NE250 Homework 0 **Mitch Negus**
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RTGs

- First public demonstration of RTG to pres Eisenhower, 1959 (1)
- Largely US produced (Russia has favored reactor based power systems) (3)
- Two components thermoelectric converter and heat source (1,2)
- Seebeck effect −¿ produces electricity from heat (1)
- Thermoelectric converter (1)
- temperature difference/gradient across heat source (1,2)
- conductor on hot end, p/n type semiconductors, load on cold end (still several hundred K) (1)
- load (thermocouples) often connected in series to boost voltage output
- relatively low conversion efficiency 5-10% (2,3)
- Heat source is a radioactive isotope, casing dispells heat into environment (1)
- Ideal for space exploration; high energy density, long lifetime d1,2)
- low power output is a challenge
- other considerations include high melting point, safe and cost effective to produce (2)
- mass considerations due to half-life; looking for reasonably equal power distribution over space mission (half-life mission length) (2)
- goal is to keep penetrating emissions low (esp. for manned missions, also to prevent rad damage except locally, or in the event of catastrophic failure) (2)
- two manufacture methods: Used fuel isolation, neutron activation of target

-Dynamic systems being developed (better efficiencies 25+%) (2)

-even more benefit if radioactive decay leads to daughter decays (3)
-cerium 144 initially tested (plentiful from defense waste, 290 day half-life suited to military purposes) (2) - SNAP-1
-po210 used in SNAP-3 (demonstrated at WH in 1959-¿ to Ike) (2); half-life 138 days, still too short for many space missions (2)
-Sr90 used terrestrially, no space missions (requires heavy shielding) (2)
-others include H3 (12y), Am241(433y), Cm242(163d), Cm244(18y) (3)
-alpha emitting Am241 is esp. promising; produced by decay of Pu241 from snf

- pu238 is primary isotope used in RTGs (easy to produce stably, easy to encapsulate, emits absorbable radiation) (1)
- half-life of 87.7 yrs; low radiation, useful forms (2)
- domestic production ceased in 1986; availabilty has since been limited (purchasing from Russia) (2)
-1961 Transit 4A Navy nav sat = first nuclear power in space (2,3)
- as of 1991, PbTe and SiGe were primary RTG semiconductor components (1)
- SiGe beneficial for space, can withstand temps to 1000C (sublimation/oxidation effects suppressed by inert gas, vented once in space)
- Notable uses SNAP (systems for nuclear auxilary power) program (Apollo ¿ 12, Pioneer, Viking), Voyager missions (1)
- SNAP 27 designed to be loaded modularly, plutonium microspheres (1)
- GPHS (gen purpose heat source used for Space shuttle) (1)
- Used for all NASA missions after 1989 (2)
- GPHS module designed to deliver 250 W_t (2); mass = 1.43 kg (2)

As nuclear batteries (4)
- RTGs inefficient and large due to thermoelectric conversion
- for batteries in general, scale lengths of system ought to be matched — transport scale length of radiation, phyiscal

dimension of energy conversion volume (not applicable to RTGs)
- electron–hole recombination for alpha/betavoltaics
- solid state recombination

Radioactive Heat Sources (RHS) (5)
- used in radioactive heater units (RHUs) or RTGs (5)

(1) DM Rowe (2) DOE Germantown (3) Europe (4) Nuclear batteries (5) modern RHS