triazines, monomeric` or polymeric	**Conventional section: p. 154, 1.C.6.d.1.a.**
Performance improvement software, navigation systems	**Conventional Section: p. 259, 7.D.3.a; Missile Section: p. 42, 6.2.2**
Performance improvement source code, navigation systems	**Conventional Section: p. 259, 7.D.3.a; Missile Section: p. 42, 6.2.2**
Peristaltic pumps, corrosion resistant	**Chemical Section: p. 17, 10.4.2**
Personal Digital Cellular (PDC)	**Conventional Section: p. 219, 5.A.1.b.3**
Peronospora hyoscyami de Bary (Tabacina skalicky/Adam skalicky)	**Biological Section: p. 27, 1.4.9**
Peste des petits ruminants virus	**Biological section: p. 26, 1.2.31**
PETN (See Pentaerythritoltetranitrate)	**Nuclear Section: p. 127, 129**
PFIB	**Chemical Section: p. 16, B.18**
pH probes	**Biological Section: p. 21, 3.1**
Phased array antennae (in radar)	**Conventional Section: p. 249, 6.A.8.e**
Phased array/segment mirror control equipment	**Conventional Section: p. 238, 6.A.4.d.4**
Phased array antennae	**Conventional Section: p. 220, 5.A.1.d (telecommunications); p. 228, 6.A.1.a (sonar); p. 249, 6.A.8.g (radar)**
Phenylene	**Conventional Section: p. 156, 1.C.8.b.1.a**
Phenylene, as lubricating fluids	**Conventional Section: p. 153, 1.C.6.b.1**
Phenylene, methyl, tertiary butyl or phenyl substituted	**Conventional S**
Phosgene: Carbonyl dichloride (75-44-5)	**Chemical Section: p. 4, A.09**
Phosphate glass	**Conventional Section: p. 252, 6.C.4.e**
Phosphor bronze or copper mesh packings	**Nuclear Section: p. 94, 34.10(a)**

Phosphorus hydrides	**Conventional Section: p. 204, 3.C.4**
Phosphorus	**Chemical Section: p. 9, A.48**
Phosphorus oxychloride	**Chemical Section: p. 5, A.13**
Phosphorus pentachloride	**Chemical Section: p. 5, A.15**
Phosphorus pentasulphide	**Chemical Section: p. 7, A.37**
Phosphorus sulphochloride (3982-91-0)	**Chemical Section: p. 9, A.51**
Phosphorus trichloride	**Chemical Section: p. 5, A.14**
Photo-optical step and repeat cameras	**Conventional Section: p. 201, 3.B.1.f.1**
Photocathodes	**Conventional Section: p. 232 6.A.2.a.2.b**
Photographic still cameras, underwater	**Conventional Section: p. 245, 8.A.1.e**
Photomultiplier tubes	**Conventional Section (image intensifier tubes): p. 232, 6.A.2.a.2; Nuclear Section: p. 132, 83**
Photon transport codes	**Nuclear Section: p.126, 70**
Photovoltaic arrays, space qualified or radiation hardened	**Conventional Section: p. 196, 3.A.1.e.1.c**
Physical Vapour Deposition (PVD): Cathodic Arc Discharge	**Conventional Section: p. 176, 2.E.3.f. table 1.B.4**
Physical Vapour Deposition (PVD): Electron-Beam (EB-PVD)	**Conventional Section: p. 174, 2.E.3.f.table 1.B.1**
Physical Vapour Deposition (PVD): Laser Vaorization	**Conventional Section: p. 175, 2.E.3.f. table 1.B.3**
Picrylaminodinitropyridine (PYX)	**Conventional Section: p. 160, 1.C.12.j**
Piezoelectric polymer & copolymer, made from vinylidene fluoride materials	**Conventional Section: p. 145, 1.A.1.b**
Piezoelectric sensing elements, hydrophones	**Conventional Section: p. 230, 6.A.1.a.2.a.2.b**
Pinacolone	**Chemical Section: p. 15, B.16**
Pinacolyl alcohol	**Chemical Section: p. 15, B.15**

Plasma spraying	Conventional Section: p. 176, 2.E.3.f. table 1.D
Plasma spraying production equipment, with controlled atmosphere	Nuclear Section: p. 121, 60
Platinized catalysts	Nuclear Section: p. 94, 34.9
Plug-in units, for oscilloscopes	Nuclear Section: p.132, 80.2
Plutonium	Conventional Section: p.161, 1.C.14.a
Plutonium-238	Conventional Section: p. 161, 1.C.14.a; Nuclear Section: p. 59 1.2; p. 59, 1.3
Plutonium metal production systems	Nuclear Section: p. 99, 48
Plutonium nitrate conversion systems	Nuclear Section: p. 99, 47
pO_2 probes	Biological Section: p. 21, 3.1
Pockel cell electro-optical shuttering	Nuclear Section: p. 126, 68.4(c)
polyamide-imides, aromatic	Conventional Section: p. 156, 1.C.8.a.2
Polyarylene ketones	Conventional Section: p. 156, 1.C.8.d.
Polyarylene sulphides	Conventional Section: p. 156, 1.C.8.e
Polyaniline	Conventional Section: p. 149, 1.C.1.c.1
Polybenzothiazoles, technology relating to	Conventional S
Polybenzoxazoles, technology relating to	Conventional Section: p. 162, 1.E.2.a
Polybiphenylenethersulphone	Conventional Section: p. 156, 1.C.8.f.
Polybromotifluoroethylene	Conventional Section: p. 154, 1.C.6.c.3
Polybutadiene-acrylic acid (PBAA)	Missile Section: p. 34, 3.3.6.4
Polycarbosilazanes	Conventional Section: p. 155, 1.C.7.e.3.
Polychlorotrifluoroethylene	Conventional Section: p. 154, 1.C.6.c.2.

Polycrystalline alimina fibers	**Conventional Section: p. 157, 1.C.10.c.Note1.**
Polydiorganosilanes, precursor for silicon carbide	**Conventional Section: p. 155, 1.C.7.e.1.**
Polyetherimides	**Conventional Section: p. 158, 1.C.10.d.1.a**
Polyetherimides, aromatic	**Conventional Section: p. 156, 1.C.8.a.4**
Polyetherimides, fibrous & filamentary materials composed of	**Conventional section: p. 158, 1.C.10.d.1.**
Polyimides, aromatic	**Conventional Section: p. 156, 1.C.8.a.3**
Polymeric or metallo-organic materials	**Conventional section: p. 155, 1.C.7.e.**
Polymeric substances, non-fluorinated	**Conventional Section: p. 156, 1.C.8.**
Polynitrocubanes	**Conventional Section: p. 161, 1.C.12.y**
Polyphenylene-vinylene	**Conventional Section: p. 149, 1.C.1.c.4**
Polypyrrole	**Conventional Section: p. 149, 1.C.1.c.2**
Polysilazanes, precursor for silicon nitride	**Conventional Section: p. 155, 1.C.7.e.2.**
Polythienylene-vinylene	**Conventional Section: p. 149, 1.C.1.c.5**
Polythiophene	**Conventional Section: p. 149, 1.C.1.c.3.**
Porcine enterovirus type 9 (Swine vascular disease)	**Biological section: p. 26, 1.2.94**
Porcine herpes virus (Aujeszky's disease)	**Biological Section: p. 26, 1.2.32**
Porous nickel metal	**Nuclear Section: p. 64, 17.2.**
Positioning equipment/components, Global (e.g. GPS/GLONASS)	**Conventional Section: p. 257, 7.A.5; Missile Section: p. 39, 5.1.2**
Positioning systems, acoustic	**Conventional Section: p. 229, 6.A.1.a.1.d**

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Precision mandrels for filament winding machines	**Nuclear Section: p. 121, 59.3; Missile Section: p. 44, 7.1.3.6**
Precision rotor forming mandrels	**Nuclear Section: p. 117 53.2**
Precision tracking systems, usable for missiles	**Missile Section: p. 48, 8.3.4**
Precursors, CW (Chemical Warfare)	**Chemical Section: p.10, 2**
Preform production equipment	**Conventional Section: p. 147, 1.B.1; Missile Section: p. 45, 7.1.3.6**
Preforms, fibrous or filamentary materials	**Conventional Section: p. 147, 1.B.1; p. 147, 1.B.1.a; Missile Section: p. 45, 7.1.3.6**
Preforms, glass for optical fibers	**Conventional Section: p. 221, 5.C.1.**
Preforms for space vehicles (metal coated fiber)	**Missile Section: p. 45, 7.1.3.4; p. 45, 7.1.3.5**
Preforms, fibrous or filamentary materials	**Missile Section: p. 45, 8.1**
Prepreg production equipment	**Conventional Section: p. 147, 1.B.1; Missile Section: p. 44, 7.1.3.4**
Prepregs, fibrous or filamentary materials	**Conventional Section: p. 147, 1.B.1; p. 147, 1.B.1.a; Missile Section: p. 44, 7.1.3.5, 8.1**
Prepregs, when impregnated with phenolic or epoxy resins	**Conventional Section: p. 158, 1.C.10.e.2.d.Note**
Prepregs, fibrous or filamentary materials	**Missile Section: p. 45, section 8.1**
Presses, hot isostatic	**Conventional Section: p. 166, 2.B.4; Missile Section: p. 47, 8.2.3.1; Nuclear Section: p. 129, 55**
Pressure vessels, for nuclear reactors	**Nuclear Section: p. 100, 49**
Pressure tubes, for fuel elements & primary coolant (nuclear reactor)	**Nuclear Section: p. 100, 49.5**
Pressure transducers	**Nuclear Section: p. 124, 64.6**
Pressure sensors, manganin & quartz	**Nuclear Section: p. 124, 64.2; p. 124, 64.3**
Primary cells/batteries	**Conventional Section: p. 156, 3.A.1.e.1.a**
Primary coolant pumps	**Nuclear Section: p. 101, 49.7**

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Reduction gearing, light-weight marine transmissions	**Conventional Section: p. 267, 8.A.2.o.1.d**
Reentry vehicles & equipment	**Missile Section: p. 29, 1**
Reflectance measuring equipment (optical), absolute	**Conventional Section: p. 250, 6.B.4,a**
Reflectivity (electromagnetic) reducing materials	**Missile Section: p. 51, 9.3**
Reflectometers, mirror characterization	**Missile Section: p. 40, 5.4.3**
Reflectors (mirrors), optical	**Conventional Section: p. 237, 6.A.4.a**
Reflux systems, ion exchange	**Nuclear Section: p. 80**
Refrigeration units, cryogenic	**Nuclear Section: p. 95, 34.14**
Reinforced composite materials	**Conventional Section: p. 155, 1.C.7.f; Missile Section: p. 43, 7**
Reinforcement fiber, production equipment	**Conventional Section: p. 147, 1.B.1.d; Missile Section: p. 45, 8.1**
Remote filling equipment, corrosion resistant	**Chemical Section: p. 18, 10.4.5**
Remote manipulators	**Nuclear Section: p. 106, 51.5; Conventional Section: p. 266, 8 .A.2.i**
Remotely operated filling equipment, chemical	**Chemical Section 10.4.5, p. 18**
Remotely controlled manipulators, for submersibles	**Conventional Section: p. 266, 8.A.2.i**
Reprocessing plant, nuclear fuel	**Nuclear Section: p. 104, 51**
Reprocessing technology	**Nuclear Section: p. 104**
Resaturated pyrolized materials	**Missile Section: p. 45, 8.1.1**
Resin impregnated fibers	**Conventional Section: p. 158, 1.C.10.e; Missile Section: p. 45, 8.1**
Resin (thermoset) impregnated continuous materials	**Conventional Section: p. 158, 1.C.10.e; Missile Section: p. 45, 8.1**
Resin impregnated fiber prepregs, propulsion & space systems	**Conventional Section: p. 158, 1.C.10.e; Missile Section: p. 45, 8.1**
Resins, fast reacting ion-exchange	**Nuclear Section: p. 80, 27.6**
Resist materials, semiconductor lithography	**Conventional Section: p. 204, 3.C.2**
Resins, porous macroreticular	**Nuclear Section: p. 80**
Respirators	**Biological Section: p. 21, 2.6**

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Staphylococcal enterotoxins	**Biological Section: p. 27, 1.3.14**
Static components	**Nuclear Section: p. 69, 22.2**
Stators, ring shaped (centrifugal rotor motor)	**Nuclear Section: p. 70, 22.2(d)**
Steam sterilizable freeze drying equipment	**Biological Section: p. 22, 4.5**
Steel, maraging	**Missile Section: p. 46, 8.1.5, Nuclear Section: p. 120, 56.3; p. 122, 61; p. 63, 12; p. 69, 22.1**
Steel, Titanium -stabilized duplex stainless (Ti-DSS)	**Missile Section: p. 46, 8.1.7**
Step & repeat equipment, semiconductor wafer processing	**Conventional Section: p. 201, 3.B.1.f.1**
St. Louis encephalitis virus	**Biological Section: p. 26, 1.2.40**
Storage or holding vessels,	**Nuclear Section: section p. 105, 51.4**
Storage integrated circuits	**Conventional Section: p. 190, 3.A.1.a.2**
Storage tanks, chemical	**Chemical Section: p. 17, 10.4.1.5**
Storage tanks & containers, corrosion resistant	**Chemical Section: p. 17, 10.4.1.5**
Storage vessels, corrosion resistant	Chemical Section: p. 17, 10.4.1.5
“Stored programme controlled” cathodic arc deposition production equipment	**Conventional Section: p. 168, 2.B.5.f**
Stored program controlled computer, dedicated	**Conventional S**
Stored program controlled (SPC) switching equipment, equipment for the development of equipment employing	**Conventional Section: p. 220, 5.B.1.b**
Stored program controlled (SPC) switching equipment, software for the development of equipment employing	**Conventional Section: p. 221, 5.D.1.d**
Stored program controlled (SPC) switching equipment, technology for the development of equipment employing	**Conventional Section: p. 222, section 5.E.1.c**
Stored program controlled equipment controlled by 3B, software for use of	**Conventional Section: p. 205, 3.D.2**
Strap down/gimbal inertial navigation systems or equipment	**Conventional Section: p. 256, 7.A.3**
Streak cameras, mechanical type	**Nuclear Section: p. 125, 67 and 68**

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Surface vessels & components	**Conventional Section: p. 124, section 8.A.1.**
Surface finishing equipment	**Conventional Section: section 3.B.2.e.3.**
Surface-effect vehicles (fully skirted variety)	**Conventional Section: p. 125, section 8.A.1.f.**
Surface-effect vehicles (rigid sidewalls)	**Conventional Section: p. 125, section 8.A.1.g.**
Survey systems, bathymetric	**Conventional Section: p. 91, section 6.A.1.a.1.a.**
Swine fever virus (Hog cholera virus)	**Biological Section: p. 7, 1.2.42**
Swine influenza virus	**Biological Section: p. 7, 1.2.43**
Swine vesicular disease	**Biological Section: p. 7, 1.2.44**
Switching devices, modules or assemblies	**Nuclear Section: 75; Conventional Section (thyratrons), 3.A.1.g, p. 57**
Switching equipment, stored program controlled	**Conventional Section: p. 82, 5.B.1.b.**
Syntactic foam, underwater use	**Conventional Section: p. 131, section 8.C.1.**
Synthetic crystalline laser host material	**Conventional Section: p. 114, section 6.C.5.**
Synthetic diamond material	**Conventional Section: p. 114, section 6.C.4.f.**
Synthetic aperture radar (SAR)	**Conventional Section: p. 111, section 6.A.8.f.**
Systolic array computers/assemblies/components	**Conventional Section: section 4.A.4.a.**

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T	**Chemical Section: p. 12, B.04**
T4	**Conventional Section: p. 160, 1.C.12.n**
Tabun	**Chemical Section: p. 11, B.11**
TACOT (Tetranitrobenzotriazolobenzotriazole)	**Conventional S**
TAGN (Triaminoguanidinenitrate)	**Conventional Section: p. 159, 1.C.12.e**

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Tangential filtration equipment	**Biological Section: p. 22, 4.3**
Tanks, chemical storage	**Chemical Section: p. 17, 10.4.1.5**
Tanks, corrosion resistant	**Chemical Section: p. 17, 10.4.1.5**
Tantalum	**Nuclear Section: p. 67, 21**
Tantalum crucibles coated with tantalum carbide/nitride/boride	**Nuclear Section: p. 131, 77.3(b)**
Tantalum made or lined crucibles	**Nuclear Section: p. 130, 77.2; p. 131, 77.3**
TATB (Triaminotrinitrobenzene)	**Conventional Section: p. 159, 1.C.12.d**
Tape bonders, stored program controlled equipment	**Conventional Section: p. 204, 3.B.2.e.5.b**
Tape recording equipment	**Conventional Section: p. 197, 3.A.2.a**
Tape-laying machines	**Conventional Section: p. 147, 1.B.1.b; Missile Section: p. 44, 7.1.1**
Tapes, continous	**Nuclear Section: p. 62**
TATB (See Triaminotrinitrobenzene)	**Nuclear Sectiopn: p. 129**
TDMA (Time Division Multiple Access)	**Conventional Section: p. 219, 5.A.1.b.3**
Technology, advanced materials	**Conventional Section: p. 161, 1.E**
Technology, airborne avionics or navigation equipment	**Conventional Section: p. 260, 7.E.4.a; Missile Section: p. 38, 5**
Technology, development of frequency hopping (spread spectrum radio) techniques	**Conventional Section: p. 222, 5.E.1.b.4**
Technology, development of spread spectrum (radio) techniques	**Conventional Section: p. 222, 5.E.1.b.4**
Technology, diamond substrate film	**Conventional Section: p. 206, 3.E.3.d**
Technology, gas turbine engine components	**Conventional Section., p. 276, 9.E.3; Missile Section: p. 31, 2.2**
Technology, helicopter power transfer systems	**Conventional Section: p. 278, 9.E.3.d**

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Test, calibration or alignment equipment for equipment controlled by 7A	**Conventional Section: p. 258, 7.B.1; Missile Section: p. 40, 5.4**
Test chambers, aerosol challenge	**Biological Section:p. 24, 8.1**
Test equipment, semiconductor devices	**Conventional Section: p. 202, 3.B.2**
Test equipment - propellants and their constituents	**Missile Section: p. 50, 9.1.3**
Test, inspection and production equipment, advanced materials	**Conventional Section: p. 147, 1.B; p. 163, 2.B**
Test piece support structures	**Nuclear Section: p.123**
Test receivers, microwave	**Conventional Section: p. 199, 3.A.2.f**
Testing equipment, for electronic components	**Conventional Section: p. 203, 3.B.2.e**
Tethered submersible vehicles, unmanned	**Conventional Section: p. 262, 8.A.1.c**
1,4,5,8-Tetranitro-1,4,5,8 tetraazadecalin (TNAD)	**Conventional Section: p. 160, 1.C.12.w**
2,4,6,8-Tetranitro-2,4,6,8 tetraazabicyclo[3,3,0]- octanone-3 (tetranitrosemiglycouril; K-55; keto-bicyclic HMX)	**Conventional S**
Tetranitrobenzotriazolobenzotriazole (TACOT)	**Conventional Section: p. 160, 1.C.12.h**
1,3,5,7-Tetranitro-1,3,5,7-tetrazacyclooctane	**Conventional Section: p. 159, 1.C.12.a**
Tetranitroglycoluril (TNGU, SORGUYL)	**Conventional Section: p. 160, 1.C.12.g**
Tetranitrosemiglycouril (2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo[3,3,0]-octanone-3)	**Conventional Section: p. 160, 1.C.12.u**
Tetrodotoxin	**Biological Section: p. 27, 1.3.15**
Tetranitrosemiglycouril (2,4,6,8-tetranitro-2,4,6,8-tetraazabicyclo[3,3,0]-octanone-3)	**Conventional Section: p. 160, 1.C.12.u**
Tetryl (Trinitrophenylmethylnitramine)	**Conventional Section: p. 161, 1.C.12.aa**
Thallium arsenic selenide (Tl3AsSe3 or TAS)	**Conventional Section: p. 252, 6.C.4.b.3**
Thermal cyclers	**Biological Section: p. 23, 6.7**

Triaminotrinitrobenzene (TATB)	Conventional Section: p. 159, 1.C.12.d; Nuclear Section: p. 129
Trichloronitromethane	Chemical Section: p. 4, A.12
Tricothecene toxin	Biological Section: p. 27, 1.3.16
Triethanolamine	Chemical Section: p. 8, A.38
Triethanolamine hydrochloride	Chemical Section: p. 8, A.38
Triethanolamine hydrochloride	Chemical Section: p. 8, A.38
Triethyl phosphite	Chemical Section: p. 5, A.17
Triethylene glycol dinitrate (TEGDN)	Missile Section: p. 36, 3.4.4.1,
Triggered spark-gaps	Nuclear Section: p. 128, 74.2
Triisopropyl phosphite	Chemical Section: p. 6, A. 21
Trimesol -1(2-ethyl) aziridine (HX-868, BITA)	Missile Section: p. 35, 3.4.1.2
Trimethylolethane trinitrate (TMETN)	Missile Section: p. 37, 3.4.4.2
Trimethyl phosphite	Chemical Section: p. 5, A.16
1,3,5-trinitro-1,3,5-triazacyclohexane (hexogen(e))	Conventional S
2,4,6-Trinitro-2,4,6-triazacyclohexanone (K-6; Keto-RDX)	Conventional S
1,1,3-Trinitroazetidine (TNAZ)	Conventional Section: p. 160, 1.C.12.v
Trinitrophenylmethylnitramine (Tetryl)	Conventional Section: p. 161, 1.C.12.aa
Triphenyl bismuth (TPB)	Missile Section: p. 36, 3.4.2.1
Tris (2-chloroethyl) amine	Chemical Section: p. 13, B.06
Tris (2-chlorovinyl) arsine	Chemical Section: p. 12, B.05
Tris (1-(2-methyl) aziridinyl) phosphine oxide (MAPO)	Missile Section: p. 35, 3.4.1.1
Tritium, compounds & mixtures	Nuclear Section: p. 64, 18
Tritium plant or facilities equipment	Nuclear Section: p. 64, 18
Tritium production recovery, extraction & concentration handling facilities or plant	Nuclear Section: p. 64, 18

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