ITEM 18
Nuclear Effects Protection

Nuclear Effects Protection

Produced by companies in

- France
- Israel
- Japan
- Russia
- Sweden
- United Kingdom
- United States

Devices for use in protecting rocket systems and unmanned air vehicles against nuclear effects (e.g. Electromagnetic Pulse (EMP), X-rays, combined blast and thermal effects), and usable for the systems in Item 1, as follows:
(a) "Radiation hardened" "microcircuits" and detectors.

Note to Item 18 (a):
A detector is defined as a mechanical, electrical, optical or chemical device that automatically identifies and records, or registers a stimulus such as an environmental change in pressure or temperature, an electrical or electromagnetic signal or radiation from a radioactive material.

Nature and Purpose: Microcircuits require protection from ionizing radiation in the form of gamma and X-rays from detonated nuclear weapons. Ionizing radiation causes two problems in microcircuits. The first problem is the build-up of a permanent electrical charge in a circuit, which disrupts its ability to respond or causes it to fail completely (latch-up). This effect depends on the total dose of radiation delivered to the circuit. The second problem is excess flow of electrical current in a circuit, which disrupts or destroys it. This effect depends on how quickly the radiation is delivered to the circuit (dose rate). Of the several ways to protect circuits from such effects, the two covered by the MTCR Annex are to make microcircuits intrinsically resistant to the total dose of ionizing radiation (hardening) or to use a radiation detector to sense the dose rate from a nuclear event and turn the circuit power off or trigger protection devices until the event is over.

Method of Operation: Hardened microcircuits are similar in operation and appearance to regular microcircuits, but they are made of materials and by processes that resist accumulating excess charge. Improved oxide insulating layers, increased material purity, decreased porosity, and sometimes polishing of the insulating layers are all used to reduce the charge-holding tendencies of the oxide. These techniques greatly increase the cost of a hardened microcircuit, and they tend to lower digital operating rates. Radiation detectors are relatively simple devices that sense an increase in current caused by incident radiation. After the radiation passes a threshold, the detectors issue a

Photo Credit: The Charles Stark Draper Laboratory, Inc.

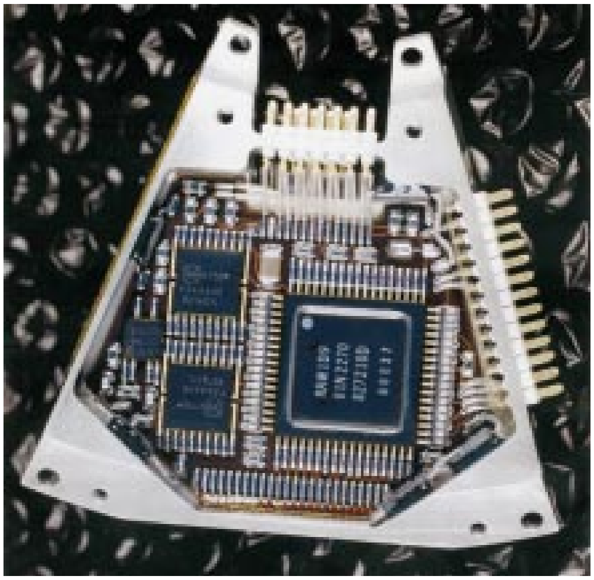

Figure 18-1: A circuit board populated with microcircuits hardened against nuclear effects.

Photo Credit: The Charles Stark Draper Laboratory, Inc.

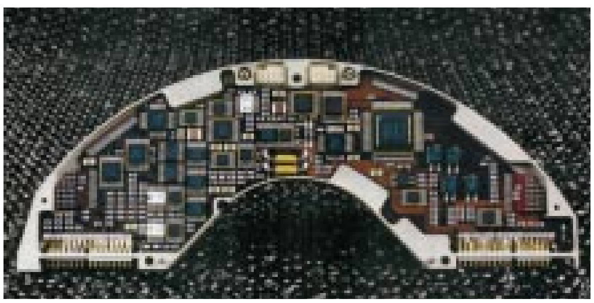

Figure 18-2: Another circuit board populated with microcircuits hardened against nuclear effects.

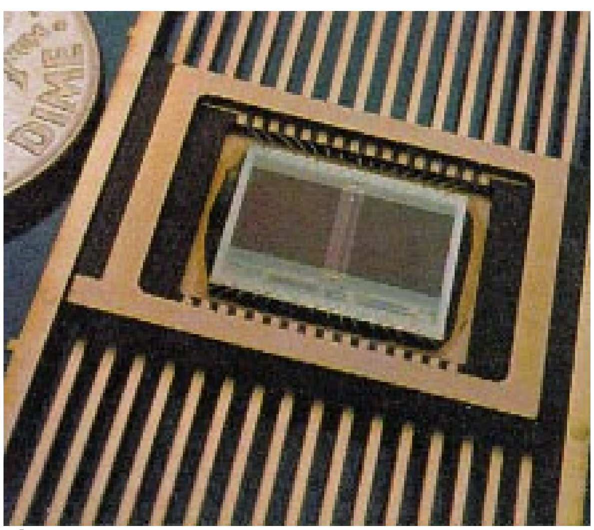

Figure 18-3: Single microcircuit radiation detector.

control signal to protection circuitry, which either shunts currents away from sensitive devices or turns off the equipment to avoid burn out. The detectors usually have a test input to activate the detector during construction or maintenance activities to verify operation. They must usually resist radiation effects (e.g., they must work again), and they must be fast in issuing protection commands before damage occurs in the microcircuits.

Typical Missile-Related Uses: Radiation-hardened microcircuits and detectors are used in ballistic missiles intended to operate in a nuclear environment. Protecting unmanned air vehicles (UAVs) from ionizing radiation is generally not required because they are usually more vulnerable to blast overpressure, which would impact a UAV at greater distances from a nuclear explosion than radiation.

Other Uses: Radiation-hardened devices are used in spacecraft for long-duration missions, including military, telecommunications, scientific, and meteorological satellites, space stations, and planetary probes. However, the total dose that these applications are required to withstand is generally significantly lower than that specified by the MTCR Annex (5×10^5 rads (Si)), but MTCR-controlled items are often used. Hardened microcircuits are also used in high-radiation environments such as nuclear reactor safety; instrumentation, control, and robotics systems; and high-energy physics accelerator instrumentation, detectors, control, and safety systems.

Appearance (as manufactured): Hardened electronic component devices and their assemblies are typically mounted in hermetically sealed metal or ceramic packages with surface-mounted devices common in high-density assemblies. They look like commercial devices, but they may have part numbers identifying them as hardened. Two circuit boards populated with hardened microcircuits are shown in Figures 18-1 and 18-2.

Radiation detector circuits can be a dozen or so square centimeters of circuit board space or a single microcircuit with a few external select components as shown in Figure 18-3.

Appearance (as packaged): Electronic assemblies and components are typically shipped in plastic bags marked to designate an electrostatic sensitive device. They are cushioned in rubber foam or bubble wrap for shock protection and packed inside cardboard boxes.

(b) Radomes designed to withstand a combined thermal shock greater than 100 cal/sq cm accompanied by a peak over pressure of greater than 50 kPa (7 pounds per square inch).

Produced by companies in

- Russia
- United States

Nature and Purpose: Radomes are non-metallic structures that protect antennas from the environment while allowing transmission of radio frequency signals with minimal signal loss and distortion. They are usually made of an insulating material such as ceramics or silicon phenolic. The indicated specifications limit concern to radomes intended to survive a severe heat and pressure environment.

Method of Operation: Radome materials are selected for their strength and signal transparency in the frequency bands of interest throughout the expected temperature range. They are usually shaped to enhance the aerodynamic performance of the vehicle and to avoid undue perturbations of the signal from prismatic, or lens, effects. Properly designed radomes allow the enclosed antenna to transmit and receive signals through the radome with minimal distortions.

Typical Missile-Related Uses: The severe environments specified in this Item typically limit the missile-related uses of these radomes to some cruise missiles and to the reentry vehicles (RVs) carried by short- to intermediate-range ballistic missiles. One use of such radomes is to protect active radar seekers installed in the nose of RVs as they guide the RVs to their targets. Longer-range missiles reenter the atmosphere too fast for nose mounted radomes to survive. For these RVs, radomes (windows) may be located further back on the RV body. These radomes are not generally needed for UAVs because most UAVs cannot survive the specified nuclear effects. In any case, radomes also can be hardened to the specified nuclear effects to protect antennas at missile silos or command posts designed to survive nuclear attack.

Other Uses: These radomes have few if any commercial uses.

Appearance (as manufactured): Radomes used to protect nose-mounted sensors in RVs are conical, as shown in Figures 18-4 and 18-5. They range in size from 30 cm to 1 m or more in diameter and length, depending on the size of the RVs to which they are

Photo Credit: British Aerospace Defense Limited

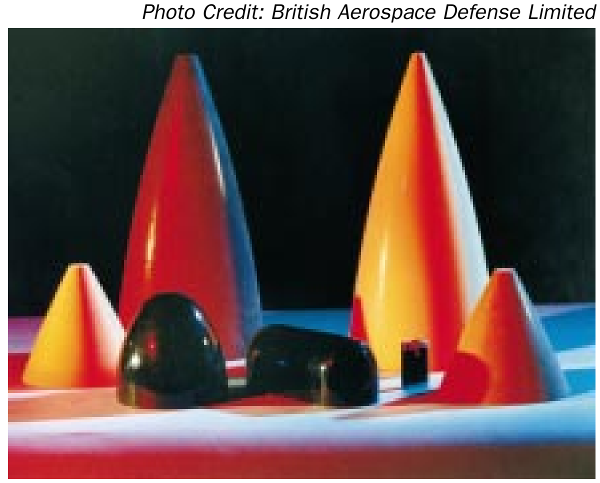

Figure 18-4: Aerodynamic radomes.

Photo Credit: American Technology & Research Industries, Inc.

Figure 18-5: Radomes similar to those that might be used to protect RV seekers on reentry.

attached. The materials are basically dielectrics in solid laminates or sandwiched foam formed as a single, one-piece molded radome. A thin wall, dielectric space frame (DSF) radome, usually 0.1 cm or less in thickness, may be used for small antennas. A solid laminate-wall DSF radome typically is 0.25 cm in thickness. For two-layer, sandwich DSF radomes, a foam layer is added to the inside of the thin wall radome. The foam thickness is chosen primarily for thermal insulation and resistance to thermal shock loads of 100 cal/sq cm. A composite sandwich, foam-core wall radome is the most expensive design and provides the strength to withstand peak over-pressure loads greater than 50 kPa. A sandwiched foam-core wall is one-quarter wavelength thick for the highest radio frequency signal.

Appearance (as packaged): Radomes are shipped in wooden crates that have contour braces within them to support their thin wall structure. Radomes have closure frames mounted on their aft flanges to maintain structural rigidity in transit and are wrapped in polyethylene bags. Crates can use either formed wooden bulkheads for contour bracing or polyurethane, foamed in place, to support the radome.