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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

TELS. WO 2-4155
WO 3-6925

FOR RELEASE: IMMEDIATE
February 25, 1967

RELEASE NO: 67-38

NOTE TO EDITORS:

The attached statement by NASA Administrator James E. Webb, and report by Deputy Administrator Robert C. Seamans, Jr., were released at 5:30 p.m. today.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

February 25, 1967

STATEMENT BY
JAMES E. WEBB

NASA is releasing today a third interim report on the work of the Apollo 204 Review Board resulting from two days of meetings with the Board by Deputy Administrator Robert Seamans at Cape Kennedy. These meetings took place on February 23 and 24.

This statement and Dr. Seamans' third interim report have been reviewed with Chairman Clinton Anderson and Senior Minority Committee Member Senator Margaret Chase Smith and with Congressman George Miller. In continuation of the Senate Committee's review of the Apollo 204 accident, Senator Anderson has announced that the Senate Committee will hold an open hearing on the preliminary findings of the Board and actions to be taken by NASA at 3 p.m., Monday, February 27.

In addition to the information set forth by Dr. Seamans in his three interim reports, I have had the benefit of a review by three members of the Board--the Chairman, Dr. Floyd Thompson, Astronaut Frank Borman, and Department of Interior combustion expert Dr. Robert van Dolah. This included the preliminary views of the Board as to the most likely causes of ignition, the contributing factors in the rapid spread of the fire, the inadequacy of the means of emergency egress for the astronauts, and the need to recognize that all future such tests be classified as involving a higher level of hazard.

The following emerges from the preliminary views of the Board and the Board's preliminary recommendations:

(1) The risk of fire that could not be controlled or from which escape could not be made was considerably greater than was

recognized when the procedures for the conduct of the test were established. Our experience with pure oxygen atmospheres included not only the successful Mercury and Gemini flights but a number of instances where a clearly positive source of ignition did not result in a fire. In one such instance an electric light bulb was shattered, exposing the incandescent element to the oxygen atmosphere without starting a fire.

(2) Our successful experience with pure oxygen atmospheres in Mercury and Gemini, our experience with the difficulty of storing and using hand-held equipment under zero-gravity conditions, and our experience with the difficulty of making sure before flight that no undiscovered items had been dropped or found their way into the complex maze of plumbing, wiring, and equipment in the capsule,

led us to place in the Apollo 204 capsule such items as Velcro pads to which frequently used items could be easily attached and removed, protective covers on wire bundles, nylon netting to prevent articles dropped in ground testing from being lost under or behind equipment in the capsule, and a pad or cushion on which, in the planned escape exercise, the hatch could be placed without damage to the hatch itself or to the equipment in the spacecraft. While most of these were constructed of low-combustion-potential material, they were not so arranged as to provide barriers to the spread of a fire. Tests conducted in an Apollo-type chamber since the accident have shown that an oxygen fire in the capsule will spread along the surface of Velcro and along the edges of nylon netting much faster than through the material itself.

(3) Soldered joints in piping carrying both oxygen and fluids were melted away, with resultant leakage contributing to the spread of the fire.

(4) The bursting of the capsule happened in such a way that the flames, as they rushed toward the rupture and exhausted through it, traveled over and around the astronauts' couches. Under these conditions, and with just a few seconds of time available, the astronauts could not reach the hatch and open it.

(5) This fire indicates that a number of items related to the design and performance of the environmental control unit will require the most careful examination and may require redesign.

Astronaut Borman, in commenting on his reactions to the conditions surrounding the Apollo 204 test and the subsequent knowledge he has gained as a result of serving on the Review Board, stated to Dr. Seamans, Dr. Thompson, and to me that he would not have been concerned to enter the capsule at the time Grissom, White and Chaffee did so for the test, and would not at that time have regarded the operation as involving substantial hazard. However, he stated that his work on the Board has convinced him that there were hazards present beyond the understanding of either NASA's engineers or astronauts. He believes the work of the Review Board will provide the knowledge and recommendations necessary to substantially minimize or eliminate them.

Dr. Thompson, Astronaut Borman, and Dr. van Dolah have returned to Cape Kennedy and are proceeding with the work of the Board This will require several weeks to complete.

Chairman George Miller, of the House Committee on Science and Astronautics, has announced that as soon as the Board's work is complete, the Committee's Oversight Subcommittee, chaired by Congressman Olin Teague, will conduct a complete investigation of all factors related to the accident and NASA's actions to meet the conditions disclosed. Chairman Teague spend Friday and Saturday at Cape Kennedy with members of the Manned Space Flight Subcommittee, of which he is also Chairman, reviewing progress in the Apollo program. Dr. Seamans, Dr. George Mueller, and I will report further to him at 10 a.m., Monday, February 27.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

February 25, 1967

MEMORANDUM

To: Mr. James E. Webb
Administrator

From: Dr. Robert C. Seamans, Jr.
Deputy Administrator

Subject: Interim report of the Apollo 204 Review Board

On February 22, 1967, I heard a presentation by the Apollo 204 Review Board at Kennedy Space Center of the significant information developed to date and of their tentative findings concerning the circumstances of the accident. The Board also discussed preliminary recommendations. These tentative findings and preliminary recommendations will serve as guides for those interim decisions to be made in the conduct of the Apollo Program prior to the completion of the Board report. I also reviewed the status of the investigation and of spacecraft disassembly, and followed up on items previously noted in earlier reports.

The spacecraft has been removed from the launch vehicle and is now housed in the industrial area. There detailed disassembly continues under careful supervision, each action being undertaken in response to a specific Board directive. This disassembly is far from complete, but a number of the major systems have been removed and are being checked for further verification of the part they played during the fire, the effect of fire on the equipment, and the evidence that analysis might add to the overall picture being built up of the accident. The heat shield has not yet been removed, nor has sufficient internal equipment to permit full view from inside of the entire pressure hull, and a large number of tests, checks and analysis are continuing at NASA, university, and industrial facilities around the country. At present, the Board has over 1,500 individuals, from nine government agencies and departments in addition to NASA, from thirty-one industrial groups, and from several universities, directly participating in the review and analysis. The Board currently estimates that its report will be completed by the end of March. The Board is developing procedures to assure that an orderly and rapid transition of the personnel under its control from the current accident investigation to redesign, qualification, and test effort where required can be made.

In my last report, I noted that an intact on-board biosensor recording was being analyzed for possible additional information; this analysis is now complete and provides a little more than one second's additional information and duplicates data already examined that was available from the telemetry recorded during the test and subsequent accident. The S-band recording also mentioned in the previous report has been completely analyzed by the Bell Laboratories, including computer reconstruction and comparison, but no significant new information could be derived therefrom.

The Board has not identified the source of ignition at this time. Ignition sources that have been under review include: possible chemical reactions, such as those in the on-board batteries or in the air purifier of the environmental control unit; possible spontaneous combustion of certain materials used in the spacecraft; and possible electrical phenomena, such as electro-static spark discharges, electrical arcing, or wiring overheating from shorts or malfunctions.

Examination of the environmental control unit lithium hydroxide and of the batteries indicates these were not the source of ignition. Tests of the combustible materials used in the spacecraft show that at least a 400°F temperature would be necessary for spontaneous combustion, and that no such materials could have been subjected to that temperature except by the malfunction of some other part of the spacecraft systems. An electrical malfunction is therefore regarded as the most likely source of ignition. While not wholly ruled out, electro-static discharge is deemed unlikely in that all reasonable concentrations of flammable vapors that could have been present in the spacecraft were not sensitive to this type of sparking ignition.

By the time it has completed its final report, the Board expects to have significantly narrowed the list of ignition sources that had a relatively high possibility of contributing to the initiation of the fire, but the possibility exists that no single source will ever be pinpointed.

A good deal of the work involved in tracing the history of the fire after ignition has been completed. The Board has considerable confidence in its present theory as to the initial location, propagation mechanisms, and phasing of the fire. This hypothesis, and some of the supporting evidence, is summarized as follows:

Present evidence indicates that the fire had three distinct phases. The fire originated in the left, or command pilot side, in the front corner of the spacecraft, near the floor. It probably burned for several seconds without being noticed by the crew or recorded on instrumentation. Because it was below the couch level it was not visible at this stage; because the crew were fully suited and breathing oxygen from the environmental control system rather than from the cabin, it was not smelled or heard. The left front corner shows the evidence of highest heat and longest duration of the fire, and the witnesses watching the television monitors place the first appearance of flame in that corner (the television camera was mounted outside the spacecraft, looking in through the window in the hatch). The first crew report of fire was at 6:31:04, EST, indicating the fire had become visible. Because the metal structure of the spacecraft absorbed the initial heat, the fire did not initially cause an increase in cabin pressure.

By 6:31:12, the fire had spread and become intense, igniting various materials along the left side of the cabin. Flames were hot and smoke-free, rising along the wall and spreading across the ceiling. The cabin shows heavy damage in this area but little smoke, indicating that the oxygen in the cabin had not been depleted at this time. The fire spread and fed on nylon netting (installed to prevent objects from floating into equipment crevices while in zero-g), Velcro fastening material (used to fasten equipment to the spacecraft interior), and the environmental control unit insulation. The cabin pressure began to rise rapidly at this time as the atmosphere became heated.

At approximately 6:31:19, the internal pressure had risen to an estimated 36 pounds per square inch and the sealed cabin ruptured. This first puncture of the pressure vessel was a long tear in the floor on the right, or pilot's, side of the cabin. With the high internal pressure released, cabin gases and flames flowed both over and under the couches toward and through the hole, moving from left to right. This was the second phase of the fire. Flames passed through the hole into the air space between the cabin pressure shell and the surrounding heat shield; these flames then escaped through access hatches in the heat shield and partially enveloped the outside of the spacecraft for a moment. The short duration, left-to-right, flame motion is evidenced by heavier damage on the left than right side of equipment and wiring on the floor, of the couches, and of the front panels.

With the rupture of the cabin and the rush of flame and gas outside, the oxygen content of the cabin atmosphere was quickly reduced and the fire smoked heavily, laying a film of soot on many interior surfaces. This third and final phase of the fire was also characterized by continued localized burning. The environmental control system uses a water/glycol coolant that leaked from burnt or burst pipes. Both high and low pressure oxygen lines were connected with solder joints that fail at temperatures below 400°F. The glycol mixture from the cooling system, acting as a fuel and supported by the flowing oxygen from the failed lines, caused continued hot burning in the left corner and melted a large hole in the floor there.

The Board noted that the underlying design approach in Apollo was to control the known risk of fire--on the pad or in orbit--by isolating and rendering safe all possible ignition sources. The experience in flight and in tests prior to the accident had suggested that the probability of a spacecraft fire was low. Continued alertness to the possibility of fire had become dulled by previous ground experience and six years of successful manned missions. Ground tests at the pad were classified as especially hazardous only when propellants or pyrotechnics were involved, and different procedures and safety precautions are taken in handling or working under such conditions. Potential ignition sources inside the spacecraft had been treated so as to be considered safe; neither the crews nor the test and development personnel felt the risk of spacecraft fire to be high. The Apollo 204 accident now proves this assumption to have been wrong.

The assumption of ignition source safety led to the use of several solid combustible materials within the spacecraft, including nylon and polyurethane foams. From the point of view of possible fire, these materials were distributed within the cabin without breaks specifically designed to help localize fire if it occurred.

The Board noted that, in the event of a fire emergency, the time and effort required to open the hatch was too long, and that pad emergency procedures were focused on propellant hazards and did not include provisions to meet spacecraft fires.

The principal preliminary recommendations of the Board are designed to assist the Administrator in making his decisions concerning the continuing Apollo program effort prior to completion of the Board review. These are:

> That combustible materials now used be replaced wherever possible with non-flammable materials, that non-metallic materials that <u>are</u> used be arranged to maintain fire breaks, that systems for oxygen or liquid combustibles be made fire resistant, and that full flammability tests be conducted with a mockup of the new configuration.
>
> That a more rapidly and more easily operated hatch be designed and installed.
>
> That on-the-pad emergency procedures be revised to recognize the possibility of cabin fire.

In addition, the Board has drawn attention to a number of components, subsystems, techniques, and practices which it feels can be improved to increase crew safety and mission reliability. These include findings on the environmental control system solder joints, location of wiring, electrical equipment qualification and design, and the development of checkout procedures.

An important area of Board attention has been that of the cabin atmosphere. The atmosphere and pressure selected for the suit and the cabin, before launch and in orbit, have a very important relation to spacecraft design, hatch type, crew physiology, launch procedures, and mission capability. The Board did not recommend a change in the use of pure oxygen in the suit for either pre-launch or orbital operations. The Board did not recommend that cabin atmosphere for operations in space be changed from the currently planned 5 psi pure oxygen but did recommend that the trade-offs between one- and two-gas atmospheres be re-evaluated. The Board specifically recommended that pressurized oxygen no longer be used in pre-launch operations.

Robert C. Seamans, Jr.