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SPACELAB 3 MISSION

Bonnie P. Dalton

ABSTRACT

Spacelab 3 (SL-3) was the first microgravity mission of extended duration involving crew interaction with animal specimens. This interaction involved sharing the Spacelab environmental system, changing animal food, and changing animal waste trays by the crew. Extensive microbial testing was conducted on the animal specimens and crew and on their ground and flight facilities during all phases of the mission to determine the potential for cross contamination.

Macroparticulate sampling was attempted but was unsuccessful due to the unforseen particulate contamination occurring during the flight. Particulate debris of varying size (250 um to several inches) and composition was recovered post flight from the Spacelab floor, end cones, overhead areas, avionics fan filter, cabin fan filters, tunnel adaptor and from the crew module. These data are discussed along with solutions, which have been implemented, for particulate and microbial containment for future flights' facilities.

INTRODUCTION

SPACELAB 3 (SL-3) was launched on April 29, 1985 and heralded the use of the Spacelab in support of animal facilities for biomedical investigations. Thus the goal on this initial flight of twenty-four rodents and two squirrel monkeys, was verification of the Research Animal Holding Facilities (RAHFs) under microgravity conditions. The main objectives of the Payload were: 1) evaluate the operations and procedures for mission care of animals, 2) provide in-flight biocompatability assessment between animals and the RAHF, 3) gain mission operational experience, 4) study physiological, behavioral and morphological changes occurring as a result of containment in the RAHF during space flight, and 5) verify principal hardware elements to be reflown.[1] Much data was gained from SL-3; all of it was positive in terms of animal maintenance, but particulate contamination as a result of RAHF operations had to be corrected, before RAHFs could be flown again. This paper will address the SL-3 data and changes implemented as a result of SL-3.

ANIMAL MAINTENANCE VERIFICATION

Verification, during SL-3, included the capability of the RAHFs to maintain the animals under conditions comparable to earth based vivarium controls in the laboratory in terms of temperature, humidity, air exchange (carbon dioxide removal and oxygen replenishment), waste management, feeding and watering. The environmental control system of the RAHF utilized circulating fans and thermal electric units (TEUs) for air exchange and temperature control while a condensate separator/collection system maintained humidity control. The RAHF environmental control system is illustrated in Figure 1. Food and water were available on demand through an automated watering system with a self contained water tank and crew replaceable food cartridges. From inflight RAHF environmental data and post flight physiological analysis of the animals it was shown that the flight facilities maintained an environment comparable to that of the ground vivarium. Physiological changes obeerved in the animals post flight were readily identified as adaptations to the microgravity environment.[2,3]

CONTAINMENT VERIFICATION

Verification also included operation within the Spacelab without microbiological cross contamination between the human crew and the non-human biospecimens, without odor, and without particulate contamination. These verification requirements were to be met through the use of in-line microbiological filters (0.3 micron HEPA) for incoming and exiting air, through the use of odor absorbing charcoal beds and phosphoric acid treated waste pads to prevent ammonia accumulation and inhibit microbial growth, and through maintenance of the RAHF at a slightly negative pressure with respect to the cabin.

MICROPARTICULATES--The goals of microbiological containment were accomplished during SL-3. Extensive testing was conducted on the animals, crew, facilities housing both animals and crew, and on the Spacelab, orbiter flight deck, and RAHF surfaces during all phases of the mission to thoroughly characterize the microbiological profiles.[4] The success of that testing program was the result of a cooperative effort by the Ames, Johnson, and Kennedy Space Centers which were responsible for the flight biospecimens, crew and flight facilities, and ground facilities' sampling, respectively. Over 1500 samples were collected from the pool of animals intended for flight to insure the Specific Pathogen Free (SPF) microbiological integrity of those animals finally selected. An additional total of 175 preflight, 81 inflight, and 98 postflight samples were obtained from the selected flight animals, crew, and environmental surfaces during the SL-3 mission. This extensive sampling revealed no unusual microbiological accumulations during the course of the mission. In fact it has been reported that "levels of airborne microorganisms in the Spacelab were low compared to values obtained from the Orbiter during previous missions."[5]

Only two instances were reported of isolation of microbiological species of possible animal origin external to the RAHF. These were isolated from a crew member's hand following waste tray changeout and from an air return screen on the Orbiter Flight Deck. Unequivocal determination of origin was not possible. The Spacelab microbiological integrity was maintained even though a slight increase of bacterial growth was observed on RAHF interior samples taken immediately postflight. It must be noted that the organisms of significance, the fecal markers (E. coli, S. faecalis) and a pathogen (Staphyloccus aureus), were only isolated from RAHF interior surfaces.

Particulates were measured through use of air strip adhesion both preflight and at L+O following the opening of the Spacelab module. The postflight particulate strip could not be enumerated as a result of the extensive fine particulate dust (presumably foodbar crumbs) released during flight. Inflight particle counts observed in the Mid Deck, Fight Deck, and Spacelab ranged from <5,000 to 34,000 particulates/m^3. Particulate count during food canister and waste tray changeout ranged from <5,000 to 12,000 particulates/m^3.[6] Particulate levels in the Spacelab were highest during and following waste tray changeout. Aspergillus sp. was the only potentially pathogenic microorganism isolated during the inflight Spacelab sampling. Sample sites were external to the RAHF; no fecal coliforms were isolated.

Table 1 (SL-3 Mid Deck, Flight Deck and Spacelab Particulates) compares particulate levels from the three locations over the duration of the mission. Though measured particulates in the Mid Deck decreased during the flight, Flight Deck values were high. The elevated values were assessed to have been the result of the directional air flow from the Spacelab to the Flight Deck.

In conclusion, though increased particulate levels were observed, the microbiological filters employed in the RAHF along with maintenance of Specific Pathogen Free (SPF) animals ensured no cross contamination between crew and biospecimens. The reader is directed to Reference 4 for complete details of microbiological results.

MACROPARTICULATES--"Macroparticulates" were collected post flight by Kennedy Space Center (KSC) payloads processing personnel. Debris removed from the OV-O99 Crew Module was analyzed by the KSC Microchemical Analysis Branch. Where possible, debris was identified optically. Other methods included scanning electron microscope energy dispersive analysis (SM/EDS) or use of infrared (IR) for organic substances. Table 2 (Crew Module Particulates) indicates sample site, predominant particulates found and predominant chemical characteristics. The conclusion by the KSC analysis team was that debris in the cabin appeared to be of human origin. One bit of debris found in the airlock did provide identical analysis to that observed in the rat food, although the analysis team also stated that, "Most samples were so mixed that exact identification was very difficult."[7]

Avionics and cabin air filter debris were transferred to Marshall Space Flight Center and subsequently to Ames Research Center. The material was identified as retrieved from sever different sites: [8]

Group 1	Floor, end cones, overhead areas
Group 2	STT inlet screen debris
Group 3	Avionics fan filter debri
Group 4	Cabin fan filter debris
Group 5	Avionics fan filter, loose
Group 6	Tunnel debris

Group 7 Cabin fan filter debris, loose
Group 8 Port side rack exterior

A description the materials identified from these specific locations and their weights is indicated in Table 3 (Avionics and Cabin Filter Debri).

RAHF REDESIGN

Though odor was reduced, it was not eliminated. Control of odor and particulate release was the primary goal in the post SL-3 redesign work on the RAHF. Means of obtaining this goal addressed: 1) containment of debri at the source, 2) control of air flow during operations requiring opening the cage or module to the cabin, and 3) control of odor through reduction of module leaks.

Figure 2 illustrates the changes incorporated in the redesigned RAHF, hereafter referred to as the SLS-1 RAHF (Spacelab Life Sciences 1 RAHF). Modifications for particulate containment include the addition of a single pass auxiliary fan (SPAF) to create a high inward air flow during all open-door operations, sealing of the cage/cage module interface, and totally sealing the cages to prevent particles of 150 microns or greater from escaping. The total leak rate for the RAHF is currently less than 10 cfm at 1 in. of water which results in the RAHF operating at a negative pressure to the cabin in flight.

Cage redesign to contain particulates to 150 microns required changing the cage top from the half inch spaced grid to a multi layer 135 mesh screen. In addition, the rodent water lixit has been brought to the interior of the cage via a quick disconnect at each cage compartment and the waste tray has been snugged against the cage bottom. Feeders now sustain a longer lasting, low crumbing food bar necessitating fewer inflight changes of feeders.

The SPAF, incorporated to control air flow during cage operations, is manually activated any time a RAHF cage door is opened, a feeder or waste tray changed, or a cage removed from the RAHF. SPAF activation creates a high inward air flow permitting particulate retention to within two inches from the front of the cage.

Changes initiated in the SLS-1 RAHF were the result of attaining a fundamental undertstanding of the airflow subsystem. Airflow through the RAHF cages during nominal operations is 80 cfm (approximately 6.5 cfm at each cage). Therefore airflow could be treated as an incompressible flow (i.e., oil flow characteristics) with the distributed paths over and through cages being comparable to a "pipeline" system in oil flows. Commercial models are available for such systems. The approach used analysis data correlated with test data to review both the SL-3 and the proposed SLS-1 configuration. This allowed prediction of system performance under all important conditions and a determination of the system configuration required to meet the performance objectives. Predicted models compared within 10% to actual system test results comparing module flow rates, pressure drops, and flow patterns.

Modeling addressed various parameters including: adequate ventilation for oxygen (O_2) supply and carbon dioxide (CO_2) removal, restriction to three cfm design flow required for O_2 and CO_2 control, minimization of thermal losses, various possible leak paths in the cage module including the many wire bundles and tubing lines, and the bleed air rate. The cage configuration, i.e., cage top design, waste tray packing and materials all effected flow paths. As a result, the waste tray packing material has also been changed. Effects of a dirty waste tray were determined to be minimal. Flow models and particle retention models were correlated to cage withdrawal velocities for various expected particle sizes. The rodent RAHF system was analyzed for the velocities corresponding to cage out, feeder out, and waste tray out. Figure 3 is the Rodent System Schematic which was addressed. Figures 4 and 5 illustrate SL-3 particle escape and SPAF reverse flow, respectively.[9]

Further confirmation of predicted models was obtained during the August-September, 1988 SLS-1 RAHF Biocompatability and Systems Sensitivity Tests which were conducted with a full complement of rodents. Odor was evaluated by a panel of ten persons and SLS-1 crew persons, during their visit to the test. The panel represented personnel both within and outside the Project. The group agreed unequivocally that no odor could be detected throughout test operations or at the conclusion of the eight-day test.

In the event of power failure, a leak tight system should also result in less available O_2 over a shorter time. Tests conducted with the SL-3 RAHF in "power off" mode in 1983 showed that four hours were required before rodents exhibited the typical drowsiness associated with O_2 depletion (available O_2 measurements were also taken during the test). The same symptoms were evident in less than 45 minutes in the recent SLS-1 RAHF tests.

Table 4 (Observed Air Flow During SPAF Observations) shows air velocity measurements obtained with the SPAF. Data indicate that full SPAF operation air velocities are sufficient to contain any size particulate potentially escaping the RAHF via cage, feeder, or waste tray removal. Inlet air velocities, indicated under SPAF OFF, Normal Flow Velocity column verify that the RAHF maintains a negative pressure sufficient to contain odors, as designed. Though additional testing is still required at the sides of the cage during cage removal operations, lack of particulate during collections in the Biocompatability Test operations confirmed the conclusions that the SPAF is effective in particulate control.

Incidental confirmation of the improved "leak tightness" of the RAHF was the increased condensate collected. More than twice as much condensate (2.5 liters) was collected in the SLS-1 RAHF compared to operations with the SL-3 RAHF at comparable environmental humidity conditions. An additional opportunity to verify 1-G operation of the RAHF will occur during the SLS-1 Experiment Verification Test (EVT) scheduled for February 1989. This test is the final verification of payload experiment elements prior to release for flight integration at KSC.

SLS-1 PARTICULATE CONTROL

The SLS-1 RAHF, Figure 6, along with other ARC developed payload elements will be verified for particulate containment under microgravity operations during the SLS-1 mission which is scheduled for launch June, 1990. One rodent RAHF containing 20 rats will be flown during the mission. Two cages will be reserved for the Particulate Containment Demonstration Test (PCDT) activities, which will verify microgravity particulate containment of the RAHF and accompanying systems. In this series of tests, a particulate sample, equivalent to a 10 day accumulated load of food crumbs, feces, and hair, will be released within a cage. Following the release of the particulate load, air will be sampled around the front of the cage to verify absence of escaped particulates. Particulates will also be measured during a feeder and a waste tray change of the particulate laden cage and during transfer of the cage to the General Purpose Work Station (GPWS). The SPAF will be activated during all demonstrated RAHF operations. Stowage bags will be utilized to further insure no particulate loss during feeder and waste tray changeouts and a General Purpose Transfer Unit (GPTU) will be used during physical removal of the cage from the RAHF.

The GPTU, illustrated in Figure 7 has beon specifically designed for the SLS-1 mission as secondary containment. Particulate release from the cage will be determined post flight through observation of any deposited particulates within the GPTU. The unit is a Tyvek sock connected to a lexan frame. The frame attaches to both the RAHF and the GPWS for entry and removal of the cage. In the event no particulates are observed in the GPTU it is anticipated the unit would not be required in future flights.

Particulates, potentially released as a result of RAHF or PCDT operations, will be measured in flight using a modified RCS air sampler (used for microbiological sampling in Skylab and SL-3). The sampling head of the RCS unit has been modified to incorporate a mesh screen instead of the microbial media agar strips. The mesh screen entraps particulates from 74 to 350 microns. A series of screen heads will be provided to accompany prescribed operations; these will be analyzed post flight.

The General Purpose Work Station (GPWS), Figure 8, is the second major piece of hardware to be flown on SLS-1. The results of SL-3 effected modifications to this unit to insure particulate containment. Modifications have included: specifically designed windows for RAHF cage/GPWS interfaces, incorporation of arm gauntlets similar to those used in microbiological glove boxes, and redesigned front and rear air grilles to ensure entrapment of particulates and liquids in the lower plenum area when the air circulation blower is off.

The GPWS will be utilized for rodent processing on subsequent SLS spacelab flights and for frog egg fixations in SL-J. Available work space (8.5 cu. ft) provided by the GPWS make it a "test piece" for Space Station laboratory equipment. In addition to verifying the GPWS/RAHF cage interfaces for particulate containment, particulate containment within the GPWS will also be verified during SLS-1. Particulates will be released within the unit and their containment measured through sampling outside the GPWS at potential "leak" areas. Ease of cleaning the unit will be evaluated along with particulate and fluid release behavior in the imposed laminar flow atmosphere of the cabinet.

As a piece of laboratory equipment, the GPWS has been designed to support fixative containment, i.e, glutaraldehyde, formaldehyde, isopropanol. No volatiles will be released during SLS-1; the unit has been previously verified by Baker Corporation through the use of spores and dioctyl phthalate (DOP) trace systems. The Trace Contaminant Control System (TCCS), a series of charcoal and lithium hydroxide beds and filters, has been designed to contain components of defined characteristics, i.e., carbon chain length and molecular forces. Two different computer models exist showing the capabilities of the TCCS; chemical removal by the primary cannister has been verified under normal terrestial conditions.[10]

Initial testing of operational concepts for particulate containment in the microgravity atmosphere has been performed through use of KC-135 and Lear jet flights. Though the parabolas are of short duration, they do afford sufficient time to evaluate crew/hardware interfaces and potential design problems. In addition, these flights are readily accessible.

SUMMARY

In summary, methods are available for particulate containment. Those methods can be proven through computer modeling, through ground tests accompanied by appropriate detection methods, and through short term microgravity testing, i.e., parabolic flights. The potential impacts are increased crew operations and hardware constraints. The essential objective is that there be no compromise to the science. The final test is the microgravity Mission.

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TABLE 1
SL-3 MIDDECK, FLIGHT DECK AND SPACELAB PARTICULATES/M^3

MISSION DAY	MIDDECK	FLIGHT DECK	SPACELAB
1	35,000	23,500	3,000
2	-	-	3,750
3	14,000	24,000	4,000
4	-	-	4-12,500*
5	-	-	3,000
6	-	-	-
7		15.000	5,000

NOTES: - No count available
* Hghest count following waste tray changeout

TABLE 2
CREW MODULE PARTICULATES

SAMPLE LOCATION	ANALYSIS	PARTICULATE DESCRIPTION AND COMPOSITION
#1 DEU-1	Observation	Blue/white lint, hair, white and black velcro hooks; yellow, white, green black, orange paint
	SEM/EDS	Aluminum particles (2mm longest), Black-orange low allow steel, Green flake with high Si, K, Cr, and Zn (primer) Red high Si + Fe (RTV), small sand grains, bits of fiberglass Brown/tan organic mixture containing Cl, Si, K, and S
#2 Debris Around DEU 2 & 4 (behind closeout panel)	Observation	Wash and Dri pad holders, straw from food or drink bag, banana chip, orange peel, sugar Hair, plastic packing, photographic film, glossy paper, red snap buttons, white button Fingernail, red RTV, blue-black-white-gray-and yellow paint chips
	IR	Tan organics analyzed as carbohydrate, starch, and soybean oil Brown organics of proteinaceous material containing oil, like soybean oil
	SEM/EDS	Brown organic contained Cl and K Other brown/red glassy organic-high in S, K, Cl 5 mm Al particle + 2 small wires of Stainless (A-286 or 300 series)
#3 Debris Found In Tunnel Adaptor	Observation	Fiberglass, red synthetic fiber, white paint, cellulosic flake
	IR	Plastic film of polyamide, i.e., nylon 6 Brownish clump containing sucrose and starch-carbohydrate Brittle yellow material with spectra like corn syrup
	SEM/EDS	Particles observed were organics: Amber particles contained S, Cl, K, P, Ca, Orange flake contained K, glassy particle contained Cl Red/white particle contained Si, Cl, K, and Ca
#4 Debris Found In Airlock	Observation	3/4" square of black rubber covered with white glossy plastic/paper with felt tip pen number "8" inscribed, plastic film, white nylon thread, green polystyrene, 1 cm fiberglass bundle, cellulosic fiber , black rubbery film, blue-black-white fibers
	IR	Tan crystalline material organic*
	SEM/EDS	Red rubberymater with Si and Ni (IR indicated polyisoprene rubber) Brown spongy material of Si, Al, K, Ca, Fe *Tan crystalline organic with P, K, Ca (thought to be rat food bar) Small aluminum particle and large (6mm dia.) rock high in Si and Al

TABLE 3[1]
AVIONICS AND CABIN AIR FILTER DEBRIS

SAMPLE LOCATION	TOTAL WEIGHT GRAMS	DESCRIPTION OF DEBRIS	ITEMIZED WEIGHT GRAMS
Group #1-Floor, end cones, overhead areas	3.2621	Food, metal filings <500 um	.8354
		Tile wraps	.0265
		Clear silicone like material	.0938
		Hair	.0421
		Lint, string	.5026
		Green primer coating	.0626
		Food particles, metal filings >7500 mm, <1mm	.7787
		Scotch tape	.0469
		Metal filings, wire twists	.1449
Group #2-STT inlet screen debri -SL-FU03-P017	.0252	Hair, food particles	
Group #3-Avionics fan filter OMI L1044	3.5189	Rat feces	.0267
		Fibers, string, plastic	.0045
		Food >1 mm	.4232
		Potting compound, epoxy	.1714
		Lint	7113
		Plastic, epoxy	.1038
		Hair, fingernail	.0123
		Metal shavings, drill twists	.3452
		Food, metal shavings, etc. <500 um	0328
		Palmetto bug legs	.0315
		Plant material (sticks to clothing)	.0548
		White, hard chalk-like pieces	.0062
		Cloth, tie wrap, paper	.0703
		Food, metal filings 250 um	.0527
		Food, metal filings <1mm	.5683

TABLE 3 (CONTINUED)[2]

SAMPLE LOCATION	TOTAL WEIGHT GRAMS	DESCRIPTION OF DEBRIS	ITEMIZED WEIGHT GRAMS
Group #4-Cabin fan filter	7.6173	Lint	2.6052
		Feces	.1120
		Metal filings, lock washer	.1424
		Green epoxy, yellow epoxy chips	.0162
		Small feces piecies, epoxy >1 mm	1.7615
		White, dried bread crumbs	.3003
		Food pieces, metal filings <500 mm	.4815
		Notation (not decipherable)	.0399
		String, tie wrap	.1486
		Food, feces <250 um	.0899
		Hair	.0156
		Plastic, epoxy like pieces	.4156
Group #5-Avionics Filter, loose	C.3237	Food, black specs >500 um	.0273
		Palmetto bug	.2578
		Feces like material (black)	.0203
		Hair -3 strands	no weight
		Lint	.0045
		Cloth	.2708
		Metal shavings, washers, nuts, etc.	1.7715
		Food particles >1mm	.0224
		Pencil lead	.0047
		Food particle composition	.0198
		Plastic amphenol inserts (green and white)	1.7187
		Food bar chunks	.9167
		Rubber band	.7131
		Plastic tubing, plastic pieces	.5740

TABLE 3 (CONTINUED)[3]

SAMPLE LOCATION	TOTAL WEIGHT GRAMS	DESCRIPTION OF DEBRIS	ITEMIZED WEIGHT GRAMS
Group #6-Tunnel	1.0160	Food particles, metal filings <250 um	.2923
		Food particles, metal filings <500 um	.1234
		Food particles, metal filings >500 um	.1008
		White tissue	.0008
		Plastic, silicone pieces, epoxy	.1515
		Lint	.0713
		Food bar chunks	.0315
		Scotch tape	.0115
		Hair	.0120
Group #7-Cabin fan filter, loose	3.3108	Description not decipherable	.0125
		Food, feces, dried bread like	.2605
		Food bar chunks	.5862
		Velcro , cloth tape	.4332
		Scotch tape, plastic tubing	.2089
		M&M chunks	.0115
		Feces	.0327
		Metal washers, drill twists	1.2482
Group #8-Port side rack exterior	3.0292	Scotch tape, white tape, solder bead	

TABLE 4
OBERVED AIR FLOWS DURING SPAF OPERATION

LOCATION	FULL SPAF VELOCITY (FPM)	HALF SPAF VELOCITY (FPM)	SPAF OFF NORMAL FLOW VELOCITY (FPM)
Feeder Door	1500	800	120
Waste Tray Door	3000	1500	150
Around Cage (A,B,C,D)*	410, 0, 120, 70	205, 0, 60, 35	N/A
GPTU Adaptor (A, B, C, D)*	110, 0, 80, 0	55, 0, 40, 0	N/A

NOTES: *Measurements taken at A: Cage Top Opening
B: Cage Right Side
C: Cage Waste Tray Side
D: Cage Feeder Side

RAHF ENVIRONMENTAL CONTROL SYSTEM

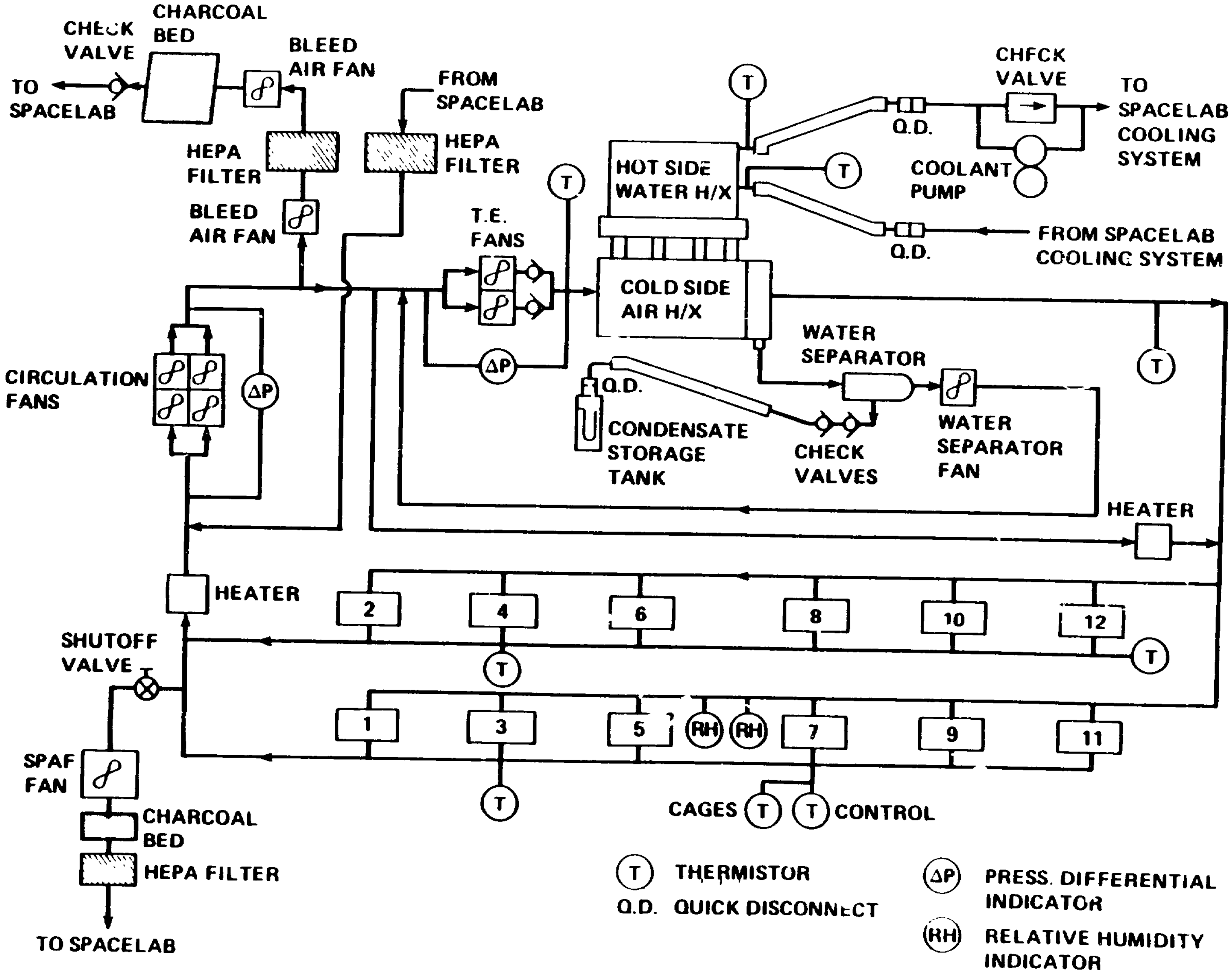

FIGURE 1

RESEARCH ANIMAL HOLDING FACILITY
CHANGES IN RAHF

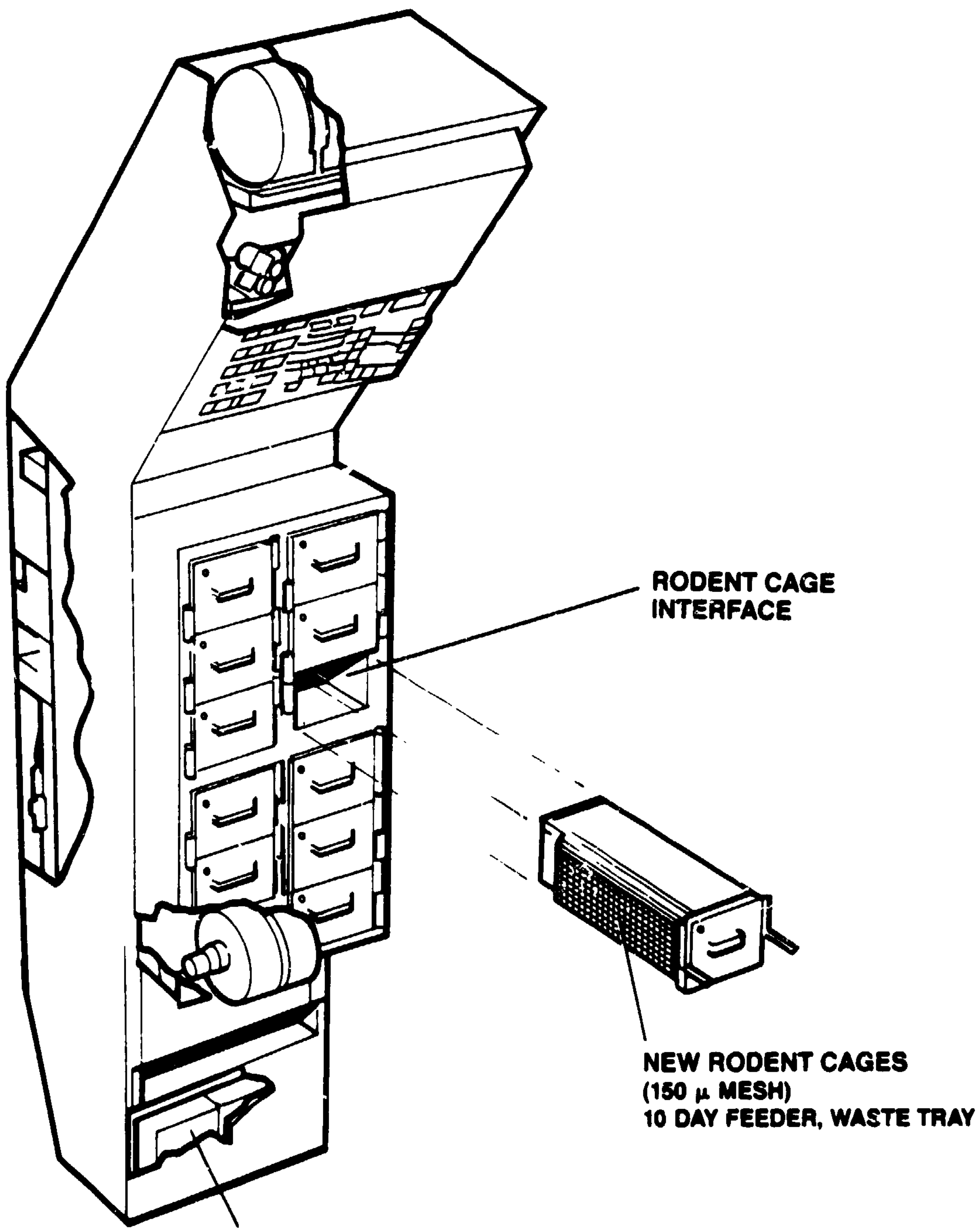

FIGURE 2

RAHF SYSTEM SCHEMATIC – RODENT CONFIGURATION

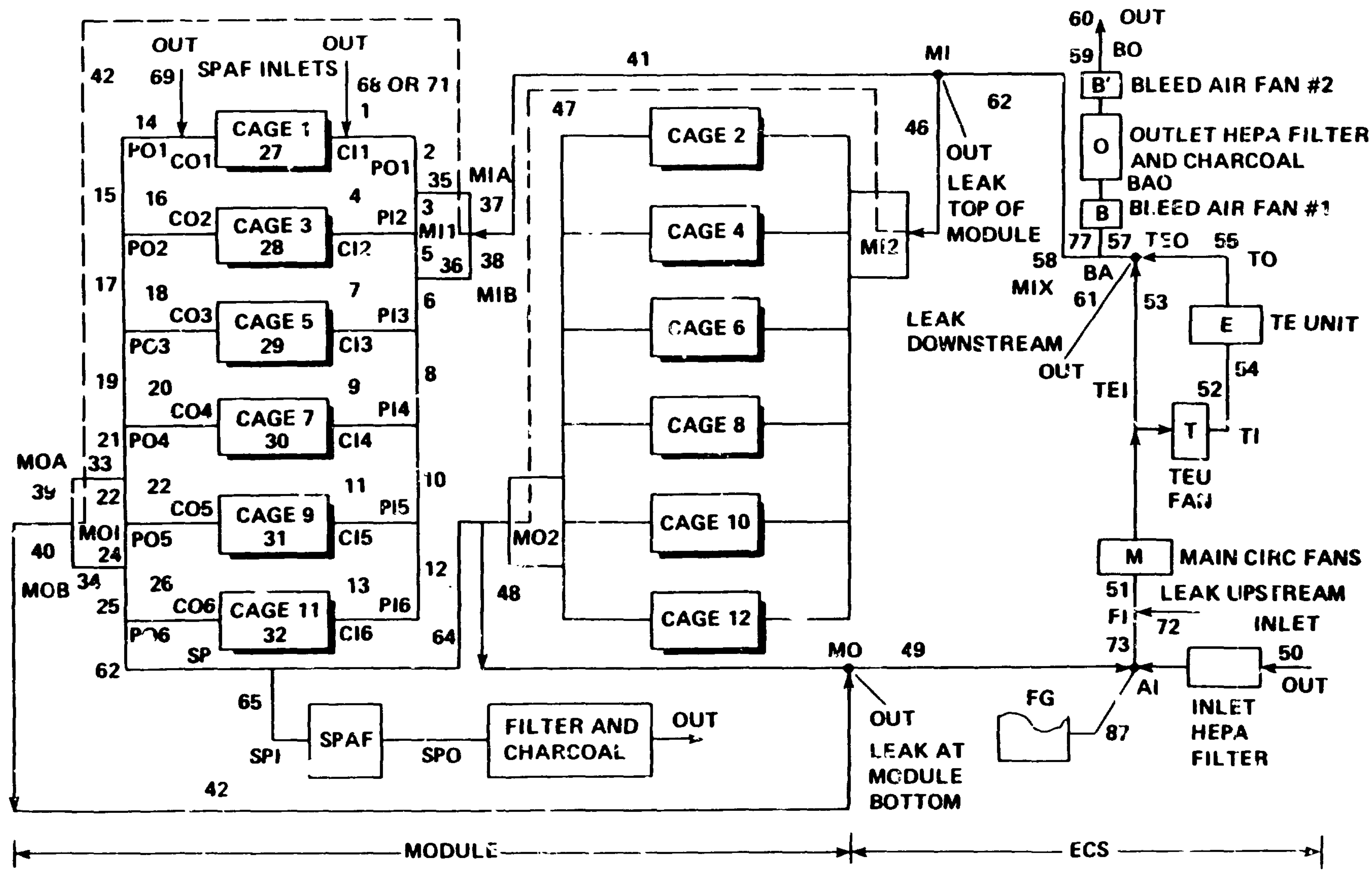

FIGURE 3

SL3 PARTICLE ESCAPE

RAHF SYSTEM SCHEMATIC – RODENT CONFIGURATION

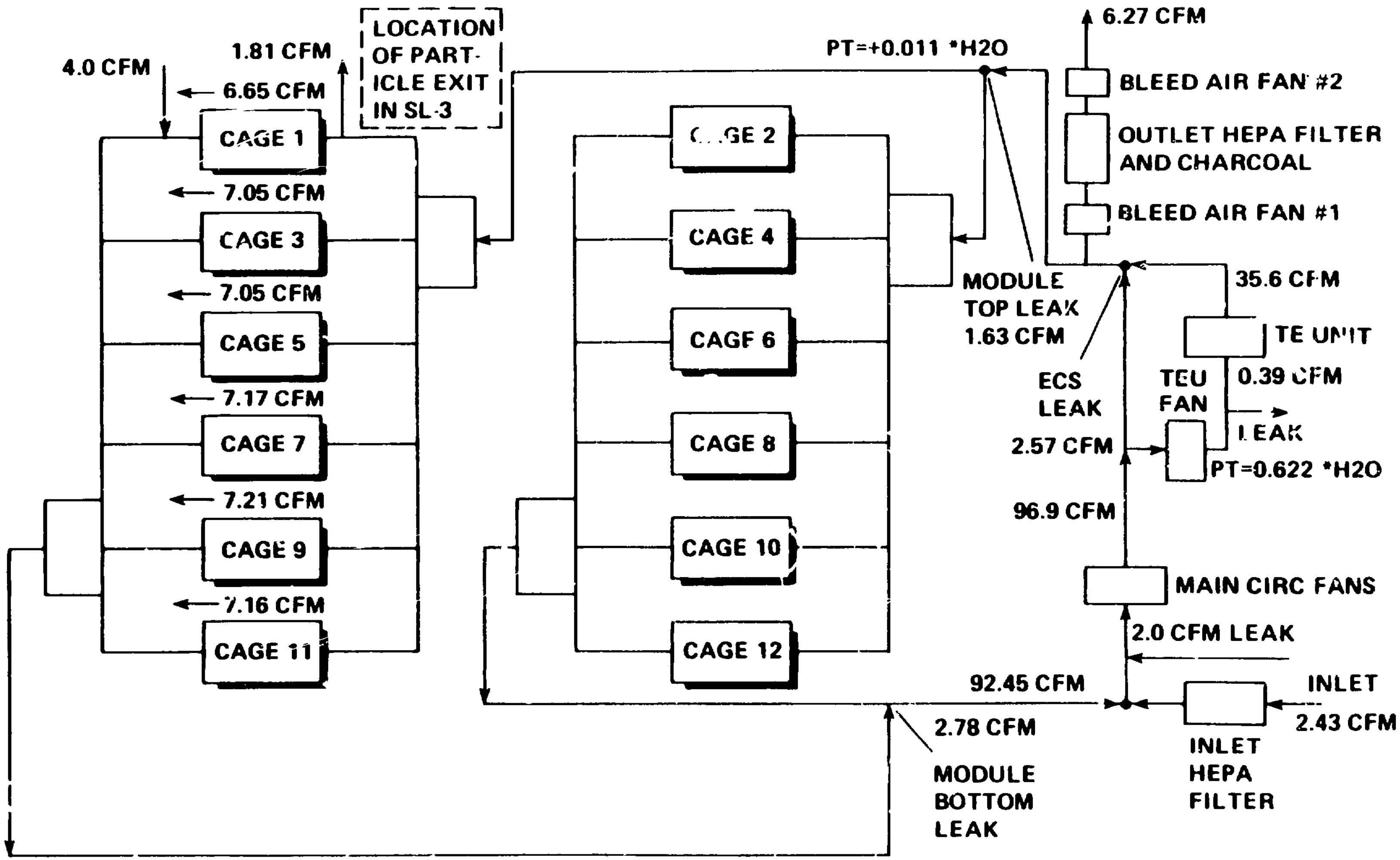

FIGURE 4

RODENT SPAF REVERSE FLOW

RAHF SYSTEM SCHEMATIC – RODENT CONFIGURATION

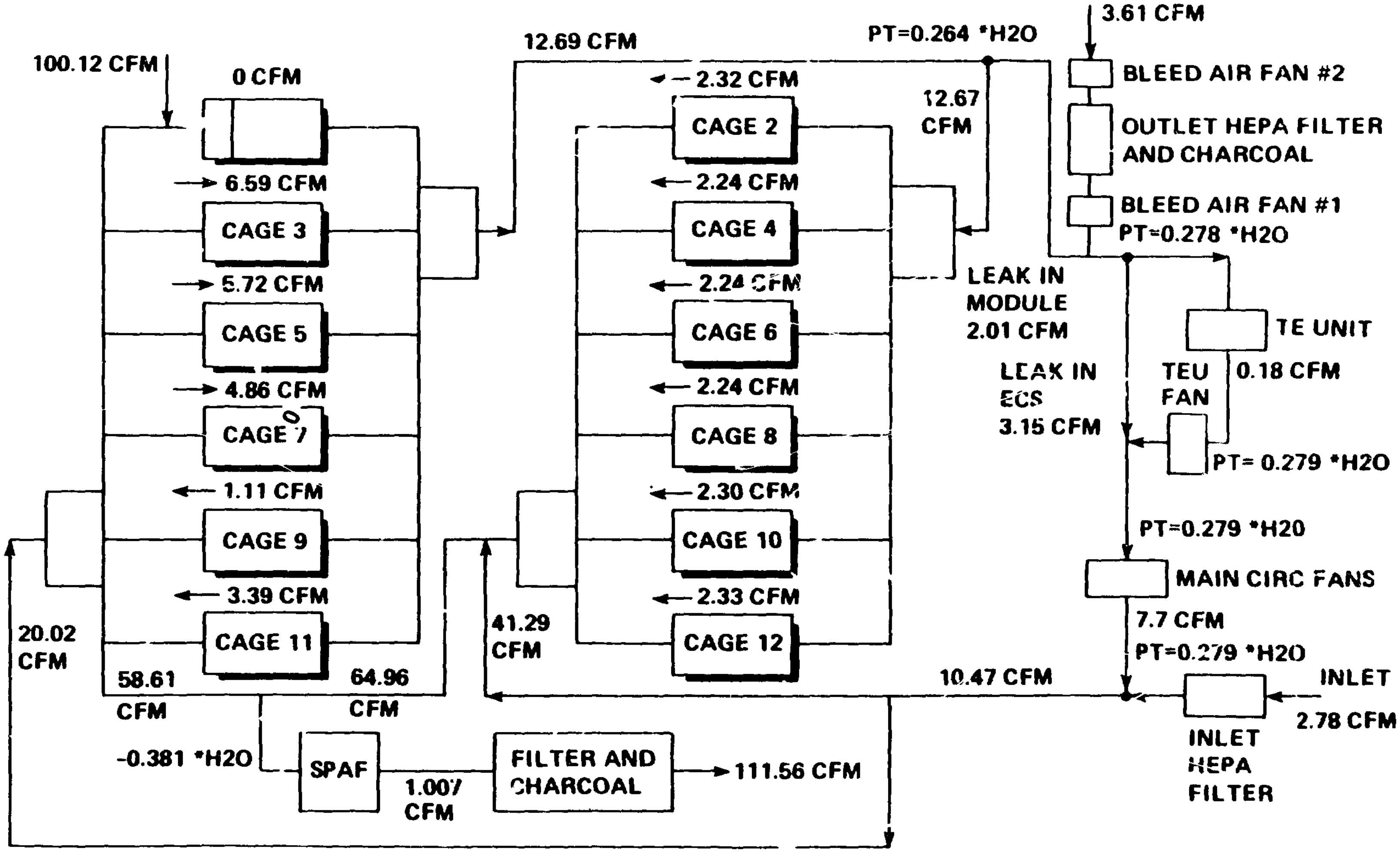

FIGURE 5

SLS-1 RAHF

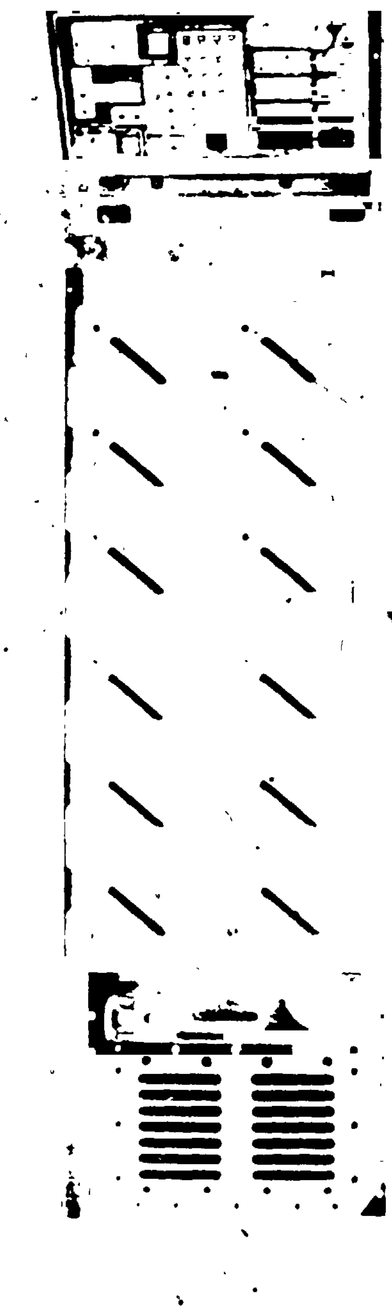

FIGURE 6

GENERAL PURPOSE TRANSFER UNIT

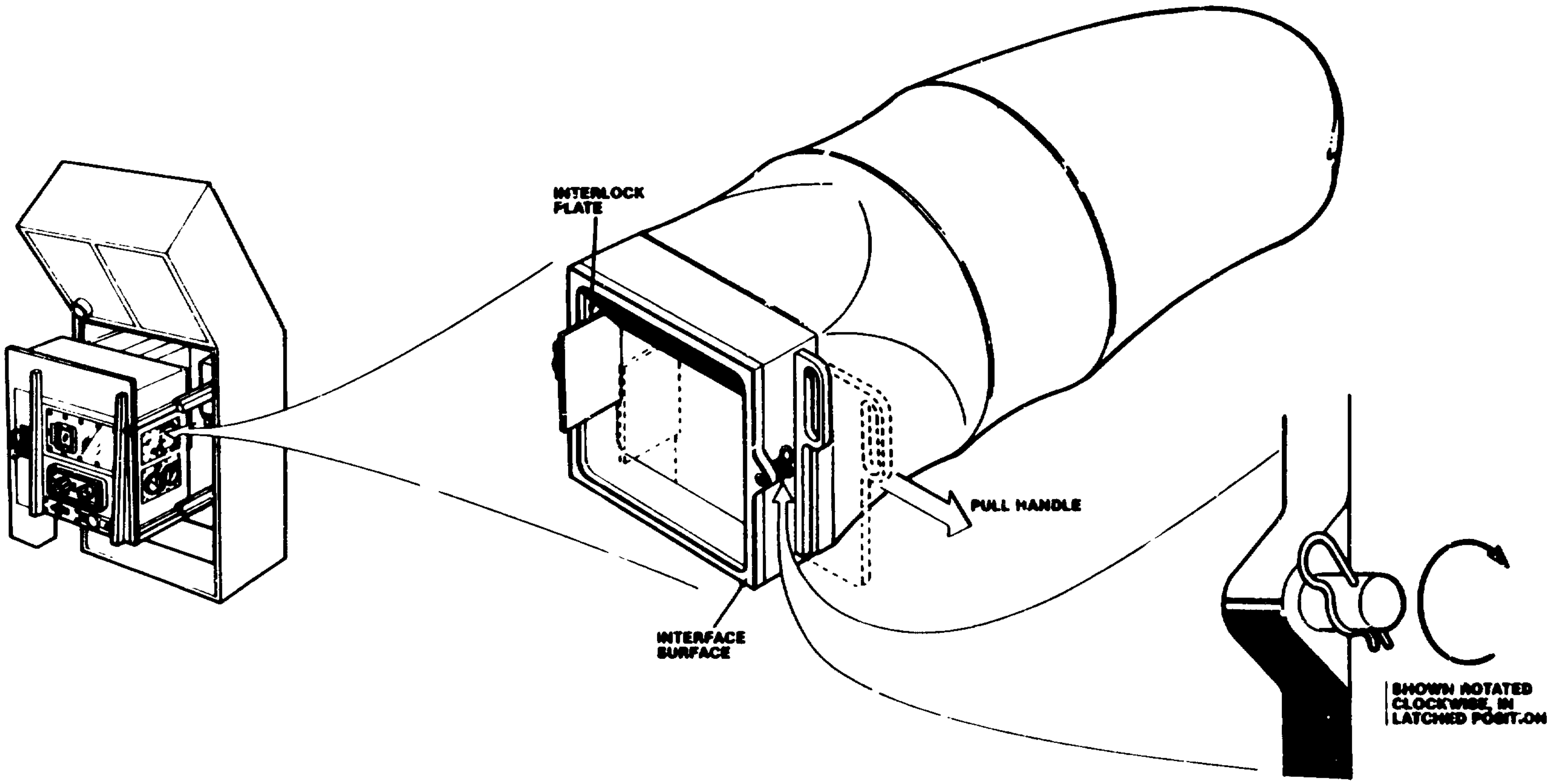

FIGURE 7

GENERAL PURPOSE WORK STATION

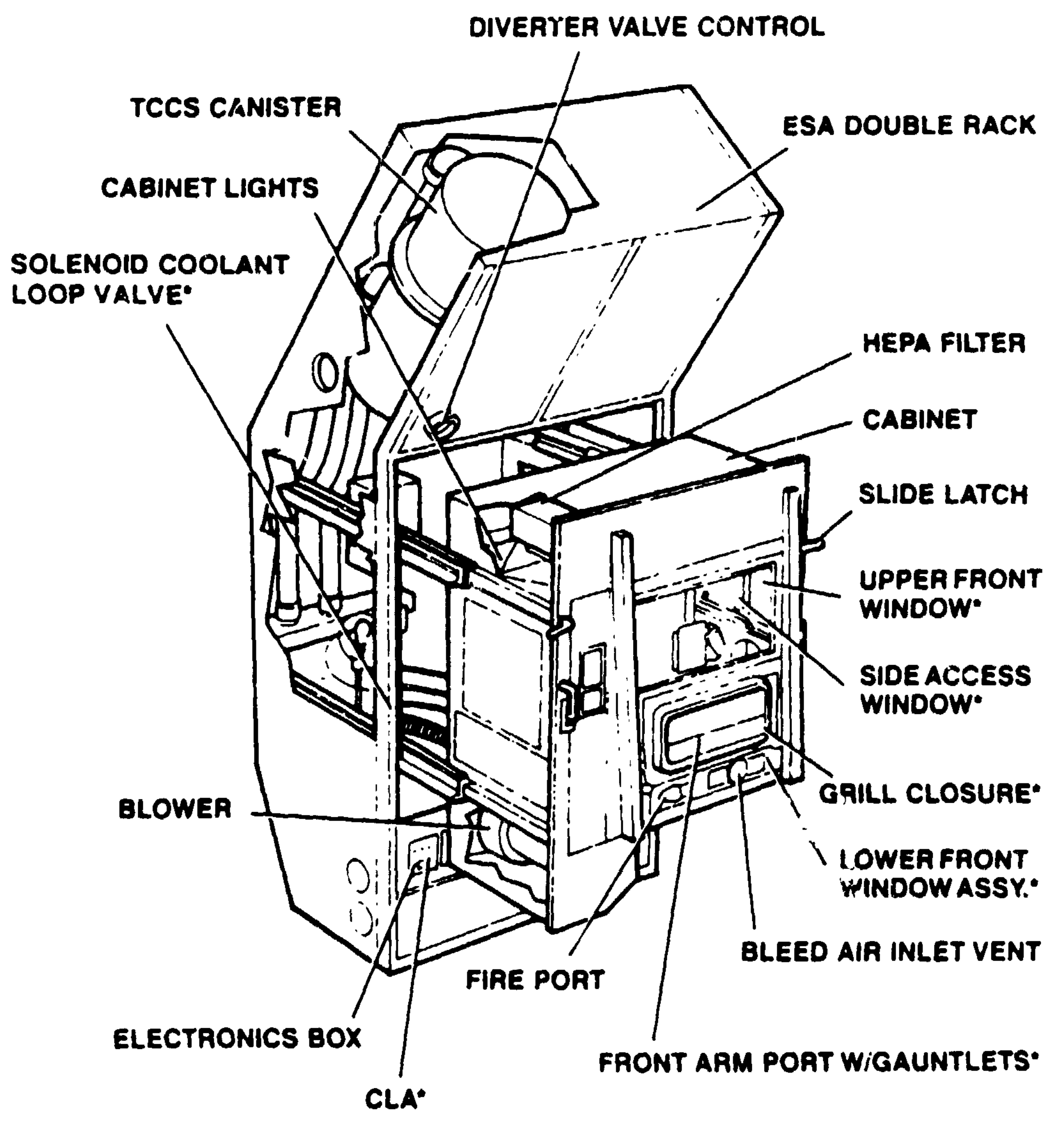

FIGURE 8

SPACE STATION FREEDOM

TOXIC AND REACTIVE MATERIALS

HANDLING WORKSHOP

NOVEMBER 29, 30 & DECEMBER 1, 1988
HUNTSVILLE, ALABAMA

SPACELAB 3 MISSION

BONNIE P. DALTON
AMES RESEARCH CENTER
SPACE LIFE SCIENCES PAYLOADS OFFICE

MISSION BACKGROUND

MISSION PURPOSE:

- CONDUCT MATERIALS SCIENCE EXPERIMENTS IN LOW GRAVITY ENVIRONMENT

MISSION FIRSTS:

- FIRST MICROGRAVITY MISSION OF EXTENDED DURATION INVOLVING CREW INTERACTION WITH ANIMAL SPECIMENS
- HERALDED THE USE OF SPACELAB IN SUPPORT OF ANIMAL FACILITIES FOR BIOMEDICAL INVESTIGATIONS

MISSION SCIENCE:

- FIFTEEN INVESTIGATIONS IN FOUR RESEARCH FIELDS

MISSION SCIENCE

EXPERIMENTS:

- MATERIALS SCIENCE
  - SOLUTION GROWTH OF CRYSTALS IN ZERO-GRAVITY
  - MERCURIC IODIDE GROWTH-VAPOR CRYSTAL
  - MERCURY IODIDE CRYSTAL GROWTH
- FLUID MECHANICS
  - DYNAMICS OF ROTATING & OSCILLATING FREE DROPS
  - GEOPHYSICAL FLUID FLOW CELL
- ATMOSPHERIC AND ASTRONOMICAL OBSERVATIONS
  - ATMOSPHERIC TRACE MOLECULES SPECTROSCOPY (ATMOS)
  - IONIZATION OF SOLAR AND GALACTIC COSMIC RAY HEAVY NUCLEI
  - AURORAL IMAGING EXPERIMENT
  - VERY WIDE FIELD CAMERA
- LIFE SCIENCES
  - AMES RESEARCH CENTER LIFE SCIENCES PAYLOAD RESEARCH ANIMAL HOLDING FACILITIES, DYNAMIC ENVIRONMENT MEASURING SYSTEM, BIOTELEMETRY SYSTEM
  - AUTOGENIC FEEDBACK TRAINING
  - URINE MONITORING INVESTIGATION

AMES RESEARCH CENTER LIFE SCIENCES PAYLOAD

- TWO RESEARCH ANIMAL HOLDING FACILITIES (RAHFs)
  - 24 RATS, 2 SQUIRREL MONKEYS

- DYNAMIC ENVIRONMENT MEASURING SYSTEM
  - MEASUREMENT OF FOLLOWING PARAMETERS DURING LIFT OFF, ORBITAL INSERTION, RENTRY, AND LANDING:
    - THREE AXIS ACCELERATION
    - THREE AXIX VIBRATION
    - NOISE

- BIOTELEMTRY SYSTEM
  - MEASUREMENT (via implanted sensors) of
    - DEEP BODY TEMPERATURE
    - HEART BEAT
    - ELECTROCARDIOGARM (ECG)

SPACELAB 3 ARCLSP GOALS AND OBJECTIVES

GOAL:

- VERIFICATION OF THE RAHF UNDER MICROGRAVITY CONDITIONS

OBJECTIVES:

- EVALUATE OPERATIONS AND PROCEDURES FOR MISSION CARE OF ANIMALS
- PROVIDE IN-FLIGHT BIOCOMPATABILITY ASSESSMENT BETWEEN ANIMALS AND THE RAHF
- GAIN MISSION OPERATIONAL EXPERIENCE
- STUDY PHYSIOLOGICAL, BEHAVIORAL, MORPHOLOGICAL CHANGES OCCURRING AS RESULT OF CONTAINMENT IN RAHF
- VERIFY PRINCIPAL HARDWARE ELEMENTS TO BE REFLOWN

ARCLSP VERIFICATION ELEMENTS

ANIMAL MAINTENANCE

- CAPABILITY TO MAINTAIN ANIMALS IN MICROGRAVITY COMPARABLY TO EARTH VIVARIUM CONTROLS
  - ENVIRONMENTAL-TEMPERATURE, HUMIDITY, AIR EXCHANGE, AND LIGHTING
  - PROVISION OF FOOD AND WATER
  - WASTE MANAGEMENT

- TESTED BY POST-FLIGHT ANALYSES
  - DATA INDICATED AN ENVIRONMENT WAS MAINTAINED COMPARABLE TO THAT PROVIDED IN VIVARIUM
  - ANIMAL PHYSIOLOGICAL CHANGES A RESULT OF MICROGRAVITY ADAPTATION

ARC VERIFICATION ELEMENTS

CONTAINMENT VERIFICATION:

- MICORPARTICULATES (MICROBIOLOGICAL CONTAINMENT AND ESM MEASURED PARTICLES)
  - HRPPC GUIDELINES FOR SPECIFIC MICROORGANISMS OF EXCLUSION (SPECIES DEPENDENT)
    - >1500 SAMPLES ON ANIMAL POOL, PERSONNEL, FACILITIES PREFLIGHT BY ARC
    - 354 SAMPLES COLLECTED IMMEDIATELY PREFLIGHT, INFLIGHT, AND POST FLIGHT
      - 175 PREFLIGHT, 81 INFLIGHT, 98 POSTFLIGHT
      - SAMPLED CREW AND QUARTERS, ANIMALS AND HARDWARE, AND MISSION VEHICLE SITES
      - COMBINED EFFORT OF ARC, JSC, KSC, FLIGHT CREW (DSO)

CONTAINMENT VERIFICATION (CONTINUED)

MICROBIOLOGICAL

- *"LEVELS OF AIRBORNE MICROORGANISMS IN THE SPACELAB WERE LOW COMPARED TO VALUES OBTAINED FROM THE ORBITER DURING PREVIOUS MISSIONS"* *(DSPO MICRO REPORT)*

  - ANIMAL ORIGIN MICROBIOLOGICALS EXTERNAL TO RAHF (2 SAMPLES)
  - FECAL MARKERS E. COLI AND S. FAECALIS ONLY ON RAHF INTERIOR SURFACES

CONTAINMENT VERIFICATION (CONTINUED)

PARTICULATES /NON-MICROBIOLOGICAL

- PARTICULATES COLLECTED WITH RCS SAMPLER (ADHESION FOLLOWED BY EMS ANALYSES)
- MEASUREMENTS PREFLIGHT AND L+0
  - INFLIGHT MEASUREMENTS IN MID DECK, FLIGHT DECK, AND SPACELAB
    - RANGE <5,000 TO 34,000 PARTICULATES/M^3
    - FOOD CANISTER AND WASTE TRAY CHANGEOUT (5-12,000/M^3)
    - MID DECK VALUES DECREASED DURING FLIGHT, FLIGHT DECK HIGH (DIRECTIONAL AIR FLOW RESULT)
    - TABLE REFERENCE

CONTAINMENT VERIFICATION
MICROPARTICULATES

CONCLUSION

- *PARTICULATE LEVELS HIGH DURING SL-3*
- *MICROBIOLOGICAL PARTICULATES CONTROLLED BY RAHF HEPA FILTERS*

CONTAINMENT VERIFICATION (CONTINUED)

- **<u>MACROPARTICULATES</u>**
  - COLLECTED POST FLIGHT BY KSC PAYLOADS PROCESSING
    - IDENTIFIED OPTICALLY, SCANNING ELECTRON MICROSCOPE ENERGY DISPERSIVE ANALYSIS (SM/EDS), INFRARED (IR)
      - TABLE 2 REFERENCE: AIRLOCK SAMPLE = RAT FOOD
    - AVIONICS AND CABIN AIR FILTER DEBRIS TRANSFERRED TO MSFC, SUBSEQUENTLY SENT TO ARC
      - 7 SITES (TABLE 3):

GROUP 1	FLOOR, END CONES, OVERHEAD AREAS
GROUP 3	AVIONICS FAN FILTER DEBRIS
GROUP 4	CABIN FAN FILTER DEBRIS
GROUP 5	AVIONICS FAN FILTER, LOOSE
GROUP 6	TUNNEL DEBRIS
GROUP 7	CABIN FAN FILTER DEBRIS, LOOSE
GROUP 8	PORT SIDE RACK EXTERIOR

- **<u>ODOR</u>**
  - QUESTIONABLE CONTROL
  - OBVIOUS WHEN RAHF DOORS OPENED

PARTICULATE CONTAINMENT - FUTURE MISSIONS

RAHF REDESIGN

- PRIMARY GOAL
  - MAINTAIN AND ENSURE MICROBIOLOGICAL CONTROL
  - PARTICULATE CONTROL
  - ODOR CONTROL

- MEANS OF OBTAINING GOAL
  - CONTAINMENT OF DEBRIS AT SOURCE
  - CONTROL OF AIR FLOW DURING OPERATIONS REQUIRING OPENING CAGE MODULE TO CABIN
  - CONTROL OF ODOR THROUGH REDUCTION OF MODULE LEAKS

- AREAS AFFECTED
  - CAGE REDESIGN - 150 MICRON CONTAINMENT
    - CHANGE CAGE TOP SCREEN
    - BRING LIXITS INSIDE
    - CHANGE FEEDER DESIGN AND FOODBAR (LOWER CRUMBING)

<u>RAHF REDESIGN</u> (CONTINUED)

- MODULE AIR FLOW CONTROL
  - ADDITION OF SINGLE PASS AUXILIARY FAN (SPAF)-VACUUM
  - COMPUTER MODELING OF SYSTEM FLOWS TO UNDERSTAND AIRFLOW (6.5 CFM/CAGE)
    - PREDICTED MODELS AND TEST DATA AGREED WITHIN 10%
    - ANALYSIS FOR CAGE SYSTEM OUT, FEEDER OR WASTE TRAY OUT
    - WASTE TRAY PACKING EFFECTS (NEW PAD TO ASSURE UNIFORMITY)
    - AIRFLOW CONTROLLED WITHIN 2" OF CAGE FRONT
- MODULE "LEAK" CONTROLLED
  - LESS THAN 10 CFM AT 1 IN. (ACTUAL 2.4 CFM)
    - RODENT CO_2 DROWSINESS EFFECTS (45 MIN. V.S. 4 HRS.)
    - INCREASED CONDENSATE (2 TIMES ORIGINAL RAHF)
    - NO ODOR REPORTED BY PANEL AND CREW
  - MICROBIOLOGICAL CONTAINMENT INTEGRITY MAINTAINED BY HEPA
    - ROOM BIOLOGICAL BIOBURDEN CONSTANT

<u>RAHF REDESIGN</u> (CONTINUED)

- COMPLEMENTARY SYSTEMS TO RAHF
  - <u>GENERAL PURPOSE TRANSFER UNIT (GPTU)</u>
    - TYVEK WINDSOCK WITH I/F DOOR
    - USED TO TRANSPORT RODENT CAGE FROM RAHF TO GENERAL PURPOSE WORK STATION (GPWS)
  - <u>GPWS</u>
    - IN FLIGHT WORK STATION (8.5 CU FT) PROVIDING PARTICULATE AND VOLATILE CONTAINMENT
      - RODENT PROCESSING (SLS-2, 3) - PARTICULATE CONTROL
      - FIXATIONS (SLS-N AND SL-J)-VOLATILE CONTROL THROUGH TRACE CONTAMINANT CONTROL SYSTEM (TCCS)
      - SERIES OF CHARCOAL BEDS AND HEPA FILTERS
      - GLUTARALDEHYDE, FORMALDEHYDE, ISOPROPANOL
    - MODIFIED FOR PARTICULATE CONTAINMENT AS A RESULT OF SL-3
      - GAUNTLETS AKIN TO MICROBIOLOGICAL GLOVE BOX
      - GRILLE CLOSURES TO ENTRAP PARTICULATES AND LIQUIDS IN LOWER PLENUM WHEN BLOWER OFF
      - WINDOWS FOR ENTRY OF CAGES

PARTICULATE CONTAINMENT VERIFICATION

- VERIFICATION OF RAHF DURING BIOCOMPATABILITY TESTING, 8/88
- VERIFICATION OF TOTAL SYSTEM DURING SLS-1 EXPERIMENT VERIFICATION TEST 2/89
  - PARTICULATE CONTAINMENT DEMONSTRATION TEST
    - RELEASE OF 10 DAY PARTICULATE LOAD IN CAGE
    - CHANGE OUT OF FEEDER AND WASTE TRAY
    - TRANSFER OF CAGE (IN GPTU) TO GPWS AND BACK
    - RELEASE OF PARTICULATES IN GPWS
    - PARTICULATE SAMPLING DURING ALL PHASES (70 MICRONS TO 300 MICRONS)

SUMMARY

- PARTICULATE CONTROL IS RESULT OF:
  - COMPUTER MODELING INCORPORATION IN DESIGN
  - ONE-G TESTING AND RETESTING ACCOMPANIED BY PARABOLIC FLIGHTS (KC-135, LEAR JET)
  - CONSTRAINED OPERATIONS (FROM THAT KNOWN IN ONE-G)
- PRIMARY OBJECTIVE:
  - PARTICULATE CONTROL WITHOUT SCIENCE COMPROMISE
- FINAL PROOF WILL ALWAYS REMAIN WITH THE OPERATIONAL MISSION