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UNITED STATES GOVERNMENT

Memorandum

TO : See list below

DATE: January 29, 1968
PA-8-1-58

FROM : PA/Manager, Apollo Spacecraft Program

SUBJECT: Apollo Command Module atmosphere

At General Phillips' request, Mr. Johnston of the Crew Systems Division prepared a brief paper on the Apollo Command Module atmosphere. Since this paper clearly describes our current thinking in this area, I am forwarding a copy for your information.

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Enclosure

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APOLLO COMMAND MODULE ATMOSPHERE

The selection of the Apollo spacecraft atmosphere is a trade-off between physiological requirements, fire considerations, and crew operational requirements. Since the spacecraft atmospheric pressure changes from 1 atmosphere for pad operations to 1/3 an atmosphere (5 psia) for inflight operations, consideration must be given to the selection of the cabin and space suit atmospheres used during the pre-launch phase of flight. In addition, the space suit system is designed to operate at a pressure of 3.7 psia to provide maximum pressurized space suit mobility. The crew is maintained throughout the launch phase in space suits which operate independent of the cabin atmosphere. This is essential to protect the crewmen from a cabin decompression which might occur as the spacecraft leaves the sensible atmosphere.

The space suit control system must be maintained with a 100% oxygen environment for prelaunch and launch activities. This is required to preclude the possibility that the crew might experience the bends during the relatively rapid change in pressure associated with the launch of the spacecraft. To insure that adequate protection is provided, the crewmen are required to prebreathe with 100% oxygen prior to spacecraft ingress to remove nitrogen from the body. During the prelaunch phase, the cabin atmosphere should contain enough oxygen to support life. This is desirable since emergencies might occur where the crewmen might have to remove the space suit helmet or gloves.

Once orbital operations are reached, the spacecraft atmosphere should contain sufficient oxygen partial (approximately 3 psia) to permit the crewmen to remove the space suits and operate in a "shirt sleeve" mode. If an inert gas is used to make up the total cabin pressure, then the amount of inert gas must be maintained at a relatively low pressure to prevent bends problems which might occur during a cabin decompression or for planned extravehicular activities.

The spacecraft fire hazard can be reduced for prelaunch pad operation by the use of a 100% inert cabin atmosphere. However, as mentioned previously, this nonviable atmosphere would be a serious hazard should a crewman have to remove his space suit helmet. A 100% oxygen cabin atmosphere for pad operations presents the other extreme in potential fire hazard. The fire hazard for orbital operations with a 5 psia 100% oxygen environment or a 60% oxygen and 40% nitrogen mixture at ambient are of the same relative level. With the stringent materials selection program being employed, it is believed that the spacecraft atmosphere of 5 psia oxygen does not represent a fire hazard.

The maintenance of a viable cabin atmosphere through the launch and early orbital operations should be automatic. The crew should not be required to either monitor the cabin atmosphere or accomplish manual system operations to maintain a safe atmosphere. The space suit system oxygen levels must be automatically maintained with a 100% oxygen atmosphere and all chances of inert gas inleakage into the suit must be eliminated. This is required to prevent a build up of inert gases in the space suit which might result in an inadequate oxygen partial pressure level and possible crewmen hypoxia.

The use of air in the spacecraft while on the pad satisfies the fire hazard consideration and the requirement for a viable atmosphere. After launch and orbital operations the air atmosphere does not provide a shirt sleeve atmosphere since total cabin pressure would be only approximately 5 psia, the oxygen partial pressure would be only 1 psia. This oxygen partial pressure is not adequate to support the crew. Two approaches could be followed to provide the required oxygen levels. The crew could manually enrich the cabin with oxygen or decompress and refill with oxygen. This is, as stated previously, undesirable. Spacecraft system changes could be made to accomplish the enrichment of the cabin atmosphere with oxygen. This would result in system complexity and added weight.

Another approach to providing a cabin atmosphere which would pose less problems to fire propagation would be an oxygen enriched air atmosphere. A nominal 60% oxygen - 40% nitrogen environment satisfies all of the atmosphere requirements. Tests have shown that from a fire hazard viewpoint, this atmosphere is relatively the same as a 5 psia oxygen environment. A liveable environment is provided for all flight phases and no crew operations are required to maintain this atmosphere. Following launch the cabin would be maintained with a minimum oxygen partial pressure of approximately 3 psia. This would allow the crew to operate in a "shirt sleeve" mode.

Full scale boilerplate fire tests have been conducted with the command module to verify that fire propagation characteristics are satisfactory within the spacecraft with the operational atmosphere of 5 psia 100% oxygen. Tests are currently being conducted with the boilerplate to demonstrate flammability characteristics of the spacecraft cabin in a 16 psi 60% oxygen - 40% nitrogen and in a 16 psia pure oxygen environment. Based on the conclusion of these tests, a decision will be made on the spacecraft prelaunch atmosphere. Changes have been made in the spacecraft environmental control system which will permit either of these latter two atmospheres to be used.