

1031. cont'd.

1. b. 1. a. Travelling wave tubes, pulsed or continuous wave, as follows:
  1. Operating at frequencies higher than 31 GHz;
  2. Having a cathode heater element with a turn on time to rated RF power of less than 3 seconds;
  3. Coupled cavity tubes, or derivatives thereof, with an "instantaneous bandwidth" of more than 7% or a peak power exceeding 2.5 kW;
  4. Helix tubes, or derivatives thereof, with any of the following characteristics:
    - a. An "instantaneous bandwidth" of more than one octave, and average power (expressed in kW) times frequency (expressed in GHz) of more than 0.5;
    - b. An "instantaneous bandwidth" of one octave or less, and average power (expressed in kW) times frequency (expressed in GHz) of more than 1; **or**
    - c. "Space qualified";
  - b. Crossed-field amplifier tubes with a gain of more than 17 dB;
  - c. Impregnated cathodes for electronic tubes, with either of the following:
    1. A turn on time to rated emission of less than 3 seconds; **or**
    2. Producing a continuous emission current density at rated operating conditions exceeding 5 A/cm<sup>2</sup>;
2. Microwave integrated circuits or modules containing "monolithic integrated circuits" operating at frequencies exceeding 3 GHz;
 

**Note**  
1031.1.b.2. does not embargo circuits or modules for equipment designed or rated to operate in the Standard Civil Telecommunications Bands at frequencies not exceeding 31 GHz.
3. Microwave transistors rated for operation at frequencies exceeding 31 GHz;
4. Microwave solid state amplifiers, as follows:
  - a. Operating at frequencies exceeding 10.5 GHz and having an "instantaneous bandwidth" of more than half an octave;
  - b. Operating at frequencies exceeding 31 GHz;
5. Electronically or magnetically tunable band-pass or band-stop filters having more than 5 tunable resonators capable of tuning across a 1.5:1 frequency band ( $f_{max}/f_{min}$ ) in less than 10 μs with either:
  - 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 1031.2.c., 1031.2.e. or 1031.2.f. beyond the limits stated therein;
- 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 of 2.5 GHz or less, and:
      1. A frequency side-lobe rejection exceeding 55 dB;
      2. A product of the maximum delay time and the bandwidth (time in μs and bandwidth in MHz) of more than 100; **or**
      3. A dispersive delay of more than 10 μs; **or**
    - c. A carrier frequency exceeding 1 GHz and a bandwidth of 250 MHz or more;
  2. Bulk (volume) acoustic wave devices (i.e. "signal processing" devices employing elastic waves) which permit 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 or circuits containing components, manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of the "superconductive" constituents, with any of the following:
  1. Electromagnetic amplification:
    - a. At frequencies equal to or less than 31 GHz with a noise figure of less than 0.5 dB; **or**
    - b. At frequencies exceeding 31 GHz;
  2. Current switching for digital circuits using "superconductive" gates with a product of delay time per gate (in seconds) and power dissipation per gate (in watts) of less than 10<sup>-14</sup> J; **or**
  3. Frequency selection at all frequencies using resonant circuits with Q-values exceeding 10,000;
- e. High energy devices, as follows:
  1. Batteries, as follows:
 

**Note**  
1031.1.e.1. does not embargo batteries with volumes equal to or less than 27 cm<sup>3</sup> (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<sup>2</sup> at an operating temperature of 301 K (28°C) under a tungsten illumination of 1 kW/m<sup>2</sup> 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 than 25 kJ;
    - b. Capacitors with a repetition rate of 10 Hz or more (repetition rated capacitors) having all of the following:
      1. A voltage rating equal to or more than 5 kV;
      2. An energy density equal to or more than 50 J/kg;
      3. A total energy equal to or more than 100 J; **and**
      4. A charge/discharge cycle life equal to or more than 10,000;
  3. "Superconductive" electromagnets or solenoids specially designed to be fully charged or discharged in less than one second, having all of the following:
 

**Note**  
1031.1.e.3. does not embargo "superconductive" electromagnets or solenoids specially designed for Magnetic Resonance Imaging (MRI) medical equipment.

    - a. Energy delivered during the discharge exceeding 10 kJ in the first second;
    - b. Inner diameter of the current carrying windings of more than 250 mm; **and**
    - c. Rated for a magnetic induction of more than 8 T or "overall current density" in the winding of more than 300 A/mm<sup>2</sup>;
  4. Circuits or systems for electromagnetic energy storage, containing components manufactured from "superconductive" materials specially designed for operation at temperatures below the "critical temperature" of at least one of their "superconductive" constituents, having all of the following:
    - a. Resonant operating frequencies exceeding 1 MHz;
    - b. A stored energy density of 1 MJ/m<sup>3</sup> or more; **and**
    - c. A discharge time of less than 1 ms;
  5. Flash discharge type X-ray systems, and tubes therefor, having all of the following:
    - a. A peak power exceeding 500 MW;
    - b. An output voltage exceeding 500 kV; **and**
    - c. A pulse width of less than 0.2 μs;