Fission Principes

"Within about 1 ms after the explosion, some 70-80% of the explosion energy... is emitted as primary thermal radiation, most of which consists of soft X-rays. "Glasstone, The Effects of Nuclear Weapons

FISSION PRINCIPLES

The binding energy per nucleon versus atomic mass has a turning point around Fe-56. Iron is the most stable element. Elements with atomic masses less than iron tend to combine, and those with masses greater than iron tend to split. Radioactivity is an indication of this instability. The problem is that protons in the nucleus tend to repel each other. There comes a stage where the nuclear binding energy cannot compete with this repelling force, even if you add more and more neutrons to the nucleus. Take as an example, the highest Z naturally occurring element - uranium.

U has many radioactive isotopes. These include U-234, U-235 and U-238. They are among the longest-living elements in a table of radioactive isotopes. The U-235 isotope is used in weapons since it has the highest fission cross section of all the U isotopes, for thermal neutrons. If you bombard U-238 with thermal neutrons, you might just cause a transuranic beta decay to Pu-239. Pu does not occur naturally, and is of use in weapons. If you bombard the radioactive isotopes with slow neutrons there is a chance that you will split the nuclei in half. In the process, you release some binding energy, and some more neutrons. For an explosion, you need a self-sustaining chain reaction which keeps on generating more and more neutrons. In effect, you need a critical mass of fissionable material to offset any loss of neutrons. (Instead of hitting other isotopic nuclei, the neutrons might just wander off.) A sphere of material is used to provide the least surface area for neutron loss. If the sphere is large enough, neutron loss will be balanced by neutron generation, resulting in a self-sustaining reaction. You have an energy release in fission since the mass of the original atom doesn't equal the mass of the two reaction atoms. The lost energy is converted to radiation and kinetic energy of the atoms via mass-energy equivalence. The fission products are around equal size, and are highly radioactive. Products include Sr, which is absorbed into human bones and stays there, since it is chemically similar to calcium. Other harmful products include cesium, similar to potassium. Cesium is distributed uniformly throughout the body. The number of fissioning nuclei increases as a geometric progression, with each generation. Most of the energy in a bomb is released during around the 80th generation. It is estimated in 10^{-6} secs, about 2×10^{-24} U-235 nuclei split, releasing HUGE amounts of energy. A single split gives you about 170 MeV on average, whereas a chemical reaction only gives you a few eV. An example of a fission reaction is:

U-235 + n -> Kr-92 + Xe-142 + 2n + 207 MeV.

The released energy is many orders of magnitude greater than that released by a chemical reaction using the same amount of matter. A solid Pu sphere of 6.2 kg mass is about 3.3" in diameter. It would be as big as a tennis ball, but as massive as a bowling ball. The sphere would be bigger if there was a Po-Be core inside. Uranium & Plutonium

Uranium-235 is very difficult to extract. In fact, for every 25,000 tons of Uranium ore that is mined from the earth, only 50 tons of Uranium metal can be refined from that, and 99.3% of that metal is U-238 which is too stable to be used as an active agent in an atomic detonation. To make matters even more complicated, no ordinary chemical extraction can separate the two isotopes since both U-235 and U-238 possess precisely identical chemical characteristics. The only methods that can effectively separate U-235 from U-238 are mechanical methods. U-235 is slightly, but only slightly, lighter than its counterpart, U-238. A system of gaseous diffusion is used to begin the separating process between the two isotopes. In this system, Uranium is combined with fluorine to form Uranium Hexafluoride gas. This mixture is then propelled by low-pressure pumps through a series of extremely fine porous barriers. Because the U-235 atoms are lighter and thus propelled faster than the U-238 atoms, they could penetrate the barriers more rapidly. As a result, the U-235's concentration became successively greater as it passed through each barrier. After passing through several thousand barriers, the Uranium Hexafluoride contains a relatively high concentration of U-235 -- 2% pure Uranium in the case of reactor fuel, and if pushed further could (theoretically) yield up to 95% pure Uranium for use in an atomic bomb. Once the process of gaseous diffusion is finished, the Uranium must be refined once again. Magnetic separation of the extract from the previous enriching process is then implemented to further refine the Uranium. This involves electrically charging Uranium Tetrachloride gas and directing it past a weak electromagnet. Since the lighter U-235 particles in the gas stream are less affected by the magnetic pull, they can be gradually separated from the flow. Following the first two procedures, a third enrichment process is then applied to the extract from the second process. In this procedure, a gas centrifuge is brought into action to further separate the lighter U-235 from its heavier counter-isotope. Centrifugal force separates the two isotopes of Uranium by their mass. Once all of these procedures have been completed, all that need be done is to place the properly molded components of Uranium-235 inside a warhead that will facilitate an atomic detonation. Supercritical mass for Uranium-235 is defined as 110 lbs (50 kg) of pure Uranium. Depending on the refining process(es) used when purifying the U-235 for use, along with the design of the warhead mechanism and the altitude at which it detonates, the explosive force of the A-bomb can range anywhere from 1 kiloton (which equals 1,000 tons of TNT) to 20 megatons (which equals 20 million tons of TNT -- which, by the way, is the smallest strategic nuclear warhead we possess today. {Point in fact -- One Trident Nuclear Submarine carries as much destructive power as 25 World War II's}). While Uranium is an ideally fissionable material, it is not the only one. Plutonium can be used in an atomic bomb as well. By leaving U-238 inside an atomic reactor for an extended period of time, the U-238 picks up extra particles (neutrons especially) and gradually is transformed into the element Plutonium. Plutonium is fissionable, but not as easily fissionable as Uranium. While Uranium can be detonated by a simple 2-part gun-type device, Plutonium must be detonated by a more complex 32-part implosion chamber along with a stronger conventional explosive, a greater striking velocity and a simultaneous triggering mechanism for the conventional explosive packs. Along with all of these requirements comes the additional task of introducing a fine mixture of Beryllium and Polonium to this metal while all of these actions are occurring. Supercritical mass for Plutonium is defined as 35.2 lbs (16 kg). This amount needed for a supercritical mass can be reduced to a smaller quantity of 22 lbs (10 kg) by surrounding the Plutonium with a U-238 casing.