Electromagnetic Shielding

**From The Vault**





A pulse grenade

An **electromagnetic pulse**, commonly abbreviated to EMP, is a burst of strong electromagnetic energy. An EMP can be generated in numerous ways, from industrial accidents to specially-designed generators. However, EMPs are best known from their first documented source: nuclear weapons.

As the primary effect of an electromagnetic pulse is the desctrucion of electronic elements, there are some weapons that generate it, used primarily against various robots. These include the Pulse Grenades and the Pulse Rifle Prototype developed by the Reaver Movement. While similarly named, the YK32 Pulse Pistol and YK42B Pulse Rifle are not EMP weapons but generate an electrical pulse effective also against living targets.

Discovery and history

The EMP effect was discovered in the earliest days of nuclear testing, and was observed during the Trinity test, mankind's first nuclear detonation. However, scientists of the day were more concerned with the physical effects of the weapon and less so with the electromagnetic consequences, so the field remained largely unstudied until after the conclusion of World War II.

As scientists began to research the EMP phenomenon, they began to hypothesize that the EMP could serve as much as a weapon as the brute destructive forces of the bomb itself. While the primary effects of a nuclear weapon would continue to remain the overpressure and thermal effects, the EMP was nevertheless recognized as a useful secondary effect.

Characteristics

The term "EMP" is a catchall term for any strong burst of electromagnetic energy, regardless of the source. Generally, however, an EMP is a very brief event, lasting less than a second. However, much happens in that span of time.

An EMP is actually the combined effect of three distinct pulses, each operating over a different duration and at a different speed.

The first pulse, called the E1 pulse, is the fastest component and arrives first. This is an electrical pulse, and is capable of inducing very high voltages in conductors in a thin fraction of a second. This leads to overloads in everything from substation transformers to microchips, making the E1 pulse the most damaging element of an EMP as far as electronics are concerned. The sudden voltage spike, exacerbated by long high-power transmission lines or similar antenna-like structures, can easily cause fires in utility transformers and will burn the delicate logic switches inside solid-state electronics, rendering them useless.

The E2 pulse, second to arrive, is actually the weakest in terms of causing damage. Its characteristics in conductors are very similar to those found in a lightning strike, making common surge-suppressor technology quite effective in arresting its effects. Any electronics that survive the E1 pulse will likely survive the E2.

The third and final pulse, E3, appears only during an EMP generated by a nuclear blast; only a nuclear weapon creates an E1 pulse strong enough to cause an E3. A nuclear weapon's E1 pulse is actually strong enough to deform the Earth's magnetic field, its E1 pulse creating a "bubble." As the E1 pulse dissipates, the Earth's magnetic field "snaps back" to its proper field lines, creating a pulse of its own. This is the E3 pulse. Effectively, the E3 pulse is an "echo" of the E1. Like the E1, the E3 pulse induces severe voltage loads in conductors, quite akin to the effects of a severe solar flare. Large utility grids are particularly vulnerable to the E3 pulse as the long "high-tension" carrier lines naturally attune and undergo induction. Transformers somehow spared by the E1 pulse can very easily fall victim to the E3.

Effects

The damage wrought by an EMP, whether created through nuclear or non-nuclear means, varies with the object being bombarded. Transformers and electrical switching gear tend to suffer most from the obscenely high voltages induced in conductors. This high degree of induction is more than capable of causing transformer coil ruptures, casing bursts, fires, and other damage. Switching gear can burn or spot weld. Arc shorting is easily possible across phases in a transformer substation, causing yet more damage.

Solid-state electronics, such as microchips and integrated circuits, suffer severe damage from the inductance pulse. Microminiaturized transistors, which ordinarily operate in the range of millivolts, are suddenly exposed to energies exponentially greater than design or even tolerance levels, leading to the abrupt destruction of the logic and memory elements of the electronics.

For humans, however, an EMP is usually absolutely harmless, often even undetectable. Unless a person has an implanted device, such as a pacemaker, an EMP will usually pass by unnoticed, save perhaps for a slight tingling sensation. This is emphasized in the Pulse Grenade/mine damage to organic targets in Fallout 3. The only damage from the grenade is possibly the shrapnel.

Owing to Fallout's timeline split, the integrated circuit revolution never really took hold. The proliferation of vacuum tubes in the classic Fallout games (*Fallout* and *Fallout 2*) is explanation enough for the survival of the computer consoles and Pip-Boys. *Fallout 3* is more of a departure from the original motif, emphasizing small-scale electronics and powerful computers, but conventional EMP shielding methods can explain the survival of these devices.

While the Fat Man weapon does use low-yield nuclear weapons, these "pocket nukes" would still produce enough of an EMP to disable computers or even the player's Pip-Boy 3000 given the ranges involved, but this was probably overlooked for the sake of game dynamics and playability.

Mitigation

Electronics can be shielded from the effects of an EMP, but effective shielding is difficult to achieve and can be quite costly depending upon the application.

Generally, EMP shielding takes the shape of some form of Faraday cage, a giant mesh antenna which grounds incoming signals, inside which the system to be protected lives. Mobile systems can be shielded with heavy metal cladding that is well grounded. Effectively, the only way to shield against an EMP is to ensure that the inbound energy will take an easy route to ground before striking the system to be protected.