Managing Toxicological Risks: The Legacy of Shuttle Operations

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Space toxicology greatly matured as a result of research and operations associated with the Shuttle. Materials offgassing had been a manageable concern since the Apollo days, but we learned to pay careful attention to compounds that could escape containment, to combustion events, to toxic propellants, to overuse of utility compounds, and to microbial and human metabolites. We also learned that flying real-time hardware to monitor air pollutants was a pathway with unanticipated speed bumps. Each new orbiter was tested for any excess offgassing products that could pollute the air during flight. In the late 1990s toxicologists and safety experts developed a 5-level toxicity rating system to guide containment of toxic compounds. This system is now in use aboard the International Space Station (ISS). Several combustion events during Shuttle Mir and also during Shuttle free-flight impelled toxicologists to identify hardware capable of monitoring toxic products; however, rapid adaptation of the hardware for the unique conditions of spaceflight caused unexpected missteps. Current and planned combustion analyzers would be useful to commercial partners that wish to manage the risk of health effects from thermal events. Propellants received special attention during the Shuttle program because of the possibility of bringing them into the habitable volume on extravehicular activity suits. Monitors for the airlocks were developed to mitigate this risk. Utility materials, such as lubricants, posed limited toxicological problems because water was not recovered. One clearly documented case of microbial metabolites polluting the Shuttle atmosphere was noted, and this has implications for commercial flights and control of microbes. Finally, carbon dioxide, the major human metabolite, episodically presented air quality problems aboard Shuttle, especially when nominal air flows were obstructed. Commercial vehicles must maintain robust air circulation given the anticipated high density of human occupants.

Learning Objective: Toxic compounds used aboard the Space Shuttle pose a health hazard to crewmembers. Commercial builders and users of human rated spacecraft must learn to avoid the use of toxic compounds whenever possible and to properly control those compounds that cannot be avoided.