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SPACE STATION FREEDOM

TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

PAST EXPERIENCE

"SKYLAB MISSION"

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The design of the Skylab missions, 1973-74, was intended to exclude any direct handling of hazardous, toxic or reactive materials. The materials processing facility and multipurpose furnace provided a contained environment for conducting metals melting, brazing, sphere forming and crystal growth experiments. At the end of the third mission, following the completion of all other experiments, the materials processing facility was used for a series of flammability experiments. The flammability tests were done last because of the contamination expected from the burning of materials within the facility. The flammability tests demonstrated a number of peculiar effects that have implications for future design(fire detection, location and suppression/control).

Although the results of the flammability tests contain lessons appropriate to planning, a number of events during the flight illustrate situations or conditions that pose considerations beyond the commonly accepted range of concern for safety-related matters. This presentation will include a discussion of:

-Skylab flammmability studies and the implications for fire suppression/control;
-False fire alarms and the Skylab fire detection system;
-Space environmental effects on materials that are normally benign;
-Spills/release of contaminants;
-The detrimental effect that the release of non-hazardous materials have on detection systems;
-The problem of locating sources/originating point of hazards.

1. Events

MISSION	ACTIVITY/EVENT	HAZARD
SL-2	Polyurethane Heating	Atmosphere Contamination Toxic/Gas: CO, Cyanide Gas, Toluenediisocyanate
SL-2	Brazing/Welding; Sphere Forming	Heat; Gas Products; Electron Beam Energy
SL-2 thru SL-4	Cooling System Leak(Water/Glycol) use of sampling techniques.	Atmosphere Contamination: Glycol No onboard system capability to evaluate samples.
	Collection of Particulates in/on ventilation Duct Filters/Heat Exchangers.	Concentration/retention of potentially hazardous materials: Particulate condensation of toxic agents, micro organisms.
	Spills of metabolic waste and natural sloughing from body & clothing.	Urine, Feces, Vomitus, etc.; Sweat; Skin; Hair; Cloth Fibers.
	False Alarms.	Delay in interpretation and absence of capability to pinpoint the location. Loss of credibility in alarm-system.
SL-4	Discharge of Fire Extinguisher.	Freon
	Puncture of Charcoal Canister (to sample for Glycol).	Particulate charcoal
	CM-RCS (Suspected leak of fuel/oxidizer)	Hydrazine, Nitrogen Tetroxide
	Fragments from photographic plates (S183: Ultraviolet Panoramic Camera).	Glass shards (observation/release during unplanned maintenance).

1. Events (cont.)

MISSION	ACTIVITY/EVENT	HAZARD
SL-4 (cont.)	Bonded Numerals came off the indicator belt drives of the Articulated Mirror System (AMS).	Particulates/Chunks of unknown composition (internal threat to mechanisms).
	Flammability tests.	Gas contaminants; spread of fire.

HAZARDOUS & TOXIC MATERIALS HANDLING
Skylab Experience Summary

2. Conclusions

EXPERIENCE BASIS	CONCLUSION
1. S IV B Insulation Heating (SL-2)	1. Environmental extremes may generate hazards from benign materials.
2. Water/Glycol Leak (SL-2 to SL-4) Freon/Fire Extinguisher Discharge CM-RCS (Hydrazine, Nitrogen Tetroxide)	2. Inadvertent leakage or vent from standard/generic spacecraft systems or the use of contingency/emergency equipment may: 2.1 Constitute a hazard. 2.2 Create confusion in assessing a known/suspected release of hazardous toxic materials. (also see 4., below)
3. Broken glass plates Bonded Numeral Release (AMS) Charcoal Canister puncture	3. Encapsulation protection of potentially hazardous materials may be negated by conducting contingency maintenance/ repair operations.
4. S IV B Insulation Heating (SL-2) CM-RCS Leak (SL-4)	4. General detection/assessment techniques were inadequate/unavailable.
5. Particulate accumulation on filters & in the heat exchanger grilles.	5. The ventilation system and cleaning systems of Skylab were inadequate to prevent/correct the flow-blockage/ clogging of fine grille heat exchangers.
6. Flammability Tests/Fire Detection	6. Microgravity inhibiting of convective circulation cannot be relied upon to prevent fire/flame propagation. Conditions detrimental to fire suppression and detection include: 6.1 Porosity of materials (O_2 captured within the flammable material)

2. Conclusions (cont.)	
EXPERIENCE BASE	**CONCLUSIONS**
6. Flammability Tests/Fire Detection (cont.)	6.2 Thermo-mechanical response of burning materials that cause local air agitation or displacement out of O_2-depleted zones. 6.3 Local airflow induced by normal cabin ventilation/circulation system. 6.4 Local airflow caused by the use of fire extinguishers (initial blowtorch effect). 6.5 False fire alarms (decreases credibility of detection system). 6.6 Poor detection system design (causing time delays and confusion in interpreting/assessing the indication)
7. Metabolic Wastes & Particulates	7. The accidental spills of metabolic products and unavoidable sloughing of particulates from skin and clothing may cause contamination of the habitable environment and accumulate in quantities sufficient to compromise system performance.

3. RECOMMENDATIONS

1. Develop an approach to identify and evaluate normally benign spacecraft materials, components that may generate hazards when subj ed to environmental extremes that can be encountered in space.

2. Design a hazardous/toxic materials detection/assessment system that will be effective for generic space environment products in addition to sources formally classified as hazardous/toxic.
   2.1 The detection/assessment system should be able to locate the source;
   2.2 The detection/assessment system should include ancillary manual devices to supplement an automated system.

3. Encapsulation (containment) design should include a careful appraisal of contingency/emergency operations to assure crew safety and equipment protection for maintenance/repair activities that entail violation of containment provisions.

4. Flow restriction zones in cabin atmosphere ventilation systems should be scrutinized during design reviews to:
   4.1 Preclude the accumulation of unremovable debris, specifically, the sizes of grille, grid or mesh openings should be optimized to enable easy removal of debris;
   4.2 Assure easy access by crew and equipment to effect maintenance/repair. In particular, more powerful vacuum cleaning capability is needed.
   4.3 Filters & grilles should be designed with removable sample plugs to support onboard assessment of contaminants.

5. Flammability control & fire suppression design approaches should consider porosity & thermal-mechanical reaction (flammable materials), local circulation velocities and initial effects of fire extinguishers.

6. Fire detection systems should be immune to false alarms and provide unambiguous indications regarding (a) the sensor triggering the alarm and (b) the suspect location of the fire or overheat condition.

3. RECOMMENDATIONS (cont.)

7. Provide a high-volume, high delta P vacuuming device to: clean up spills of metabolic/hazardous-toxic materials and to enable effective cleaning of filters, grilles and grid surfaces.