APOLLO CABIN ATMOSPHERE

DISCUSSION WITH MEMBERS OF THE
NATIONAL ACADEMY OF SCIENCES

April 3, 1968
Management Center IOB 10B

Present: NASA - Maj. Gen. J. W. Humphreys, Dr. Walton L. Jones, Dr. Leo Fox, Dr. Charles A. Berry, Dr. Sherman P. Vinograd, Dr. Ed McLaughlin, Dr. Benjamin, Mr. T. L. Powers, Mr. R. L. Johnston, Mr. Pecararo (OART),

National Academy of Sciences - Dr. Loren D. Carlson, Dr. Wallace Fenn, Dr. Arthur DuBois, Dr. Herbert Shepler, Dr. Frank Favorite.

Copy of Agenda attached.

Gen. Humphreys acted as chairman. In his opening remarks he noted that NASA has always wanted a mixed atmosphere for manned space flight. NASA would also like to have a pressure approaching sea level. However, neither of these conditions have been feasible engineering-wise to date.

The Apollo 204 fire forced a reappraisal of the plans for future Apollo missions, and Gen. Humphreys indicated that the engineers who had been responsible for post 204 testing and changes along with Dr. Berry would brief the group present on the results of tests and changes made in the command module. He then introduced Mr. T. L. Powers who first outlined actions taken to reduce the risk of cabin fire. These were in six areas: (1) Removal of all possible burnable materials, with replacement by less flammable, (2) Isolation of flammable materials from possible ignition sources, (3) Flame-resistant layers added to space suit, (4) Improved crew egress by the addition of command

module hatch that can be released in 3-5 seconds, (5) Change from oxygen to 60% O_2, 40% N_2 atmosphere at 16.2 PSI on pad, and (6) Rigorous selection of all material to be used inside spacecraft.

By a controlled leakage plan, the cabin environment can be changed from 16.2 PSI, 60% O_2, 40% N_2 to 6.2 PSIA, 100% O_2 after liftoff. This atmosphere, 6.2 PSI, 100% O_2, will continue to be used throughout the flight. Dr. Carlson raised the question of the reliability of the new system. Powers replied, yes but added that previous reliability considerations did not take fire into consideration (in the O_2 system). Dr. Fenn asked, have the changes you have described added weight to the system? Answer: Yes, the new hatch added 300 pounds; other changes, 30-50 pounds.

Dr. Fenn - How much would a two-gas system add in weight? Answer: The best figure I could give you now would be about 103 pounds (Gen. Humphreys' indicated he would check this estimate).

Dr. DuBois - Will the new hatch be used in E.V.A? Answer: It is designed for use in E.V.A.

Dr. DuBois - Raised the question of fire propagation in a weightless environment. Is it more rapid? Answer: From tests to date, apparently not.

Dr. DuBois - Was of the the opinion that NASA should confirm this point. He (DuBois) has felt concern over fire in an O_2 environment since Mercury.

Mr. R. L. Johnston then outlined the results of Flammability Tests (see attached charts). He also showed a color movie of fires set intentionally in various parts of the space-

OART

Supply copies of MSC TM (January reports)

Dr. DuBois - Raised the question of detection systems, especially in "hidden" areas of the spacecraft.

Johnston replied that much was being studied on various types of detection systems. He stated that (1) smell was still considered one of the best systems, (2) sight of smoke was another, (3) ultra-violet and ionization systems were being investigated.

R. Johnston is working

Dr. Carlson asked for the time of burning of all fires.

Dr. Charles A. Berry then discussed the physiological factors involved in the choice of a cabin atmosphere.

Since Apollo 204, have:

1. Changed spacecraft materials to non-flammable.
2. Reduced ignition sources.
3. Improved crew egress.
4. Spacecraft equipment flammability tests.

Atmosphere requirements - considerations:

1. Cannot decompress cabin in orbit. (Engineers think this would be very dangerous.)
2. Crew will accept 60 - 40 two-gas on pad, but want it enriched in orbit.
3. Atmosphere must provide sea level PAO_2 (or higher).
4. Suit loop O_2 must be 95% for extra-vehicular activities.
5. Must furnish an atmosphere that will insure peak crew performance.
6. Crew desires to take off helmet and gloves in orbit. Must then have a breathable atmosphere as soon as possible after achieving orbit.

7. Crew must de-nitrogenate for four hours pre-flight. (some individual difference has been noted in time required).

8. Is now an emergency O_2 system available to crew of Apollo. This system has a separate O_2 supply. There are 3 masks available. Is a demand-regulator type (open circuit).

Questions Raised by Carlson, DuBois, and Fenn

DuBois - The flammability criteria presented apply only to the actual ground test situation, and probably cannot be extrapolated to zero "G" condition.

Answer: Tests done in parabolic flight indicate the situation is improved under zero "G" conditions.

Carlson - Requested that chart of test results, BP 1224 Test Program, show burning time related to each test.

DuBois - How will fires in spacecraft be detected, especially the one back of panels where they cannot be seen.

(Fire detection systems were discussed)

Fenn - What type of fire extinguisher will be used? Will the extinguished material stick to the fire areas in zero "G".

Bob White will supply details of test program

Answer: Sticking properties of extinguisher not tested in space flight; presently used hand extinguisher contains material that is believed to have adequate sticking properties (Fenn might like to know composition contents of the extinguisher.

DuBois - Commenting on other factors concerning fires (in addition to flammability of materials) noted:

1. The time from ignition to recognition that a fire exists. He considered a fire sensing system necessary.
2. Human reaction time (to the fact that a fire exists) and take proper action.
3. Effective extinguisher system.

MM (Brownstein) is working. We have a report on this.

DuBois - requested information on tests relative to N_2 contamination of the suit loop in Mercury.

Fenn - raised the question of using the 60/40 tank for oxygen mask system back-up.

Items Needing Further Attention

Don't recall this & Carlson doesn't bring up in his letter.

1. Dr. Carlson's question on the reliability of the new 60/40 system.
2. Dr. Fenn's question on the additional weight of a two-gas system would add to LEM and command modules.
3. DuBois - rapidity of fire propagation in a weightless environment.

An example of something being done for future programs.

4. DuBois - would a fire detection system increase safety? ?
5. Carlson - show burning time related to each test on BP 1224.
6. Dr. Fenn - fighting fires in orbit with hand operated extinguisher - will it be effective? What is composition of content.
7. DuBois - data on N_2 contamination of the suit loop in Mercury.

8. DuBois' suggestion to lower N_2 in spacecraft while dropping pressure to 5.2 PSI - replacing O_2 used. He felt this would avoid aerotitis, aerosinusitis, atelectasis, and other undesirable effects. However, it was pointed out that these bad effects have not been encountered to date. It was agreed that atelectasis and adaptive changes due to hypoxia might be a problem in longer flights. The two-gas system for next program should answer this need.

DuBois - No bends problem going from 5.2 PSI 70/30 atmosphere to 3.5, 100% O_2 - Berry and others did not agree - cited chamber studies - may need chamber studies on astronaut like population to prove this point.

Fenn - Reasons for not going to 4 PSI cabin pressure with 100% O_2.

DuBois - summary of items to be followed up:

1. Need for a fire detection system.
2. Need for a fire extinguishing system.
3. Study of egress time under operational conditions.
4. Berry to show him (DuBois) data on carbon monoxide poisoning of Spacecraft 102, 204

Berry to handle personally.

5. NASA should pursue the use of 70% O_2 in emergency masks.
6. Avoid PAO_2 levels higher than sea level.
7. Valves in atmosphere system could be improved.
8. Should go to two-gas system.

Carlson's Summary

1. Much improvements have been made since fire.
2. 60/40 atmosphere a good move.
3. Minimum number of system changes for Apollo compatible with operational risks.
4. Hopes NASA will keep National Academy of Sciences up-dated as we go down stream in Apollo.