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COMMITTEE ON THE PEACEFUL USES OF OUTER SPACE
Scientific and Technical Subcommittee
Forty-third session
Vienna, 20 February - 3 March 2006
Agenda item 9
Use of Nuclear Power Sources in Outer Space

JOINT UNITED NATIONS/INTERNATIONAL ATOMIC ENERGY AGENCY TECHNICAL WORKSHOP ON THE OBJECTIVES, SCOPE AND GENERAL ATTRIBUTES OF A POTENTIAL TECHNICAL SAFETY STANDARD FOR NUCLEAR POWER SOURCES IN OUTER SPACE (VIENNA, 20-22 FEBRUARY 2006)

Session 3. PRESENTATIONS PERTINENT TO OBJECTIVE I.A.

Presentation on "Reactor Design Considerations for safe Launch and Operations"

Note by the Secretariat

1. In accordance with paragraph 16 of General Assembly resolution 60/99 of 8 December 2005, the Scientific and Technical Subcommittee of the Committee on the Peaceful Uses of Outer Space will organize, jointly with the International Atomic Energy Agency, a technical workshop on the objectives, scope and general attributes of a potential technical safety standard for nuclear power sources in outer space, to be held in Vienna from 20 to 22 February 2006.

2. The presentation contained in the present conference room paper was prepared for the joint technical workshop in accordance with the indicative schedule of work for the workshop, as agreed by the Working Group on the Use of Nuclear Power Sources in Outer Space during the intersessional meeting held in Vienna from 13 to 15 June 2005 (A/AC.105/L.260).

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Reactor Design Considerations for Safe Launch and Operations

February 2006

Dr. George Flanagan

- Oak Ridge National Laboratory -
Managed and Operated by UT – Battelle, LLC, for the

U.S. Department of Energy

Safety Design Considerations Will Be Addressed by Mission Phase

- Mission Phases:
  - Launch (normal/accident conditions)
  - Space Operations
    - Start-up and normal operations
    - Off-normal and Accident scenarios (including inadvertent reentry)
  - Retirement
- Design considerations should be informed through use of risk-based approach

Launch (Normal/Accident Conditions)

Normal and Accident Launch Events Can Subject the Reactor to Severe Environments

- Flight reactor not operated except at very low power prior to launch (negligible levels of fission products)
- Reactor safety focus is on preventing inadvertent sustained criticality during the launch phase of a space reactor

Several Design and Operational Measures Have Been Proposed to Prevent Criticality During Expected Launch Conditions

- Addition of neutron absorbing systems that remain in place during plausible launch conditions (high acceleration vibration, changes in temperature) and are removed before startup in a stable orbit
  - Safety rods
  - Wires or plugs made of neutron absorbing material
- Control system locks to prevent actuation during launch
- Encrypted control signals to prevent inadvertent startup
- Design reactor and launch support structure to accommodate launch stresses
- Testing of the reactor system under expected launch conditions

Additional Design Considerations for Addressing Accidents During Launch

- Design options that remain subcritical with minimum geometric distortion when submerged and flooded with water/seawater or buried in dry/wet sand
  - Safety rods
  - Neutron absorbing wires or plugs
  - Use of materials that have strong, large resonance capture cross sections (spectral shift)
    - Tungsten
    - Rhenium

Operation

Safety Considerations for Operation in Earth Orbit

- Design and operational considerations for normal operation in Earth orbit
  - Orbital characteristics and fission product inventory
  - Monitor conditions (adequate instrumentation/telemetry)
  - Operational/off-normal procedures in place
  - Provide reliable shutdown capability
  - Provide for decay heat removal
  - Selection of orbits to reduce possible collisions with space debris

Approaches to Address Inadvertent Reentry

- Design approaches can reduce the probability or consequences of a sustained criticality upon reentry
  - Essentially intact reentry (current design approach)
    - Aeroshell designed to minimize effect of reentry conditions (heat/ablation/debris/stress/vibration) on the reactor core
    - Minimize impact geometry distortion
      - *Aeroshell designed to orient reactor to minimize impact distortion (intact reentry)*
    - Ease of recovery
      - *Contain material within the impact zone boundary*
      - *Provide location indicators to facilitate recovery*
      - *Available trained recovery team (plans/deployment/notification/ retrieval/storage)*
  - Dispersal of material in upper atmosphere

Retirement

Safety Considerations for Retirement Phase

- Long-term retirement should be considered early in planning and design
- Safety considerations specific to Earth orbit:
  - Provide for end-of-life shutdown after operations unplanned event
  - Place in sufficiently high orbit to allow for decay of fission product inventory to acceptable levels before reentry
  - Current design approach is for intact reentry
    - Use of aeroshell to prevent upper atmosphere dispersal
    - Trajectory control to allow impact over ocean
    - Velocity reduction capability to reduce dispersal on impact

Summary of Important Safety Issues to be Addressed in the Design and Operation of a Space Reactor

- Negligible fission product inventory (if any) at launch
- Prevent sustained criticality during launch phase (for expected conditions and potential accidents)
- Achieve stable deployed configuration prior to start-up
- Prevent off-normal operations while in orbit
- Design to prevent sustained criticality following reentry and plan for safe recovery of reactor material following a reentry
- Design for safe retirement after operations