Electrical Shock Hazards during Extravehicular Activity on the International Space Station

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The International Space Station (ISS) is the largest, most complex space vehicle flown. Natural and induced ISS spacecraft charging processes, common to this space vehicle, can lead to electrical safety concerns during extravehicular activities (EVAs).

While flying at high speeds through Earth's magnetic field, the ISS is operating in Earth's ionosphere – an electrically conducting medium. The ionospheric plasma environment interacts with the ISS structure and electrical power system components to produce electrical potential differences (floating potentials (FPs)) between the ISS and the surrounding plasma. Electric current flows in the plasma and through the ISS conducting structure between the vehicle's different parts. For example, electrons collect at positively charged surfaces, such as the arrays, while ions impinge on metal surfaces and remove electrons at other locations, notably the Russian modules.

Known ISS EVA hazards arise from both ISS and extravehicular mobility unit (EMU) spacecraft charging processes, in combination with the vulnerability of the human body to electric current and the fact that NASA's EVA spacesuits do not provide the wearer electric shock protection. In fact, the suit shell is penetrated at numerous points by electrically conducting, metallic materials that can contact the astronaut's body (figure 1). Providing an electrically safe EVA environment is the responsibility of the spacecraft on which the EVA is being performed.

ISS has two indentified shock hazard scenarios. In one case, charge collects on anodized parts of the suit when it is exposed to negative ISS FPs. This energy can discharge in an arc resulting from breakdown of the anodized layer on the EMU suit. Figure 2 illustrates arcing observed when an artificial plasma source was switched on and off at 5-minute intervals in a laboratory. The spike-like signatures occurring every few seconds are associated with high current that is potentially catastrophic to the human body.

A second shock hazard is associated with direct current passing through an astronaut's body when in contact with positively biased ISS environments. Although the ISS space flight environment is sometimes erroneously treated as an electrical insulator, in fact the ionospheric plasma brings the electrical ground into close proximity with the astronaut's suit and can provide substantial electric current to exposed metallic conductors. Plasma electrons collect easily on positively charged, bare metal surfaces, and current can move through the human body to the positively charged ISS structure or power system components.

Fig. 1. *Astronaut conducting EVA on the ISS.*

Generally, an EVA astronaut is exposed to a variety of positively and negatively charged environments, depending on the location of the ISS in its orbit and the EVA worksite on ISS. We currently manage these risks through active hazard monitoring and hazard mitigation hardware in combination with ISS flight procedures that control ISS FPs. Careful assessment and control of EVA procedures also contributes to making the chance of an astronaut sustaining an electric shock during EVA small.

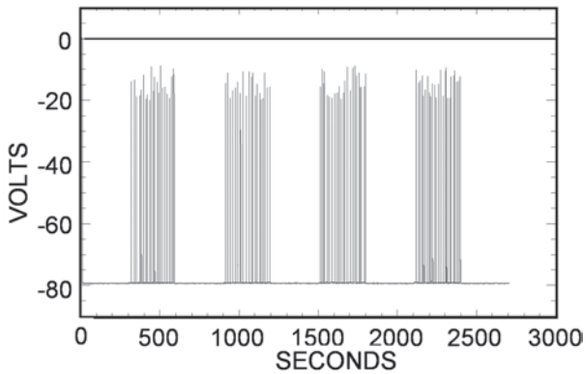

Fig. 2. *A laboratory test illustrating electrical arcing of anodized EMU suit materials.*

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