<table>
<thead>
<tr>
<th>SOURCE</th>
<th>CONTAMINANT</th>
</tr>
</thead>
</table>
| MAN                                | METABOLIC PRODUCTS:  
|                                    | $\text{CO}_2$, $\text{NH}_3$, $\text{CO}$, $\text{H}_2\text{S}$, $\text{H}_2$  
|                                    | $\text{CH}_4$, ORGANIC ACIDS, MERCAPTANS  
|                                    | BACTERIOLOGICAL CONTAMINANTS                                   |
| SPACECRAFT SUBSYSTEMS, EXPERIMENT  | WIDE VARIETY OF ALCOHOLS,                                       |
| EQUIPMENT AND PAYLOADS             | ALDEHYDES, AROMATICS, ESTERS,                                  |
|                                    | ETHERS, CHLOROCARBONS,                                         |
|                                    | FLUOROCARBONS, HALOCARBONS,                                   |
|                                    | HYDROCARBONS, KETONES, ACIDS                                  |
| EMERGENCY SITUATIONS:              | CO, $\text{CO}_2$, HYDROCARBONS,                              |
| FIRE, SPILLS, EQUIPMENT FAILURES   | AROMATICS, ACID GASES, OXIDES                                  |
|                                    | OF $\text{N}_2$, $\text{SO}_2$, $\text{NH}_3$,                |
|                                    | ALCOHOLS, FORMALDEHYDE                                         |
| ANIMAL AND PLANT EXPERIMENTS       | ME OLIC, BACTERIOLOGICAL                                       |
TECHNOLOGY BASE

- Definition of activated charcoal sorption characteristic for a wide variety of contaminants and charcoals
- Development of analytical tools for predicting charcoal sorption and sizing of bed
- Development of in-flight charcoal bed regeneration methods using heat and vacuum
- Definition of condensing heat exchanger removal capacity
- Definition of high temperature catalytic oxidizer performance characteristics and pre and post sorbent requirements
- Definition of pre and post sorbent bed performance
- Development of room temperature catalytic oxidizer bed
- Development of acid gas removal bed
- Development of ammonia removal sorbent
- Development of formaldehyde removal sorbent
CONTAMINANT CONTROL SYSTEM ELEMENTS

<table>
<thead>
<tr>
<th>DEVICE</th>
<th>CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIXED CHARCOAL BED</td>
<td>LOW MOLAR VOLUME WELL ABSORBED CONTAMINANTS</td>
</tr>
<tr>
<td>REGENERATIVE CHARCOAL BED</td>
<td>HIGH MOLAR VOLUME MODERATELY WELL ABSORBED CONTAMINANTS</td>
</tr>
<tr>
<td>PHOSPHORIC ACID IMPREGNATED CHARCOAL</td>
<td>AMMONIA</td>
</tr>
<tr>
<td>CONDENSING HEAT EXCHANGER</td>
<td>HIGHLY SOLUBLE CONTAMINANTS</td>
</tr>
<tr>
<td>ROOM TEMPERATURE CATALYTIC OXIDIZER</td>
<td>CARBON MONOXIDE, HYDROGEN</td>
</tr>
<tr>
<td>HIGH TEMPERATURE CATALYTIC OXIDIZER</td>
<td>POORLY ABSORBED HYDROCARBONS</td>
</tr>
<tr>
<td>PRE AND POST SORBENT</td>
<td>ACID GASSES, SULFUR COMPOUNDS</td>
</tr>
</tbody>
</table>
APPROACH TO CONTAMINANT CONTROL

- Define contaminant load model and production rates
- Define spacecraft maximum allowable concentrations (SMAC)
- Establish fixed charcoal bed size for each contaminant
- Define need for regenerative bed
- Define contaminants not handled by fixed and regenerative beds
- Size special sorbent beds or catalytic oxidizers
- Optimize system considering contaminant load and system interaction
CONTAMINANT LOAD MODEL DEFINITION

DATA SOURCES
0 WSTF MATERIALS OFFGASSING TESTS
0 SPACE COMPONENTS OFFGASSING TESTS
0 PAYLOAD EQUIPMENT OFFGASSING TESTS
0 MANNED SPACECRAFT CONTAMINANT MONITORING (GROUND AND FLIGHT)
0 GROUND BASED MANNED SIMULATOR TESTS
0 LITERATURE AND TEST DATA FOR METABOLIC CONTAMINANTS

DATA COMPILATION
0 DETERMINATION OF PAYLOAD GENERATION RATES PER UNIT WEIGHT
0 ESTIMATE OF TOTAL PAYLOAD WEIGHT
0 DETERMINATION OF SPACE SYSTEMS GENERATION RATES PER UNIT WEIGHT
0 METABOLIC LOADS FROM CREW SIZE
0 COMPOSITE CONTAMINANT LOAD
SPACECRAFT MAXIMUM ALLOWABLE CONCENTRATIONS

0 ESTABLISHED BY NASA JSC MEDICAL DIRECTORATE
0 DOCUMENTED IN NHB 8060.113 FOR UP TO 7 DAYS
0 SOME CONTAMINANTS NOT INCLUDED IN NHB 8060.113
0 SEVERAL CONTAMINANTS HAVE VERY LOW ALLOWABLE LEVELS
CHARCOAL BED SIZING

0 CHARCOAL BED INCLUDES SATURATED ZONE PLUS ABSORPTION ZONE

0 CAPACITY DEPENDS ON CONTAMINANT CHARACTERISTICS
   - TEMPERATURE
   - MOLAR VOLUME
   - VAPOR PRESSURE
   - INLET CONCENTRATION

   "A" VALUE

0 "A" VALUE PLUS EXPERIMENTALLY DETERMINED POTENTIAL PLOT PROVIDES SATURATION CAPACITY

0 ADSORPTION ZONE LENGTH IS ADDED TO SATURATED ZONE TO DETERMINE TOTAL BED SIZE

0 BED SIZE ADJUSTED FOR CO ADSORPTION

0 SIZING ACCOMPLISHED BY COMPUTER PROGRAM (ICHAR)
TYPICAL CHARCOAL PERFORMANCE CHARACTERISTICS

POTENTIAL PLOT FOR VARIOUS CHARCOALS

SATURATION CAPACITY, \( q \) (CC LIQ/GM CHARCOAL)

\[
A = \frac{T}{V_m} \log \frac{C_i}{C_f}
\]

BARNEBEY-CHENEY BD
PITTSBURGH BPL
SUPERACTIVATED COCONUT ($154$)
BARNEBEY-CHENEY CI

ADSORPTION ZONE LENGTHS FOR VARIOUS CONTAMINANTS

LINEAR VELOCITY 1.3 FT/Min.

FREON 11
ACETONE
CATALYTIC OXIDIZER SIZING

- Establish contaminants that require oxidation for control
- Determine need for high or low temperature catalytic oxidizer
- Select most effective catalyst from test data
- Determine flow rate, residence time and catalyst bed size
- Optimize insulation requirements versus bed size
TYPICAL CATALYTIC OXIDIZER PERFORMANCE CHARACTERISTICS

CONVERSION EFFICIENCY FOR VARIOUS CATALYSTS

CONVERSION EFFICIENCY FOR VARIOUS RESIDENCE TIMES

[Graphs showing conversion efficiency as a function of temperature and catalyst type]
SPECIAL SORBENT BED SIZING

- Used for ammonia, acid gases and other special contaminants
- Bed size determined by:
  - Allowable concentration
  - Total contaminant generation rate
  - Experimentally determined contact time
  - Mission duration
- Generally integrated into fixed charcoal bed
- Lithium hydroxide and potassium hydroxide impregnated charcoal used for acid gases
- Acid impregnated charcoal used for ammonia
- Chromate impregnated charcoal used for formaldehyde
BIOTECHNOLOGY

ANIMAL AND PLANT RESEARCH PAYLOAD PROBLEMS

PROBLEMS

0. WASTE REMOVAL AND STORAGE
0. BACTERIOLOGICAL CROSS CONTAMINATION

SOLUTIONS

0. COMPLETE ISOLATION OF CREW AND EXPERIMENTS BY USE OF SEPARATE ENVIRONMENTAL SYSTEMS
0. USE OF HIGH EFFICIENCY BACTERIOLOGICAL FILTERS
0. USE OF ONLY SPF ANIMALS
0. USE OF ISOLATION TRANSPORTERS FOR WASTE REMOVAL AND STORAGE
0. USE OF SPECIALY DESIGNED ISOLATION WORK STATIONS (GLOVE BOX DESIGN)
EMERGENCY UPSET CONTAMINANT REMOVAL

- Safe Haven Crew Shelter
- Emergency Contaminant Removal System Remotely Activated
- Portable Breathing Apparatus
  - Oxygen Line
  - Superoxide Breather
- Cabin Decompression and Repressurization
CONCLUSIONS

0 TRACE CONTAMINANT CONTROL TECHNOLOGY BASE IS RELATIVELY FIRM
0 HARDWARE AND DESIGN TOOLS ARE AVAILABLE
0 PREVIOUS DESIGN PHILOSOPHY STILL APPLICABLE
   I.E., CONSERVATIVE LOAD MODEL REFINED LATER AS ACTUAL
   OFFGASSING DATA ARE AVAILABLE
0 MAJOR CONCERNS
   - CATALYTIC OXIDIZER (NEED VS. DANGER)
   - CONTAMINANTS WITH VERY LOW ALLOWABLE CONCENTRATIONS
   - IMPACT OF RELAXING MATERIALS REQUIREMENTS
Detection and Control

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Mass Spectrometry at the Jet Propulsion Lab

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