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SPACE STATION PRESSURIZED LABORATORY SAFETY GUIDELINES

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SPACE STATION TOXIC AND REACTIVE MATERIALS HANDLING WORKSHOP

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SPACE STATION PRESSURIZED LABORATORY SAFETY GUIDELINES

The development of space based laboratory guidelines is a mixture of consideration of past experience, contemplation of present operations and conjecture regarding proposed endeavors. This is not to say that we must grope for answers but that we must understand the limits of our experience and factor those limits in as we step forward cautiously. Underlying the development of laboratory safety guidelines for Space Station Freedom must be the recognition of the uniqueness of this resource. While safety requirements for ground-based laboratories have come about literally by accident (and the loss of many laboratories and a few researchers as well), we can ill afford to generate safety requirements for space laboratories in the same manner.

Before we begin to establish technical safety guidelines and requirements a common understanding of their origin and importance must be shared between Space Station Program Management, the User Community, and the safety organizations involved. This is done through organization and communication, of course, but there must also be an appreciation of each others' interests. A space-based laboratory in which the experiments are received and returned in unopened containers, while useful and safe, does not take full advantage of the facilities' potential for more interesting experiments. Safety can be built into the facility to allow more interesting experiments but at a cost to the program manager. Safety guidelines and requirements will be driven by the nature of the experiments and degree of crew interaction. The greater and more complex the potential risk the more stringent and complex the safety requirements. Once a programmatic decision has been made regarding the level of acceptable potential risk, safety guidelines are then applied to generate safety requirements to prevent the potential risk from becoming a reality.

IDENTIFY THE HAZARDS

The first guideline to be applied is that of hazard identification. Ground-based laboratory and previous flight experience are combined to yield generic requirements such as those for safety showers and containerization of experiments. For as much experience as we have, however, there are still significant gaps left when it is applied to the Space Station laboratory. SKYLAB, SPACELAB, and shuttle mid-deck experiments allowed limited crew interaction or manipulation and a high degree of training specific to each experiment was given to assigned crewmembers. The new and different work proposed for the Space Station laboratory, i.e. material transfer and characterization, increases the probability of material spills to the point that serious consideration must be given to hazardous material spill response capability. We have no significant experience with micro gravity spill propagation, control or cleanup of toxic and reactive materials.

The primary tools for identifying hazards are the various hazard analyses that can be applied to experiment proposals. SSP 30309, "Safety Analysis and Safety Risk Assessment Requirements and Processes Document for the Space Station Program", provides the detailed instruction relative to the application of specific hazard analysis techniques. Safety Engineers are generally well-versed in the techniques of hazard analysis but they may or may not have a background in the area that a given experiment is designed to investigate. It will be necessary to have experimenters involved in the hazard analysis process in order to more accurately characterize the associated hazards and controls. As hazards are identified, methods of controlling them are developed and requirements are established to implement the controls. The hazard elimination and control precedence sequence is found in SSP 30000, Section 9. In the design of the laboratory, eliminating the hazard source or hazardous operation is the foremost consideration. For laboratory usage, introduction of many experiments also introduces a hazard source or hazardous operation. To perform meaningful experiments a certain amount of risk has to be accepted, however, the level of risk acceptance needs to be established by informed management to screen out those experiments that pose too great a threat to the Space Station. This level need not be fixed but may change as the capabilities of the laboratory and of space-based laboratory experience mature. Other actions for control of hazards incorporate safety devices, special procedures and personnel protective clothing or equipment.

... LOP TECHNICAL SAFETY REQUIREMENTS

Technical safety requirements fall into two categories; those imposed upon the Program Manager and those imposed upon the User. These are found in SSP 30000, section 3; SS-SPEC-0002; SS-IRD-0200 and other Space Station documents.

IMPOSED ON SPACE STATION

SSP 30000, SECTION 3

Emergency decontamination of crew members in the event a crew member becomes contaminated by a toxic substance used within the lab. (2.1.2 2.1.1.F)

Containment, transfer and management of both general and toxic trash, materials, and waste used within this laboratory to support payloads. (2.1.2.2.1.2.B)

Stowage of ... emergency equipment. (2.1.2.2.1.1.E)

Accommodation of safe general storage for payloads in the laboratory. (2.1.2.2.1.1.G)

Capability shall be provided for detecting and extinguishing any fire in Space Station habitable volumes. (2.1.11.2.12)

Contaminant Sampling (2.1.11.2.16)

Safety interlocks, hardware and/or software implemented, shall be provided wherever practical to prevent unsafe operations from being executed. (2.1.11.2.1.D)*

A caution and warning system shall provide warning to the Space Station on-board crew and ground personnel (as required) of impending or existing dangerous conditions that pose a threat to station personnel and/or safety critical equipment. (2.1.11.2.2.3)*

Potentially explosive containers shall be located outside habitable areas, shall be isolated and protected so that the failure of one will not cause the failure of the others, and shall be designed to leak before rupture. (2.1.11.2.4.1)*

Triple containment of hazardous materials. The use of chemicals which would create a toxicity problem or cause a hazard to SSP hardware if released shall be avoided where practical. If use of such chemicals can not be avoided, they shall be triple contained. (2.1.11.2.4.5)*

Hazardous accumulation of fluids. Provisions shall be made to prevent uncontrolled hazardous accumulations of gases or liquids within the space station. Detection, monitoring, and control of hazardous gases or vapors shall be required in critical areas and closed compartments. (2.1.11.2.5)*

Exposed surface temperatures. Exposed surfaces within pressurized elements shall not exceed a high temperature of 45 degrees Centigrade or be protected from crew interaction with the surface, and a low temperature less than 4 degrees Centigrade. (2.1.11.2.8)*

Hazardous materials. The space station materials requirements for hazardous materials, flammability, and off gassing are specified in SSP 30233. (2.1.11.3)*

SS-SPEC-0002 CEI SPECIFICATION FOR LABORATORY MODULE

Atmosphere Revitalization. The atmospneric revitalization (AR) subsystem will regenerate the module atmosphere, as necessary, to provide a safe and habitable environment for the crew. The basic elements of the AR subsystem will include... atmosphere contamination control and monitoring. The atmospheric contaminants include trace gases, odors, microbial load, particulate and debris loads of the module atmosphere. (3.7.9.3.1)

The Process Material Management Subsystem (PMMS) shall provide... compatible waste disposal, ...transporting process inputs or outputs while maintaining isolation from the general USL atmosphere, ...decontamination equipment, ...safe storage of chemicals and materials (includes user provided materials and fluids), ...support (for) routine laboratory cleanup, ...decontamination equipment. (3.7.16)

The PMMS shall provide decontamination services for the crew, laboratory equipment, and payload equipment as follows:

1. PMMS shall accommodate contaminated effluent generated in the process of crew or equipment decontamination.
2. The PMMS shall provide the capability to support routine internal cleanup of US Lab facilities.

3. The PMMS shall have the capability to support non-standard cleanup of leaks and spills in contained volumes.
4. The standard PMMS hardware shall assist in cleanup/decontamination of non-hazardous leaks/spills of solids and liquids into the open cabin environment. **The PMMS shall not be designed for cleanup of hazardous open cabin spills.** (3.7.16.2)

General Laboratory Support Facilities. The general laboratory support facilities provide standard work areas with subsystem utility support for USL payload operations These facilities consist of a laboratory sciences workbench, a materials processing glovebox, and a life sciences glovebox. (3.7.18)

IMPOSED ON USERS

SSP 30000, SECTION 3

Several requirements imposed on the space station contain an element of User responsibility. In some cases (2.1.11.2.2.3) a sensor interface with the Caution and Warning system may be needed. In other cases (2.1.11.2.8) design of the experiment equipment will be required to incorporate the standard. Applicable requirements are 2.1.11.2.1.D, 2.1.11.2.2.3, 2.1.11.2.4.1, 2.1.11.2.4.5, 2.1.11.2.5, 2.1.11.2.8, & 2.1.11.3. These are marked with an * in the section above.

SS-IRD-0200 CUSTOMER TO USL INTERFACE REQUIREMENTS

EQUIPMENT INTEGRITY / SAFETY FACTORS (3.3.18.1)

All customer equipment shall be designed to withstand the launch, on-orbit, and landing environments as defined in SS-SRD 0001, Section 3, Paragraph 2.2.1. These environments shall be withstood without the following events occurring: failures; leaking of hazardous fluids; or the releasing of equipment, loose debris, or particles which could damage the USL or cause injury to the crew. USL customer equipment shall be designed such that the equipment integrity and load-carrying capability of structural mounting provisions fulfill the following requirements:

a. Factors of Safety: The minimum factors of safety to be used against load limit conditions to establish design loads shall be as defined in SS-SRD-0001, Section 3, Paragraph 2.2.1.2.4.

b. Fatigue Life: Customer equipment shall have a fatigue life consistent with the requirements specified in SS-SRD-0001, Section 3, Paragraph 2.2.1.2.7.

c. Fracture Control: Customer equipment shall be designed to meet the fracture control requirements specified in SS-SRD-0001, Section 3, Paragraph 2.2.1.2.6.

d. Depressurization: During normal operations, pressure within the USL shall be maintained at 760 + 10 torr. Under some emergency conditions, evacuation of the module will be required and depressurization of the module will occur. Customer facilities shall withstand the environment created by the depressurization/repressurization without creating an uncontrollable hazard.

FIRE (3.3.18.2)

a. In addition to the fire detection and suppression capabilities of the ECLSS, customer equipment which pose a potential fire hazard shall be instrumented by the customer to provide for early detection and warning through the Caution and Warning Subsystem (CWS) of the USL.

b. In the event a fire is detected in the customer equipment, appropriate fire suppression techniques will be implemented. Airflow and utilities shall be disconnected by the USL.

OVERTEMPERATURE (3.3.18.3)

a. Equipment which has failure modes which can produce dangerously heated surfaces in crew areas shall provide an interface to the CWS to alert the crew to the hazard and allow them to take corrective and avoidance action.

b. Customer loads shall be configured such that in the event of power disconnect or failure, the load will cool down and/or cease operation in a safe manner.

ALERT (3.3.18.4)

The USL DMS and CWS will provide an equipment malfunction alerting system that will be available to all customers. This system will notify the USL crew members of any abnormal or hazardous conditions and allow them to take timely corrective action.

LEAKAGE (3.3.18.5)

a. Hazardous materials shall be contained within the customer equipment or the hazardous materials work area. All materials representing life-threatening hazards shall be so contained that any predictable sequence of failures will not result in releasing them into the USL atmosphere. Appropriate customer equipment shall be instrumented to detect any leakage which would present a hazard to crew or equipment. Such instrumentation shall be connected to the USL CWS and shall initiate both an audible and visual alarm at the site of the offending condition.

b. No release of particulate matter, liquids, vapors or fumes into the habitable volume shall be permitted unless it can be shown that the contaminant can be handled by the ECLSS. All potentially contaminating substances associated with payloads and processes shall be identified by type, toxicity, quantity, hazard level, use, and location by the customer. Customer contamination control is to be performed at the assembly and rack levels.

SURFACE TEMPERATURE (3.3.18.6)

Under normal operations, the mean radiant temperature of the habitable interior volume shall not exceed 30°C. Exposed surfaces within the USL (both USL and customer equipment) shall remain within the high and low limits of 45°C to 4°C, respectively. Surface temperatures exceeding 45°C shall require specific interfacing agreements. No external equipment surfaces within the USL, whether reachable or not, shall be cooler than the dewpoint temperature of the module atmosphere.

MATERIALS (3.3.18.7)

Customer equipment materials requirements are provided in SS-SRD-0001, Section 3, Paragraph 2.2.1.3.

DEVELOP OPERATING PROCEDURES AND CONSTRAINTS

SSP 30000, Section 4, Paragraph 2.2.H states that "all hazardous operations shall be designed to minimize exposure of the crew to the hazardous condition." This requirement is supported by the hazard analyses performed to identify hazards. Part of the process is to develop controls to counter the identified hazards. At this point in the Space Station Program, a useful project would be the development of a Space Station Laboratory User's Manual wherein user requirements could be consolidated and laboratory procedures could be codified.

PROVIDE TRAINING AND EDUCATION

SSP 30000, Section 4, Paragraph 3.12.B requires that "crew and designated ground support personnel shall be certified to perform their assigned duties." This would certainly include those duties performed in the laboratory. A major resource in the development of the training would be a laboratory procedures guide such as discussed in the previous section.

SSP 30000, Section 4, Paragraph 3.12.D requires that "all crewmembers shall be trained in space systems associated with... safety, and emergency procedures."

CONDUCT REVIEWS AND EVALUATIONS

From time to time it will be necessary to conduct reviews and evaluations to determine if the requirements imposed on the laboratory and on the users are adequate and whether or not they are having the desired effect. Safety is also concerned with whether or not the approved operating procedures are being followed. The mechanics of such a review and evaluation would have to be developed with the view that on-site inspections would be difficult but not necessarily impossible. Membership of a review committee is anticipated to include both the safety and user community. This committee could also be tasked with development and maintenance of the proposed Laboratory User's Manual.

PREPLAN FOR EMERGENCIES

In spite of our best efforts to design against hazards, emergencies will arise which will require timely response. The history of man's endeavors verifies this statement. Preplanning is the only way to have the response capability available when necessary. Included in a good preplan will be equipment, such as hazardous material spill response, control and clear) equipment and rehearsals in the use of the equipment.

AREAS FOR FURTHER DEVELOPMENT

1. TRANSACTION MANAGEMENT. A goal of the Space Station Program is to allow the users maximum autonomy in manipulating their experiments from the ground. Safety has concerns regarding conflicts between operations requested from the ground and conditions on-orbit which could result in hazards to the crew. This problem is currently being worked at Level II and satisfactory resolution is anticipated.

2. OPEN CABIN HAZARDOUS MATERIAL SPILLS. Current no system or subsystem has been identified to handle open cabin spills of hazardous materials. Candidate systems are PMMS, Man Systems, and ECLSS. Work needs to be done first in the characterization of the problem in terms of required responses to a number of different types of materials.

3. SPACE STATION LABORATORY PROCEDURES MANUAL. This type of manual is necessary for the consolidation of requirements imposed upon the user and the codification of procedures (including emergency procedures). This document would also be used in review and evaluation of the laboratory and its operat' ,n.

NASA Lyndon B. Johnson Space Center

Internal Contamination Requirements and Guidelines

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AGENDA FOR PRESENTATION

ROLE OF JSC TOXICOLOGY GROUP

GENERAL REQUIREMENTS FOR TOXIC CONTAMINATION CONTROL AND MONITORING

PAYLOAD CHEMICALS THAT MAY BE TOXIC CONTAMINANTS

RECYCLED WATER CONCERNS

POTENTIAL SOURCES OF ENVIRONMENTAL CONTAMINATION

ESCAPE OF PAYLOAD AND GENERAL USAGE CHEMICALS
- STYRENE
- MERCURIC IODIDE

CREW METABOLISM
- CARBON DIOXIDE
- CARBON MONOXIDE
- SKATOLE

THERMODEGRADATION AND COMBUSTION OF MATERIALS
- CARBON MONOXIDE
- HYDROGEN FLUORIDE
- HYDROGEN CYANIDE

OFFGASSING
- ACETALDEHYDE
- CARBON DISULFIDE
- METHY ETHYL KETONE

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WHY TOXICOLOGICAL SAFEGUARDS WILL BE ESPECIALLY IMPORTANT IN THE SPACE STATION

A. VERY LITTLE AIR EXCHANGE

B. LONG TIME FOR TOXINS TO ACCUMULATE

C. WIDE DIVERSITY OF OPERATIONS

D. LARGE SCALE OF OPERATIONS

E. GREAT COST IMPACT OF CREW IMPAIRMENT OR EVACUATING MODULE

F. LIMITED MEDICAL CARE AVAILABLE

NSTS MISSION SUPPORT BY THE JSC TOXICOLOGY GROUP

PREFLIGHT

A. ESTABLISH SMAC LIMITS FOR POTENTIAL ATMOSPHERIC CONTAMINANTS

B. CONDUCT AND INTERPRET OFFGAS TESTS
   1. INDIVIDUAL FLIGHT ARTICLES
   2. FLIGHT CONFIGURED ORBITER AND SPACELAB

C. TOXICOLOGICAL SUPPORT FOR PAYLOADS
   1. PAYLOAD SAFETY REVIEWS
   2. TOXICOLOGICAL ASSESSMENTS AND CONTINGENCY PROCEDURES

D. ADDRESS OTHER TOXICOLOGICAL ISSUES
   1. SPECIAL PROBLEMS RELATED TO SPACE FLIGHT
   2. SPECIAL PROBLEMS RELATED TO GROUND OPERATIONS

INFLIGHT

PROVIDE CREW WITH MEANS TO COLLECT AIR SAMPLES
- STAINLESS STEEL AIR CYLINDERS
- SOLID SORBENT AIR SAMPLER (TENAX RESIN)

POSTFLIGHT

GC/MS ANALYSIS OF INFLIGHT ATMOSPHERIC SAMPLES

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REPRESENTATIVE PAYLOAD CHEMICALS THAT HAVE FLOWN OR ARE SCHEDULED FOR FLIGHT

CHEMICALS	MISSIONS
SOLVENTS	
DODECANE	SL-1, D-1
TETRADECANE	" "
DISINFECTANTS	
HClO4	SEVERAL SHUTTLE MISSIONS
SALTS (CRYSTAL GROWTH)	
HgI, GaAs, AgNO3	SL-1, SL D-1
METAL ALLOY	
Cd, Cr, Pb,	SL-1, SL-J, SL D-1
Bi, Co, AG	" " "

PROBABLE SPACE STATION PAYLOADS CHEMICALS FROM PROCESS MATERIALS MANAGEMENT SYSTEM (PMMS) LIST

CORROSIVES AND IRRITANTS - AQUEOUS SOLUTIONS OF:

HCl	NaOH	ACETIC ACID
H2O2	H2SO4	FORMALDEHYDE
KOH	NH4OH	GLUTARALDEHYDE

A. ADVERSE EFFECTS: EYE, SKIN AND MUCOUS MEMBRANE IRRITATION AND INJURY.

B. RECOMMENDED CLEAN-UP IN EVENT OF MAJOR SPILL

SOLUTIONS: USE ADSORBENT MATERIAL; WEAR GLOVES, EYE PROTECTION, AND MASKS.

PARTICULATES: USE HAND HELD VAC OR VAC HOSE

CHEMICALS FROM PMMS LIST - CONTINUED

B. VOLATILE ORGANIC LIQUIDS

ACETONE	ACETONITRILE
METHANOL	DIMETHYL SULFOXIDE (DMSO)
XYLENES	TOLUENE

TOXICOLOGICAL CHARACTERISTICS

1. ALL ARE MILDLY TO MODERATELY IRRITATING
2. ALL HAVE SOME DEGREE OF SYSTEMIC TOXICITY

ACETONITRILE: INTERFERES WITH OXIDATIVE METABOLISM, CAUSING ANOXIA

XYLENES: TOXIC INJURY TO LIVER, KIDNEY AND CENTRAL NERVOUS SYSTEM

TOLUENE: REDUCED RBC COUNTS, MENTAL IMPAIRMENT, MUSCLE INCOORDINATION

METHANOL: NEUROTOXIN (ESP. OPTIC NERVE)

REMOVAL OF VAPORS:

CHARCOAL: ACETONE, ACETONITRILE, XYLENES, TOLUENE

DEHUMIDIFIER: METHANOL

CURRENT MEANS OF ENVIRONMENTAL CONTAMINATION CONTROL IN THE SPACE SHUTTLE

CABIN AIR FAN AND PARTICULATE FILTER MAINTAINS AIR MOVEMENT AND REMOVES PARTICULATES

LITHIUM HYDROXIDE/CHARCOAL AIR SCRUBBER
- LiOH: REMOVES CO_2 AND ACID GASES
- CHARCOAL: REMOVES VOLATILE CHEMICALS

DEHUMIDIFIER
- REMOVES WATER SOLUBLE CONTAMINANTS

WASTE MANAGEMENT SYSTEM (WMS)
- H_3PO_4 TREATED CHARCOAL: REMOVES NH_3, OTHER ALKALINE GASES

AMBIENT TEMPERATURE CATALYTIC OXIDIZER
- PLATINUM ON CHARCOAL: CATALYTIC OXIDATION OF CO AND H_2

GENERAL REQUIREMENTS FOR TOXIC CONTAMINATION CONTROL IN HABITABLE MODULES

A. SAFEGUARDS AGAINST CHEMICAL ESCAPE FROM CONTAINMENT

LEAK AND MATERIALS COMPATIBILITY TESTING

REVIEW DESIGN AND OPERATION BY PAYLOAD SAFTEY GROUP

B. MATERIALS CERTIFICATION

OFFGASSING AND FLAMMABILITY

C. PREVENT EXCESSIVE TEMPERATURE AND PRESSURIZATION

ADEQUATE FUSES AND THERMOSTATS

GENERAL REQUIREMENTS FOR TOXIC CONTAMINATION CONTROL IN HABITABLE MODULES CONTINUED

D. MINIMIZE RISK OF TOXIC EXPOSURES DURING CONDUCT OF EXPERIMENTS AND CLEANING, REPAIR AND MAINTENANCE PROCEDURES.

WORK IN FUME HOOD OR GLOVE BOX IF POSSIBLE.

WEAR PROTECTIVE GEAR AND RESPIRATOR

USE ADDITIONAL SCRUBBERS & VENTILATION IF NEEDED DURING PROCEDURES.

E. BRIEF CREW, SUPPORT PERSONNEL AS TO TOXIC HAZARD POTENTIAL OF MATERIALS AND OPERATIONS.

F. LABEL CONTAINERS OF ALL HAZARDOUS CHEMICALS.

REQUIREMENTS FOR CONTINGENCY PLANS AND EQUIPMENT FOR RESPONDING TO TOXICOLOGICAL ACCIDENT

- FLIGHT CREW AND GROUND SUPPORT PERSONNEL TRAINING
- EMERGENCY CARE FACILITIES AND ANTIDOTES
- RESPIRATORS, PROTECTIVE CLOTHING AND GOGGLES IN EACH MODULE
- ADEQUATE DECONTAMINATION SYSTEMS AVAILABLE
- MEANS OF ISOLATING CONTAMINATED MODULE FROM OTHERS
- CREW, FLIGHT SURGEON AND GROUND SUPPORT TEAM ACCESS TO TOXICOLOGY DATA BASES
- A SAFE HAVEN CONTAINING LIFE SUPPORT PROVISIONS AND DECONTAMINATION EQUIPMENT

GUIDELINES FOR ENVIRONMENTAL DECONTAMINATION SYSTEMS

ADEQUATE TO REMOVE MAXIMUM CHEMICAL SPILL

EFFECTIVE AGAINST ALL POTENTIAL TOXINS

DO NOT RELEASE SIGNIFICANT AMOUNTS OF TOXIC BY-PRODUCTS

MAJOR ADSORBENT MATERIALS SHOULD BE REGENERABLE.

ADEQUATE VACUUM HOSES, ADSORBENTS, AND/OR FILTERS TO REMOVE MAXIMUM AMOUNT OF SOLIDS AND LIQUIDS WITHIN A REASONABLE TIME.

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THE REAL-TIME ANALYZER

A. GENERAL RECOMMENDATIONS

1. CAPABLE OF ANALYZING A WIDE RANGE OF CONTAMINANTS AT LOW LEVELS
2. CAPABLE OF ANALYZING AIR IN ALL HABITABLE MODULES AT INTERVALS OF ONE DAY OR LESS
3. REQUIRES A MINIMUM OF CREW TIME AND TRINING
4. HAS BACK-UP OR MODULAR PARTS AVAILABLE IN EVENT OF MALFUNCTION

B. ANALYZERS UNDER CONSIDERATION

1. BROAD SPECTRUM, MULTICOMPONENT ANALYZER AS GAS CHROMATOGRAPH/ MASS SPECTOMETER
2. PORTABLE ANALYZER
   AS GAS CHROMATOGRAPH
3. NONSPECIFIC ANALYZER FOR QUICK DETECTION
   AS TOTAL HYDROCARBON ANALYZER
4. COMPOUND SPECIFIC ANALYZER
   AS ELECTRO-CHEMICAL DETECTORS
5. PARTICULATE ANALYZER
   AS X-RAY SURVEY METERS AND
   AERODYNAMIC PARTICLE SIZERS

ENVIRONEMTAL CONTAMINANTS IN RECYLCED WATER

A. DEHUMIDIFIER IS PROBABLY A MAJOR AIR DECONTAMINATION SYSTEM

1. TYPE CONTAMINANTS REMOVED:

VAPORS - MOST EFFECTIVE FOR WATER SOLUBLE, LOW VAPOR PRESSURE COMPOUNDS

SOME LOW SOLUBILITY COMPOUNDS SEEN IN CONDENSATES

PARTICULATES - MAY COME DOWN WITH WATER CONDENSATES

2. RESULTS OF SPACELAB WATER CONDENSATE ANALYSES

COMPOUND	CONCENTRATION (MG/L)		
	SL-1	SL-3	SL D-1
CAPROLACTAM	0.07	4.30	8.80
DECANOIC ACID	1.60		0.07
ETHANOL	0.52	1.10	0.15
ISOPROPANOL	13.0	0.32	0.04
TOLUENE	0.24	0.01	
PHENOL	0.24		0.66
ACETONE	3.31	2.00	1.80

NORMAL WATER LOSS INTO AIR: 1.6 L/PERSON/DAY

B. MEANS OF CONTAMINANT REMOVAL FROM WATER: ACTIVATED CARBON, ION EXCHANGE RESINS

PROBABLY HARDER TO SCRUB CONTAMINANTS FROM WATER THAN FROM AIR

C. TOXICITY CONCERNS:
INGESTION
ADSORPION THROUGH SKIN