

- b. Whose design or production origins are either proscribed countries or unknown to the manufacturer;

NOTE:

1091.3. does not embargo multiple domed combustors operating at average burner outlet temperatures equal to or less than 1,813 K (1,540°C).

1091. 4. Space launch vehicles or "spacecraft" (not including their payloads);
(For the embargo status of products contained in "spacecraft" payloads, see the appropriate Categories.)
1091. 5. Liquid rocket propulsion systems containing any of the systems or components embargoed by 1091.6.;
1091. 6. Systems or components, as follows, specially designed for liquid rocket propulsion systems:
- 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);
1091. 7. Solid rocket propulsion systems with any of the following:
- a. 1. Total impulse capacity exceeding 1.1 MNs; *or*
2. Specific impulse of 2.4 kNs/kg or more when the nozzle flow is expanded to ambient sea level conditions for an adjusted chamber pressure of 7 MPa;
 - b. 1. Stage mass fractions exceeding 88%; and
2. Propellant solid loadings exceeding 86%;
 - c. Any of the components embargoed by 1091.8.; *or*
 - d. Insulation and propellant bonding systems using direct-bonded motor designs to provide a strong mechanical bond or a barrier to chemical migration between the solid propellant and case insulation material;
1091. 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;
 - b. Filament-wound "composite" motor cases exceeding 0.61 m in diameter or having structural efficiency ratios (PV/W) exceeding 25 km;
Technical Note:
The structural efficiency ratio (PV/W) is the burst pressure (P) multiplied by the vessel volume (V) divided by the total pressure vessel weight (W).
 - c. Nozzles with thrust levels exceeding 45 kN or nozzle throat erosion rates of less than 0.075 mm/s;
 - d. Movable nozzle or secondary fluid injection thrust vector control systems capable of:
 - 1. Omni-axial movement exceeding $\pm 5^\circ$;
 - 2. Angular vector rotations of $20^\circ/\text{s}$ or more; *or*
 - 3. Angular vector accelerations of $40^\circ/\text{s}^2$ or more;
- Technical Note:**
For the purposes of 1091.7.d. and 1091.8.a., a strong mechanical bond means bond strength equal to or more than propellant strength.
1091. 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;
1091. 10. Specially designed components or structures, for launch vehicles or launch vehicle propulsion systems, manufactured using metal "matrix" "composite", organic "composite", ceramic "matrix" or intermetallic reinforced materials embargoed by 1013.7 or 1013.10;
1091. 11. Ramjet, scramjet or combined cycle engines and specially designed components therefor;

1092. Test, Inspection and Production Equipment

1092. 1. Specially designed equipment, tooling or fixtures, as follows, for manufacturing or measuring gas turbine blades, vanes or tip shroud castings:
- a. Automated equipment using non-mechanical methods for measuring airfoil wall thickness;
 - b. Tooling, fixtures or measuring equipment for the "laser", water jet or ECM/EDM hole drilling processes embargoed by 1095.3.c.;
 - c. Directional solidification or single crystal casting equipment;
 - d. Ceramic cores or shells;
 - e. Ceramic core manufacturing equipment or tools;
 - f. Ceramic core leaching equipment;
 - g. Ceramic shell wax pattern preparation equipment;
 - h. Ceramic shell burn out or firing equipment;
1092. 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 embargoed by 1095.3.a.;
1092. 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 specially designed parts or accessories therefor;
1092. 4. Tools, dies or fixtures for the solid state joining of gas turbine "superalloy" or titanium components;
1092. 5. On-line (real time) control systems, instrumentation (including sensors) or automated data acquisition and processing equipment, specially designed for use with the following wind tunnels or devices:
- 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;
 - c. Wind tunnels or devices, other than two-dimensional sections, capable of simulating Reynolds number flows exceeding 25×10^6 ;
1092. 6. Specially designed acoustic vibration test equipment capable of producing sound pressure levels of 160 dB or more (referenced to 20 micropascals) with a rated output of 4 kW or more at a test cell temperature exceeding 1,273 K (1,000°C), and specially designed transducers, strain gauges, accelerometers, thermocouples or quartz heaters therefor;
1092. 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;
1092. 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);
1092. 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;

1093. Materials

None.

1094. Software

1094. 1. "Software" required for the "development" of equipment or technology embargoed by 1091., 1092. or 1095.3.;
1094. 2. "Software" required for the "production" of equipment embargoed by 1091. or 1092.;
1094. 3. "Software" required for the "use" of full authority digital electronic engine controls (FADEC) for propulsion systems embargoed by 1091. or equipment embargoed by 1092., as follows: