e::MISSION SPACE STATION ALPHA

Radiation Reference Guide

Topics: Symptoms, Emergency Procedures, and Reducing Exposure

During massive solar storms, Space Station Alpha may be subject to high doses of ionizing radiation. Fortunately, NASA is able to monitor the levels of radiation and compensate if needed. The following briefing sheet overviews:

- *Space station emergency procedures*
- *What symptoms to expect for given levels of radiation*
- *Options for reducing radiation exposure*

Effects of Acute Radiation Exposure on the Human Body

Exposure to radiation can have a dramatic and immediate effect on the human body. The gastrointestinal system is very sensitive to radiation, leading to nausea and vomiting immediately after exposure. The blood system is often the hardest hit, although antibiotics and transfusions may allow a recovery.

But severe radiation damage to the immune system can cause overwhelming infections. And although nerves and the brain are most resistant to radiation, acute exposure usually results in damage to the central nervous system. High doses can kill outright. The long-term effects of radiation exposure can include sterility, cancer and genetic damage that can be passed to children.

An acute radiation dose is defined as a large dose (10 rems or greater, to the whole body) delivered during a short period of time (on the order of a few days at the most). If large enough, it may result in effects which are observable within a period of hours to weeks. Radiation sickness symptoms are apparent following acute doses $\geq$100 rem. Acute whole body doses of $\geq$400 rem may result in a statistical expectation that 50% of the population exposed will die within 60 days without medical attention.

Exposure to radiation yields the following physiological effects. At lower exposure levels, the body is sometimes able to recover. At higher levels of exposure, damage is permanent. These impacts are based on cumulative exposure. Specific effects to the human body at varying exposures are described below.

50-100 rem	
Effects	**Symptoms**
Cells may die or abnormal cells can be produced	Cells could become cancerous. Temporary hair loss 2-3 days after exposure
Suppressed immune response	Changes in blood count and bone marrow production
Gastrointestinal Tract	Nausea, vomiting, fatigue,
Reproductive organs	Temporary sterility in men
Eyes	Acute conjunctivitis
50 rem to the thyroid gland can result in non cancerous tumors.	
Later symptoms include weight loss, loss of appetite, infection, and bleeding	

Critical: 100-400 rem	
Effects	**Symptoms**
Effects to the blood system, spleen, and lymphatic system	Depression of bone marrow, platelet count falls
Gastrointestinal Tract	Nausea, vomiting, fatigue, increase in temperature, dehydration, electrolytic imbalance, loss of digestion ability, bleeding ulcers
Reproductive organs	Temporary sterility in women, or prolonged or permanent suppression of menstruation
Central Nervous System	Agitation, apathy, disorientation
Death may occur 1-2 months after exposure if not medically treated	

Debilitating: 400-600 rem	
Effects	**Symptoms**
Blood system	Bone marrow is almost completely destroyed
Cognitive Impairment	Inability to perform routine tasks

Life Threatening: 600 rems and up	
Effects	**Symptoms**
Gastrointestinal Tract	Destruction of intestinal lining, intense nausea, vomiting, and diarrhea soon after exposure
Blood system	Complete destruction of bone marrow
Ovaries or Testicles	600 rem- Permanent sterilization
Death within several weeks even with medical attention	

Space Station Emergency Procedures

On the Space Station during a massive radiation event, the astronauts would consider these options (in the order in which they would be considered):

- One: The radiation monitor on board the station (called a TEPC) issues an alarm, and astronauts begin monitoring the situation closely.
- Two: Mission Control asks the astronauts to change the "attitude" or orientation of the station. The station is placed in a position where the bulk of its mass is placed to face the sun and the astronauts move to the rear, using the station itself as a shield. Do not confuse attitude (orientation) with altitude (height above the Earth).
- Three: Astronauts find a means within the station to shield themselves. These options are described below.
- Four: Astronauts either deorbit the station, taking it in closer to the Earth, or they escape in the crew return vehicle and come back to the surface.

Reducing Radiation Exposure: ALARA

Ionizing radiation can be harmful, especially if the body receives too much of it. For this reason, nuclear scientists, engineers, and technicians are constantly refining a set of rules, or "best practices," which should be followed to keep anyone who works in an area exposed to dangerous radiation protected as much as possible. The set of rules, or practices, is called ALARA. ALARA stands for "as low as reasonably achievable." While monitoring the astronaut's exposure to radiation, you will want to keep in mind the three ALARA rules: *time, distance*, and *shielding*.

- Shielding: Very dense materials (like lead) or materials high in hydrogen (like polyethylene or water) act as effective radiation shields. Such shields act to stop or slow down the ionizing protons and radioactive particles. The thicker the shield the better, although the thickness has to double each time to be only 50% more effective. The aluminum shell of the station provides some protection, but not very much. There is very little Lead (Pb) on board the station.
  - When the station is reoriented to a new "attitude" (see above), then the bulk of the station itself serves as a shield.
  - Water: There are approximately 40 cube-like "bags" of water stored in Zarya. Each measures 18"x18"x18" (46x46x46 cm).
  - Polyethylene: There are also 96 blocks of flame-retardant polyethylene which astronauts have strapped together to create two sleep stations in the Destiny module (each block measures 2"x14"x14" or 5x36x36 cm). These sleeping stations may be moved around, or unassembled and reassembled into a new configuration.
  - Other sources of hydrogen: In rare, extreme circumstances where no water bags or polyethylene are available, one astronaut may shield another with their own body mass. Of course, the benefit of this approach is only for the astronaut who is shielded.
  - Space suits offer little shielding protection.
- Distance: Radiation exposure decreases as distance from the source increases. Astronauts have little control over how far they are from the sun's rays, due to the prescribed orbit of the station.
- Time: It is common sense that limiting the time exposed to a source of radiation will reduce radiation exposure. On the space station, however, astronauts have little control over exposure time. They will spend almost 60 minutes of every orbit fully exposed to the sun's rays. If astronauts use some form of

shielding to protect themselves, they should limit the amount of time spent outside the shielded area to conduct any necessary work.

Measuring Radiation Exposure (TEPCs)

How do astronauts know how much radiation they are receiving while they are in the space station? There are many types of monitoring devices that can aid the astronauts in the detection of radiation. One such monitoring device is called a Tissue Equivalent Proportional Counter, or TEPC. It is slightly larger than a Game Boy and has a cell filled with low-pressure propane gas. This hydrocarbon gas is used to simulate the hydrocarbon content of a human cell. When radiation passes through the counter, an appropriate radiation quality factor can be estimated to see how much radiation the astronaut has received.

Exposure Limits

NASA has adopted the recommendations of the National Council on Radiation Protection and Measurements (NCRP) as the basis for spaceflight crew radiation exposures. The maximum exposure limits are shown below. Medical personnel carefully monitor the astronauts' monthly and annual dosages to prevent short term physiological effects of exposure. Career limits exist to lessen the risk of cancer. These limits are one of the primary reasons that NASA does not allow astronauts to stay in space for prolonged periods.

Organ specific exposure limit

Exposure Interval	Depth (5 cm*)	Eye (0.3 cm)	Skin (0.01 cm)
30 Days	25 rem	100 rem	150 rem
Annual	50 rem	200 rem	300 rem
Career	100 to 400 rem	400 rem	600 rem

*Note: Organs at 5 cm include heart, lungs, stomach

Career exposure limits for males and females by age

	Age			
Sex	25	35	45	55
Male	150 rem	250 rem	325 rem	400 rem
Female	100 rem	175 rem	250 rem	300 rem