Subject: Absolutely fascinating
Posted by gibberish on Fri, 02 Jul 2004 19:43:08 GMT
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On the subject of atmospheric plutonium releases, particularly those involving accidental releases from radioisotope thermoelectric generators (RTGs) carrying the short-lived isotope Pu-238, the book SPACE NUCLEAR POWER, by J.A. Angelo Jr. and D. Buden (Orbit Book Co., 1985) is a good reference.

On p. 244 is the following section (chapter 13) :

Aerospace Nuclear Incidents

To date, the United States has launched 19 space missions with radioisotope
power sources. After four successful RTG launches, the Transit-5BN-3 failed
to achieve orbit on 21 April 1964 due to a launch vehicle abort that was traced to conflicting guidance controller signals occurring during ascent. This guidance malfunction caused the launch vehicle to pitch improperly and
orbital insertion of the payload was not achieved. Despite the ascent abort,
however, the SNAP-9A RTG on board the spacecraft as designed for a launch/mission abort and it burned up on reentry into the earth's atmosphere. The RTG's plutonium-238 metal fuel was injected into the atmosphere in the Southern Hemisphere at an altitude between 45 and 60 kilometers. Airborne and surface sampling was initiated following this abort
and four months later plutonium dioxide (PuO2) was first positively identified at an altitude of 32.9 km at 35 degrees south latitude. It was subsequently concluded that, as designed, the radioisotope fuel had completely burned up during reentry over the West Indian Ocean north of Madagascar [2,6].
The second U.S. RTG aerospace nuclear incident occurred on 18 May 1968 and involved a SNAP-19 generator on board the Nimbus B-1 meteorological spacecraft. In this case, erratic behavior of the launch vehicle forced its
intentional destruction by the Range Safety Officer when the vehicle and its
payload were at an altitude of 30 km and traveling downrange from the Vandenberg Air Force Base launch site. Tracking data placed the impact point
of the launch vehicle and spacecraft debris in the Santa Barbara Channel about 5 km north of San Miguel Island off the California coast. Here, the water depth is about 90 meters. The SNAP-19 generator was designed for intact reentry and had been tested in a marine environment. Since data

indicated that the radioisotope fuel capsules were still intact and that
they posed no immediate environmental or health problem, there was no
immediate urgency to recover them from the ocean floor. In fact, the
SNAP-19
generator was recovered from the Pacific Ocean five months later (see Fig.
13.1). The entire incident verified that the radioisotope fuel capsules of
this design could remain in a marine environment for long periods of time
following a launch/mission abort without concern for fuel release.
Post-incident examination of the fuel capsules revealed that no
detrimental
effects were suffered from the destruction of the launch vehicle, impact
in
the ocean, or nearly five months residency on the ocean bottom. The
graphite
ablators surrounding the capsule were also intact [2,6].
A third RTG aerospace nuclear incident involved the aborted Apollo 13
mission to the Moon in April 1970. In this event, the SNAP-27 fuel
capsule,
containing 44,500 curies of plutonium-238 oxide microspheres, reentered
the
Earth's atmosphere along with the Aquarius Lunar Module (LM) which had
served as a translunar trajectory lifeboat for the in-flight stranded
Apollo
13 astronauts. En route to the Moon, an oxygen tank had exploded in the
Service Module. Following the near fatal explosion, astronauts Lowell,
Swigert, and Heise powered up the Aquarius, battened down the crippled
command ship Odyssey, and continued on a course around the Moon and back
to
the Earth. For more than 90 hours these three men rode a lunar landing
craft
designed to accommodate just two astronauts for two days. Then,
approaching
Earth, they again fired the Aquarius (LM) engine to thread themselves
carefully through a narrow reentry corridor, shifted to the lifeless
Odyssey
command module (CM), and cut loose both the damaged Service Module and
their
LM lifeboat. The three astronauts were recovered within 45 minutes of
splashdown in the Pacific Ocean [7].
The Apollo 13 SNAP-27 fuel capsule, on the other hand, was contained in a
graphite fuel cask attached to the LM. Both reentered at approximately 122
km above the South Pacific Ocean. Atmospheric monitoring at several high
and
low altitudes in the area indicated that no nuclear fuel was released.
Consequently, it was assumed that the SNAP-27 capsule impacted intact, as
designed, in the deep ocean south of the Fiji Islands and now resides near
the Tonga Trench in some 6 to 9 kilometers of water. There was no
observable

adverse effect on the biosphere as a consequence of this incident --
indicating again the efficacy of the U.S. aerospace nuclear safety
program.

On page 140 :

Consistent with aerospace nuclear safety philosophy of the day, the fuel capsules were designed for intact impact under launch abort conditions and for high altitude burnup and dispersal in the event that a mission abort caused the spacecraft to reenter the Earth's atmosphere.
The liner... material accommodated atmospheric burnup.
The segmented fuel block design permitted separation of the capsules for exposure to aerodynamic heating during a reentry abort.
[Comment : the metal form of Pu-238 also contributed to the burning up -- in contrast to the PuO2 used today, which is already oxidized & will therefore not support a chemical reaction with oxygen...]

page 136 :

The SNAP-3B and -9A systems were designed for nuclear fuel burnup and high altitude dispersal in the event of an atmospheric reentry of the nuclear-powered spacecraft.

Tables 8.1, 8.2 and 8.3 give technical details :

The 12.2 kg SNAP-9A power source [with 17,000 Ci of Pu-238 METAL (!!)], which was launched on the Transit-5BN-3 Navigational Spacecraft on 21
April
1964 burned up on reentry after the mission was aborted during launch.

All subsequent RTGs [SNAP-19 and later models] used PuO2 rather than
metal
and were designed to survive reentry intact.
The SNAP-27 in the Apollo 13 incident had 44.5 kCi of PuO2 - 30.8 kg
without
the cask - when it crashed intact into the South Pacific Ocean on 11 April
1970.

In the SNAP RTGs the primary reentry heat shield, consisting of graphite, formed an outer cylinder around all the fuel capsules. The larger RTG developed for the Galileo and Cassini missions is composed of General Purpose Heat Sources (GPHS-RTGs), and is a modular power unit design providing flexibility for different spacecraft power demands. Each 250 watt-thermal module has its own passive safety provisions, including an aeroshell serving as the structural element and an ablator