INVESTIGATION INTO APOLLO 204 ACCIDENT

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BEFORE THE

SUBCOMMITTEE ON NASA OVERSIGHT

OF THE

COMMITTEE ON SCIENCE AND ASTRONAUTICS

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INVESTIGATION INTO APOLLO 204 ACCIDENT

MONDAY, APRIL 10, 1967

EVENING SESSION

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE AND ASTRONAUTICS,
SUBCOMMITTEE ON NASA OVERSIGHT,
Washington, D.C.

The subcommittee met at 7 p.m., pursuant to recess in room 2318, Rayburn Building, Washington, D.C., Hon. Olin E. Teague (chairman of the subcommittee) presiding.

Mr. TEAGUE. The subcommittee will come to order.

Mr. WYDLER. Mr. Chairman.

Mr. TEAGUE. Mr. Wydler.

Mr. WYDLER. I would like to understand exactly—and I thought I did but I am not so sure that I do any more—I understand the future plans of the committee are tonight, tomorrow morning, and tomorrow afternoon and tomorrow night. Could you explain those as far as they are known at this time?

Mr. TEAGUE. We have to finish with this board tonight. I will go as long as necessary to satisfy the members of this committee that they have everything from the board they want.

In the morning at 10 o'clock we will hear from Mr. J. L. Atwood, the president and chairman of the board of North American Aviation. He will be accompanied by the vice president and the vice president of space information division, and also Mr. Dale Myers. They will be accompanied by two other quality control people, one from California and the other I believe the chief quality control man from Cape Kennedy.

Tomorrow afternoon we have a bill on the floor that is controversial, that will be read for amendment. I don't think we can meet. We will meet tomorrow night with North American. If we finish with North American, the next morning we will have Dr. Miller, Dr. Debus, Dr. Gilruth, probably Dr. Berry, Gen. Sam Phillips, and anyone else they want to bring that will have the information we might want. We will continue through the day and afternoon and evening with them.

Mr. WYDLER. That is on Wednesday.

Mr. TEAGUE. Yes. After that meeting I would expect our committee to go into executive session and decide on anyone that the committee wants to hear that hasn't been scheduled.

Mr. WYDLER. Are you talking about on Wednesday or Thursday?

Mr. TEAGUE. On Wednesday, for us to know who else we should

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hear from Dr. Mueller's group. Then I have had conversations with the astronauts. I think probably we would ask Col. Frank Borman to come back as an astronaut and probably Deke Slayton and Alan Shepard, and maybe a couple of the others who have been in on this investigation. They are the ones who are going to fly the Apollo spacecraft and I think it would be good for us to hear some of these men.

Then I would expect Dr. Seamans and Mr. Webb to come back as well as Dr. Mueller, for a wrap-up of the whole investigation.

Mr. WYDLER. I have a great deal of difficulty understanding just exactly how I could possibly proceed with the Review Board, as such, just directing my attention to that part of the problem. I went back to my office today and I found there a pile of documents called an appendix which was at least a foot high and which have been referred to constantly in the hearings today—panel 6, report No. D, or something of that nature—as answers to questions. It is going to take me time, certainly, to try to evaluate some of that material. I may try to get a hold of particular parts and get some questions concerning it. But that is not going to take place by the end of this evening under any circumstances because I am here to begin with. I don't know what I am supposed to do on questioning the Board.

Mr. TEAGUE. I can assure you gentlemen that the chairman has the same problem, too. These people have a job ahead of them. It is important that they get through and carry on a space program. I would expect our committee would not make their report for some time. I would think if any member who has some questions, and particularly if there is a panel member you want to hear from, it is not the intent of the chairman to cover up anything or cut off any member. I think it is most important to all of us that we get through with these hearings and let these people get back to work. But certainly if any member of this committee who thinks of questions later that they would like to have answered, we can contact any member of the panel or NASA or North American, or anybody. I would hope that our committee might run down to Cape Kennedy and see the two capsules that are laid down there. I was hoping that the gentleman from New York would go. The chairman has been urging me to do it.

Mr. ROUDEBUSH. Would it be possible for the individual members to ask additional witnesses?

Mr. TEAGUE. It will be possible for individual members to ask any witness and the committee will decide whether we want to hear them or don't want to hear them.

Mr. WYDLER. Thank you.

Mr. ROUDEBUSH. Thank you.

Mr. TEAGUE. The chairman reminds me this is the Oversight Committee and not the full committee. Of course that is true. There was something I didn't say this morning, and I should have. I have been asked a number of times whether our committee's activities were limited. I would like to say in no way, form, or fashion has the chairman imposed any limitation on this subcommittee.

Mr. MILLER. Just get to the truth.

Mr. TEAGUE. Colonel Borman, we would be glad to hear from you.

Colonel BORMAN. I would like to put on the record some information that was requested of me this afternoon.

Mr. TEAGUE. It will be placed in the record.

Colonel BORMAN. Mr. Gurney asked for a breakdown of test expe-

rience at 16.5 pounds per square inch. During the altitude chamber test, there were 2.7 hours unmanned and 3.5 hours manned, for a total of 6.2 hours, at 16.5 pounds per square inch absolute. We had another total of 34 hours unmanned at 6.2 pounds per square inch absolute and 22 hours manned at 5.5 pounds per square inch absolute. This gives you a total of 62.2 hours for this particular spacecraft with a 100 percent oxygen environment.

Does that answer your question?

Mr. GURNEY. Yes.

Mr. DAVIS. Mr. Chairman.

Mr. TEAGUE. Mr. Davis.

Mr. DAVIS. Were the load factors the same on the 28 volt direct current and the 115 volt alternating current tests as were in effect during the actual fire?

Colonel BORMAN. Essentially, yes; for all practical purposes they were.

Mr. DOWNING. Colonel, there has been some discussion that there was a preliminary test eliminated, and this test was the 100 percent oxygen, 16 pounds per square inch unmanned, just prior to the time the astronauts boarded it for the manned test. Was there an elimination of an unmanned 16 pounds per square inch 100 percent oxygen test?

Colonel BORMAN. Not to my knowledge. Mr. Williams is the best man to answer that.

Mr. WILLIAMS. No, there wasn't.

Mr. TEAGUE. Colonel Borman has stated that he would like questions as he goes along, and then when he is finished the Board will be before us to ask any questions you may care to.

Colonel BORMAN. Sir, I didn't volunteer for questions. I would like to put that on the record.

Mr. TEAGUE. You came mighty close to it, though.

STATEMENT OF COL. FRANK BORMAN, U.S. AIR FORCE, ASTRONAUT

Colonel BORMAN. I think perhaps, sir, before we go into the findings and determinations, it might be well to recap just briefly the area that the Board has settled on as the probable source of ignition. If I may have the first slide.

(SLIDES REFERRED TO IN THIS STATEMENT ARE PRINTED IN VOLUME II—PART 2)

Can you dim the lights, please?

This is a picture of spacecraft 012, the one that burned, taken on the 30th of December last year. You see here the wire that we pointed out before going over the stainless steel urine dump line. This is the area where we believe the arc occurred, this general area, that ignited the combustionable located nearby and caused the tragedy.

If I may have the next slide, I will show you exactly the same area after the fire. You will notice the cables, they were carrying bus A and bus B d.c. 28 volts, have been completely destroyed. The intensity of the fire has already been pointed out. Here you see the molten aluminum and the aluminum drippings on the floor. This is the area which the Board considered to be the probable source of ignition.

Thank you.

Mr. WYDLER. Mr. Chairman.

Mr. TEAGUE. Mr. Wydler.

Mr. WYDLER. Were those urine lines in use at the time?

Colonel BORMAN. No, they were disconnected; we never used those lines during ground tests.

Mr. DAVIS. May I ask this question? From the most probable source of combustion, what would be the lowest point of ignition or from point of combustion for combustible material from the highest source?

Colonel BORMAN. It is all nylon material that did meet the specifications as they existed at the time.

Mr. DAVIS. Did you reach a conclusion how high the temperature may have risen?

Colonel BORMAN. Do you mean that ignited it?

Mr. DAVIS. Yes.

Colonel BORMAN. The best person that can answer is Dr. Van Dolah.

Dr. VAN DOLAH. Temperature is not the appropriate term. Rather, it is an energy term. The arcs have sufficient energy to ignite nylon in this oxygen atmosphere.

Mr. DAVIS. The temperature falls off very rapidly with distance, does it not?

Dr. VAN DOLAH. It does except where bits of molten metal from the arc are projected by the energy of the arc. These can be projected some distance while retaining their high temperature.

Mr. DAVIS. I assume, from reading some of your recommendations that by removing the so-called combustible material from a possible source of arcing you might render this module safe with an oxygen atmosphere. Have you considered you might separate flammable materials as a solution to the problem?

Dr. VAN DOLAH. They would have to be rather far removed from potential arcing sources in order to be safe. The other thing that can be done is to reduce in quantity the amount of material in any one location so that if a fire was started it would be a very small fire and would not tend to spread to other combustibles.

Colonel BORMAN. May I have the next slide?

The first finding: (a) There was a momentary power failure at 23:30–55 Greenwich mean time. This was discussed by Dr. Faget. (b) There was evidence of several arcs found in the postfire investigation. We found an explanation for all except the one I mentioned. (c) No single ignition source of the fire was conclusively identified, although, as I mentioned earlier, we have a most probable source.

From these findings the Board determined the most probable initiator was an electrical arc in the sector between the minus Y and plus Z spacecraft axes. The exact location best fitting the total available information is near the floor in the lower forward section of the left-hand equipment bay where environmental control system (ECS) instrumentation power wiring leads into the area between the environmental control unit (ECU) and the oxygen panel. No evidence was discovered that suggested sabotage.

Next finding: (a) The command module contained many types and classes of combustible material in areas contiguous to possible ignition sources.

The test was conducted with a 16.7 pounds per square inch absolute, 100-percent oxygen atmosphere.

Determination: The test conditions were extremely hazardous. The recommendation——

Mr. TEAGUE. Would you answer a question right there?

Colonel BORMAN. Yes.

Mr. TEAGUE. Before this happened, what kind of condition did you think existed?

Colonel BORMAN. I don't believe that any of us recognized that the test conditions for this test were hazardous. I myself in Gemini 7 flew for 2 weeks in a 100 percent O_2 environment. We tested on the ground with 14.7 pounds per square inch absolute O_2, we purged with 20.7 pounds per square inch absolute O_2. In no way did I consider the test condition hazardous.

Mr. HECHLER. Have there been any discussions ever about previous fires in other experiments by the military services?

Colonel BORMAN. Yes, sir. In Gemini 7 we removed our space suits for the first time in American flight. This is when fire in flight becomes a real concern because our primary means of protection is to vent the cabin in vacuum and extinguish the fire. When you are not in a space suit this becomes impractical if you are interested in longevity. We looked very seriously to controlling in-flight fires. We are very aware of the fires that occurred at Johnsville Naval Air Station and also at Brooks Air Force Base. We came to the conclusion that the best available fire extinguisher that we had on board was our water pistol and these were the plans that we used. This was not done lightly. There was a report of considerable length and considerable detail that we looked into before we flew.

Mr. HECHLER. Thank you.

Colonel BORMAN. The Board recommends, based on the previous determination, that the amount and location of combustible materials in the command module be severely restricted and controlled. We not only must reduce the amount, but we have to make sure that the amount that we must have is strategically located.

Next slide——

Mr. GURNEY. Question.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. Have these combustibles been the subject of discussion at all in your program prior to this time, whether there were too many and whether they were a hazard?

Colonel BORMAN. Yes, sir. This spacecraft had several items removed during the inspection at Downey. There was a regulation that no combustible should be within 12 inches of a possible ignition source.

Mr. GURNEY. A combustible item was a matter of concern among the astronauts, would that be fair?

Colonel BORMAN. No; because none of us really placed any stock or gave any serious concern to a fire in a spacecraft. This is the real crux of the problem.

The third finding: (a) The rapid spread of fire caused an increase in pressure and temperature which resulted in rupture of the command module and creation of a toxic atmosphere. Death of the crew was from asphyxia due to inhalation of toxic gases due to fire. A contributory cause of death was thermal burns. (b) Nonuniform distribution of carboxyhemoglobin was found by autopsy.

Mr. TEAGUE. What does the last mean?

Colonel BORMAN. Sir, the last finding (b), and I must tell you that this is what has been explained to me, essentially means that portions of the blood that have been exposed or combined with carbon monoxide

in the lungs were not completely distributed throughout the body; so that the blood that was essentially without oxygen did not have time to be distributed throughout the body before cardiac arrest occurred.

Mr. DOWNING. These astronauts had helmets on at the time of the fire and the suits were supplied with oxygen.

Colonel BORMAN. Yes, sir.

Mr. DAVIS. Was there enough residual oxygen in the suits to keep them going?

Colonel BORMAN. We scrub the oxygen to remove the carbon dioxide. As long as the suit loop was intact they were getting pure oxygen. But when it broke through, they were breathing toxic gases.

Mr. RUMSFELD. To go back to your comment that none of the astronauts gave concern to fires in the capsule. You, naturally, and the other astronauts are concerned with what is known to be a serious and dangerous aspect of flying, the potential of fire. Do you mean in this particular situation you and the astronauts didn't feel that there was any unusual danger of fire or anything unique that caused you to pursue it?

Colonel BORMAN. Yes, sir. For in-flight fire, we were concerned, and we had investigated the means of best handling an in-flight fire. Under the particular test conditions with which we were dealing, there was no undue concern over the hazards.

Mr. RUMSFELD. Then your comment is restricted to the test conditions?

Colonel BORMAN. Yes, sir.

Mr. ROUSH. Colonel Borman, you stated you did not consider the test conditions extremely hazardous. I would like to ask if any responsible person connected with NASA, any prime contractor involved in this particular testing or involved in the supplying of equipment for the particular test, or if any of the astronauts had, prior to this fire, ever raised the question or indicated that they were concerned about these test conditions being extremely hazardous and dangerous to the astronauts?

Colonel BORMAN. To the best of my knowledge the answer is "No." The crew that was killed certainly wasn't concerned because in the final analysis the crew has the undeniable right not to enter any spacecraft that they feel would be hazardous. Although there are sometimes romantic and silk-scarf attitudes attributed to this type of business, in the final analysis we are professionals and will accept risks but not undue risks.

Mr. ROUSH. Thank you.

Mr. KARTH. Referring to your relatively low concern for fire hazards while on the ground, isn't it true that you actually have less concern for the fire hazard while you are in flight because of the lowering of pressure while you are in flight?

Colonel BORMAN. Yes, sir.

Mr. KARTH. You should be less concerned in flight.

Colonel BORMAN. The potential of fire is less at lower pressure but when you are 180 miles away from terra firma and a fire station it becomes more significant than it is on a launch pad.

Mr. KARTH. Unless you are locked in, Colonel.

Colonel BORMAN. That is correct.

The autopsy data leads to the medical opinion that unconsciousness occurred rapidly and that death followed soon thereafter.

The fourth finding: Due to internal pressure, the command module inner hatch could not be opened prior to rupture of the command module.

Next slide. Determination: The crew was never capable of effecting emergency egress because of the pressurization before rupture and their loss of consciousness soon after rupture.

Recommendation: The time required for egress of the crew be reduced and the operations necessary for egress be simplified.

Mr. ROUDEBUSH. Colonel, I wanted to ask you there, in regard to emergency egress. Hadn't any of the astronauts ever expressed concern about the lengthy time to operate the hatch in the Apollo command module?

Colonel BORMAN. No, I practiced it myself. The crew that was in there had practiced. Perhaps you haven't had time to read the 3,000 pages, but there was an emergency egress practice planned at the completion of this test. We had planned for rapid egress. We did not identify, as I pointed out, the crux—in my opinion, the main problem. We did not identify the potential of the spacecraft fire as being a real hazard. Consequently, the egress procedures were primarily concerned with the potential hazard from the booster or the hypergolic fuels that existed in the service module. For the identified hazards, the time required to get out of the spacecraft except in the event of a spacecraft fire was, in my opinion, adequate with that hatch.

Mr. WYDLER. The hatch that now exists on the spacecraft would take 90 seconds to open from inside and to get out, is that right?

Colonel BORMAN. Approximately. It depends upon the training of the crew.

Mr. WYDLER. What would be the emergency in which they would utilize that hatch?

Colonel BORMAN. If you had an impending emergency in the booster, for instance a pressure rise that you couldn't explain or a hold of some unforeseen nature that might be deemed an emergency, you would leave under those circumstances.

Mr. WYDLER. If there actually was any type of explosion or fire that was started in the boosters, that won't be adequate for that.

Colonel BORMAN. You wouldn't wait until it started. We have instrumentation and we can identify trends.

Mr. WYDLER. When the new hatch is designed, how long will it take the three astronauts in the capsule to get out physically?

Colonel BORMAN. I am not sure exactly what the design will call for. They are talking on the order of 2 to 3 seconds to open the hatch. I am hopeful that we don't end up with a hatch that opens too easily. This is another concern when you are operating in orbit. The last thing that you are interested in is a hatch that might accidentally open.

Mr. WYDLER. How long does it take for the three astronauts to get out if the hatch were to open in 5 seconds?

Colonel BORMAN. I would imagine it is on the order of 17 or 18 seconds.

Mr. WYDLER. How long was it before the astronauts in this case were killed?

Colonel BORMAN. Again we can't determine it within that close a time schedule.

Mr. WYDLER. I am just trying to point out that this improvement

in the hatch may not accomplish anything when you are all through with it. The 17 or 18 seconds may not be sufficient for any purpose.

Colonel BORMAN. If they had had a hatch that opened outward and opened in 2 seconds there is no question in my mind that they would have escaped. There was a considerable amount of time from the time the fire was identified or recognized by the crew until it became really a massive burning and, of course, the opening of the hatch would have eliminated the rupture and the attendant swirling inside. It is my firm opinion that the crew would have escaped with a hatch that opened in 2 seconds.

Mr. FULTON. Mr. Chairman.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON. What kind of emergencies were you talking about when you made this escape emergency plan of 90 seconds?

Colonel BORMAN. You must realize that for the last 30 minutes, the last 30 minutes before launch, you have a very swift means of escape by using the escape tower.

Mr. FULTON. You are talking of launch and we are talking of test.

Colonel BORMAN. All right, sir.

Mr. FULTON. So, under test conditions, there are then emergencies that might happen. What are those?

Colonel BORMAN. Under the test conditions that existed at Cape Kennedy for this particular test, I could identify no hazard, none of us could. That was the problem. We did not have fuel in the booster. We did not have hypergolics in the service module. There was no live pyrotechnics. The escape motor was safetied.

Mr. FULTON. Was it ever called to your attention that there might be a short circuit or an arcing that would ignite materials in a pure oxygen atmosphere?

Colonel BORMAN. We were aware of this but we did not consider this a hazard under the ground test conditions that existed.

Mr. FULTON. Was there any procedure in case the occupants of the capsule were incapacitated that somebody outside could take emergency procedures to get them out?

Colonel BORMAN. Yes, sir; but since this test was not classified hazardous the team was not on duty.

Mr. FULTON. Why didn't they use ordinary atmosphere when they spent so many hours on it? We have had testimony that the difference between pure oxygen or any other two- or three-gas atmospheres like ordinary air, would make little difference on the test. Why wasn't a nondangerous atmosphere used?

Colonel BORMAN. I think we will discuss that a little later on if you will wait for another finding.

Mr. TEAGUE. Mr. Waggonner.

Mr. WAGGONNER. This might not necessarily be a question for you but can you tell me whether or not at any time during the design of this spacecraft NASA or some advisory source or some contractor supplying NASA ever recommended a hatch other than the one which was actually in service on this particular spacecraft?

Colonel BORMAN. Yes, sir. We did have recommendations and a new hatch design was in the process at the time of the accident. But the main concern of the new hatch was not for rapid egress on the ground but rather for a more compatible hatch for extra vehicular activities in orbit.

Mr. WAGGONNER. One that would make egress a little bit easier on station.

Colonel BORMAN. On station.

Mr. WAGGONNER. Nobody suggested or laid claim to the fact that this hatch would require 90 seconds to open against change pressures and open under certain conditions would be unsatisfactory. Is that a true statement?

Colonel BORMAN. Yes, sir; I was on the crew safety committee for 3 years. We tried to identify every hazard we could. This is one we never concerned ourselves with. I am sure there is somewhere on the record a proposal for a quicker opening hatch; for rapid egress on the ground. I personally am not aware of it. In all the time that I served on the crew safety committee I cannot recall that this was questioned.

Mr. MILLER. Mr. Chairman.

Mr. TEAGUE. Mr. Miller.

Mr. MILLER Colonel, if you had been a member of the crew, would you have hesitated on that day to get into the vehicle that then existed?

Colonel BORMAN. No, sir.

Mr. MILLER. Thank you.

Mr. ECKHARDT. I am interested in your reference to the crew safety committee. It would seem to me that most of the persons involved in NASA operations are rather narrow specialists. To a certain extent you astronauts are the generalists of the group, and the problem that was involved here was one perhaps not so much within the specialty of anyone, but rather within the knowledge of a generalist, as you astronauts are. I was wondering if it might not be desirable to have a staff, perhaps not trained in the particular special test of the operation, but the kind of persons who would have the knowledge of inspections, general inspections that would be at your service as sort of an auxiliary safety force.

Colonel BORMAN. We have that, sir.

Mr. ECKHARDT. You do?

Colonel BORMAN. Yes; we have a whole team of people, including representatives of our flight safety people. In preparing for Gemini VII, I had 16 people that reported directly to me and who I used as my eyes, ears, and bird dogs for making sure that the things were going the way I thought they should go.

Mr. ECKHARDT. I am as much interested in finding ways to avoid other accidents which may be far from direct relationship to this accident as finding out what caused this accident. Is there any way that this process that you are describing could be improved in order to accomplish that objective.

Colonel BORMAN. I would hesitate to answer this offhand. I haven't thought about it until you asked the question. Perhaps I could defer and answer this later on for you.

Mr. HECHLER. Mr. Chairman.

Mr. TEAGUE. Mr. Hechler.

Mr. HECHLER. On that point, let me try to see if my characterization of the general attitude is correct. Isn't it true in all of these things that you are saying here and in the rest of the things that you will say, that the general feeling, not only in NASA, but in the Nation and the Congress was one of overconfidence? We had done so well that perhaps we could afford to be just a little bit overconfident in approaching possible dangers. What you really need is a somewhat dif-

ferent attitude all the way up and down the line in Congress and in NASA and the Nation concerning the potential threats, and the way in which we can guard against these threats to the lives of the men that are in the program.

Colonel BORMAN. Sir, I think I can best answer that by saying that I don't know of a person that is more interested or a group of people that are more interested in performing the mission well than the crew that is assigned to the flight. There is no resting on the oars. There is no laxness. There is no feeling that we have done so well before that we can slow up. Each crew attempts to make their particular flight the perfect flight, so to speak. I was assigned to the spacecraft behind 204, and I observed the 204 crew many hours at Downey and frequently at the Cape, and I can assure you there was no laxity, there was no feeling that this was "a piece of cake" as we say in the Air Force.

They did their utmost to assure that this flight would be a success.

Mr. HECHLER. Don't you think that attitude may be improved a little bit in the future?

Colonel BORMAN. It has never been evidenced to me anywhere in NASA management. I might say that I have never seen a decision where crew safety was sacrificed for anything; money or schedule. If there was ever an issue of crew safety that was identified that was the predominant concern. Unfortuately we did not recognize this particular hazard.

Mr. TEAGUE. Can you identify those items that have been changed from Block I to Block II?

Colonel BORMAN. To the best of my ability. I think we would have to have Dr. Mueller tell us what is going to be done.

Mr. TEAGUE. Mr. Cabell.

Mr. CABELL. This follows somewhat the question of Mr. Hechler. During your course of training and your operational experience, at any time have the recommendations of the astronauts for safety, for changes in procedure, ever been ignored by NASA?

Colonel BORMAN. They have never been ignored. They are always considered. I won't say that everything the flight crew proposes is accepted, that is not true. But concerning safety, I have never been associated with any decision where safety was recognized as a factor where the decision was not made to provide safety.

Mr. CABELL. Then to follow what you said, and I think this is somewhat redundant, the answer to that is, if you as a crew and other crew members made recommendations, you got very definite ear to your recommendations.

Colonel BORMAN. Yes, sir.

Mr. CABELL. And if it involved safety of the crew it got more than token interest; is that correct?

Colonel BORMAN. Yes, sir.

Mr. CABELL. Have you felt very strongly about safety recommendations concerning the safety of the crew that were not given credence by NASA as such, by the Administration?

Colonel BORMAN. No, sir.

Mr. CABELL. You feel as a member of the crew, as one of our astronauts, that you have had the complete cooperation of NASA as such in developing your program and in protecting your interest in your safety.

Colonel BORMAN. Yes, sir.

Mr. CABELL. Thank you.

Mr. TEAGUE. Mr. Gurney.

Mr. GURNEY. Colonel, we all recognize, I think I state this correctly, that the use of pure oxygen does present severe fire hazards. I think actually that is the language used in the report and I guess there has been a great deal of discussion between using pure oxygen or some other combination in the cabins of spacecraft and yet it puzzles me when you say that under these specific test conditions you never considered fire as a hazard. Now, what generally do you consider as a fire hazard in this kind of an atmosphere? Then let me say in trying to illustrate, if you were going into a filling station to have a car serviced you wouldn't strike up a match and have a cigarette while the gas was going into the tank. What areas do you identify as rather severe risks in this business of working in a pure oxygen atmosphere?

Colonel BORMAN. I think what you say about going into the gas station and striking a match is true. Mr. Rumsfeld can tell you when he flew in the Navy in jets he was using 100-percent oxygen all the time. There is oxygen right up above your head when striking matches on a commercial airliner. Oxygen per se is not dangerous, only when associated with a fuel and ignition source. Quite frankly we did not think, and this is a failing on my part and on everyone associated with us; we did not recognize the fact that we had the three essentials, an ignition source, extensive fuel and, of course, we knew we had the oxygen.

Mr. TEAGUE. Mr. Fulton.

Mr. FULTON. When complaints were made or suggestions by any of the astronauts as to developments on the capsule or safety, those complaints would be made either to people who were in the manufacturing team for the contractor or to the programing director. My question is on how the complaints could be made. For a number of years now I have introduced a bill to provide an inspector general in NASA to do inspecting as an independent operator reporting only to the Administrator or maybe the top assistants, so that there is no obstacle to getting a final judgment and decisions do not have to go up through people pushing the program.

Now, either in NASA an inspector general is needed or the one in the Air Force should be disbanded and the money saved. Which do you say?

Colonel BORMAN. I am a colonel, but I think I would have to defer to a higher rank to answer that particular question. I think there is national policy involved. I really am not qualified, sir.

Mr. FULTON. Do you think it would help if there were a continuing function that would permit the astronauts to have consultation with an independent group so that they don't make their complaints to the people who are pushing the program, the contractor, nor the administrators of the program on the operating level? Supposing an astronaut sees something unsatisfactory and he tells someone in authority. Suppose they say, "We have discussed that and it is all right, you just go ahead, buddy." Is there really anyone to follow up for him?

Colonel BORMAN. While some astronauts may think they know everything there is to know, it doesn't follow that they do. I have never had any problem making my position known to the proper people. Dr. Gilruth's door was always open. I have never had any problem getting an ear. We weren't always granted what we asked

but never was a safety request turned down. Dr. Mueller and I have discussed some requests many times.

Mr. TEAGUE. Mr. Wydler.

Mr. WYDLER. Colonel, you said before that the particular exercise was termed "nonhazardous." Therefore, did I understand the rescue team was not on duty?

Colonel BORMAN. Yes, sir. They were to come on duty at the completion of the test because they were to run an emergency egress exercise. They were not on duty at any other time.

Mr. WYDLER. They were not on duty while the astronauts were in the capsule?

Colonel BORMAN. That is correct.

Mr. WYDLER. They had not been on duty at any time the astronauts were in the capsule.

Colonel BORMAN. That is correct. They were to come on duty at the completion so they could participate with the astronauts in an exercise which involved getting out of the capsule as rapidly as possible.

Mr. WYDLER. Where were they at the time of the accident?

Colonel BORMAN. They were preceding toward the launch pad.

Mr. WYDLER. Have they ever had the rescue team on duty while the astronauts were in the capsule.

Colonel BORMAN. Not for a nonhazardous test.

Mr. WYDLER. What are the hazardous tests?

Colonel BORMAN. During a launch you have them in a fire-resistant vehicle—in deference to Dr. Van Dolah I find nothing is fireproof. They are ready to go with their equipment and breathing packs. During a launch demonstration they would be on duty. At this time the vehicle is completely loaded and it simulates a launch except you don't fire the booster.

Mr. WYDLER. Who was the closest man at the time of the accident?

Colonel BORMAN. We are getting way away from the recommendations. I would be happy to proceed along this line.

Mr. TEAGUE. There are 11 findings in the book you have had since yesterday. If you look at these findings, you can see what he is going to discuss.

Mr. WYDLER. I will look.

Who was the closest man?

Colonel BORMAN. Two or three technicians who were standing right beside it.

Mr. WYDLER. You did not realize that there was any hazard in this. I wonder if you, anyone in NASA, or connected with NASA, or the contractor, are aware of a report that was done in December of 1965 by Atlantic Research Corp. under contract to the U.S. School of Aerospace Medicine concerning the extreme risk of fire that exists in the exact instance as in this case.

Colonel BORMAN. Yes, sir; we did a complete study ourselves before Gemini VII. McDonnell Aircraft Co. did the study.

Mr. WYDLER. The conclusion of the study was the fact that this was extremely hazardous and probably the greatest hazard was the carbon monoxide itself, that it could cause almost instantaneous death. Were you aware of that?

Colonel BORMAN. Not only are we aware of it, it has been proven. I agree with you.

Mr. WYDLER. I am talking about the time of the accident.

Colonel BORMAN. As I mentioned before, I was certainly aware of the fact that if you had a fire it would be a very hazardous thing and we had overlooked the possibility. I accept my share of the blame. We had overlooked the possibility that we were apt to have a fire.

Mr. WYDLER. All right.

Thank you.

Mr. TEAGUE. Mr. Davis.

Mr. DAVIS. The reason you have over 16 pounds of pressure per square inch in this command module was the fact that that was about 2 pounds more than the outside atmospheric pressure, was it not?

Colonel BORMAN. 16.7 pounds per square inch absolute.

Mr. DAVIS. Which is about 2 pounds more than 4.5, that is about sea level atmospheric pressure.

Leakage would be from the inside.

Colonel BORMAN. That helped seal the hatch.

Mr. DAVIS. The reason was to prevent contamination from the outside atmosphere.

Colonel BORMAN. It was to keep air from leaking in and another reason was to keep the hatch sealed.

Mr. DAVIS. It was far more economical, and simple to use pure oxygen as you elevated the pressure inside.

Colonel BORMAN. Yes; because you introduce many problem areas if you go to a diluent gas or a two-gas system.

Mr. DAVIS. The course which you decided, from all the data you had, from all the premises you had, to form conclusions, was the safest and quickest, and you could find no reason to have misgivings about it.

Colonel BORMAN. Yes, sir.

Those organizations responsible for the planning, conduct and——

Mr. RUMSFELD. Could you identify them?

Colonel BORMAN. They are, under the procedures in force, the contractor who had the responsibility to identify the test as being hazardous.

Mr. RUMSFELD. "Those organizations" means the contractor.

Colonel BORMAN. This does not dispel the fact that NASA had the authority and the responsibility to monitor this and identify it, also.

Mr. RUMSFELD. The reason I ask is because it has been said that prior to the time of the accident you didn't regard the operation as involving a substantial hazard. But after your work on this Board you were convinced that there were hazards. It is clear that there is a hazard evaluation gap.

Colonel BORMAN. Not in my mind. I have evaluated it and I have determined it was hazardous.

Mr. RUMSFELD. But there was a gap.

Colonel BORMAN. There was a gap in that we did not recognize it as being hazardous before the test.

Mr. RUMSFELD. Now, we have come to a specific where those organizations responsible failed to identify the hazard.

Colonel BORMAN. Yes, sir.

Mr. RUMSFELD. I am of the opinion that this accident is important, and pursuing it is important. But, from my personal standpoint, I am equally anxious to try to get to the root of the procedures that permitted a gap between the actual hazard and the evaluation and identification of a hazard, and see along with the line of questioning that Mr. Fulton pursued, whether or not an inspector general or an independent safety review board, such as those of the Navy or the Air Force or

the Atomic Energy have, might have been in a position to close that gap.

You said to Chairman Miller that you wouldn't have hesitated to enter that capsule. I suspect that today knowing what you know, that you would hesitate to enter that capsule.

Colonel BORMAN. That is correct. As I mentioned, now I would.

Mr. RUMSFELD. It is my thought that possibly some mechanism could be developed to help to identify other gaps that exist. If one existed, there is a possibility that others may exist. Through the establishment of some mechanism as an inspector general or a safety review board it is possible we might be able to narrow down the number of instances such as this. This is the reason I think it is important to go to the question of what organizations and at exactly what level the problem happened.

Colonel BORMAN. I think this is beyond the scope of my capability to testify.

Mr. RUMSFELD. In civilian airliners there is often an announcement that if the cabin loses pressure an oxygen mask comes down and you are supposed to put out your cigarette. I have never been in a civilian airliner that lost pressure. I suppose the mask just provides oxygen.

Colonel BORMAN. I haven't been in an airliner that lost pressure, but on one we had a hard landing and the masks fell down.

Mr. RUMSFELD. It must have been an ex-Air Force pilot.

Colonel BORMAN. I checked on it and he thought he was practicing a carrier landing.

[Laughter.]

Colonel BORMAN. Sir, if we may go on——

Mr. FULTON. Before you leave that point, you mentioned a possibility that might have occurred. Let me ask your judgment. If you had known then what you realize now you would not only not have entered the capsule under those same conditions but you also would have advised the crew not to enter, isn't that correct?

Colonel BORMAN. That is correct.

Mr. RYAN. Mr. Chairman, may I ask if the question previously asked about the organizations responsible can be more clearly amplified?

Colonel BORMAN. I can probably give it to you.

Mr. RYAN. Was not NASA ultimately responsible for the safety of the crew?

Colonel BORMAN. In my opinion, yes, sir.

Mr. RYAN. Previously, you pinpointed responsibility to the contractor. Wasn't the ultimate and final responsibility on NASA?

Colonel BORMAN. Yes, sir. What I said was that the first step in the indication of the test as being hazardous was, in the procedures in use, incumbent on the contractor. I don't mean to imply that NASA shouldn't have evaluated the test and done this also.

Here is finding 5:

(*a*) No procedures for this type of emergency had been established either for the crew or for the spacecraft pad work team.

(*b*) The emergency equipment located in the "white room" and on the spacecraft work levels was not designed for the smoke condition resulting from a fire of this nature.

(*c*) Emergency fire, rescue, and medical teams were not in attendance.

(*d*) Both the spacecraft work levels and the umbilical tower access

arm contain features such as steps, sliding doors, and sharp turns in the egress paths which hinder emergency operation.

Next slide.

Determinate adequate safety precautions were neither established nor observed for this test.

Next slide.

We recommend: (*a*) Management continually monitor the safety of all test operations and assure the adequacy of emergency procedures.

(*b*) All emergency equipment (breathing apparatus, protective clothing, deluge, systems, access arm, et cetera) be reviewed for adequacy.

(*c*) Personnel training and practice for emergency procedures be given on a regular basis and reviewed prior to the conduct of a hazardous operation.

(*d*) Service structures and umbilical towers be modified to facilitate emergency operations.

Mr. FULTON. Was there in process a reevaluation of the materials within the capsule which might have been flammable? Was NASA in the process of upgrading the safety at the time this occurred, for example, better insulation or better clothes—I am speaking particularly of suits. Wasn't NASA already doing such things?

Colonel BORMAN. To my knowledge, no, sir.

Mr. FULTON. How about the beta cloth?

Colonel BORMAN. That was part of long-range development. I was not aware of any plan to incorporate it.

Mr. TEAGUE. I think Dr. Thompson would like to comment.

Dr. THOMPSON. We have learned that considerable work had been done on beta cloth or Fiberglas, making it suitable for wear, that is, even as underwear.

Colonel BORMAN. That is right.

Dr. THOMPSON. Which is a very demanding requirement. The progress has reached the point where we have been assured by the director involved that there is a very good chance that they can make extensive use of beta cloth at this time.

Mr. FULTON. I was really being an attorney for NASA by saying, weren't they then, even at the time this accident occurred, in the process of upgrading the safety of materials within the capsule, for example, either the suits, the various nylon items, the Teflon, and the Fiberglas? Weren't they even then looking into that angle of safety?

Colonel BORMAN. Yes, sir. This was under development. You asked me were there plans to incorporate them in the suits. My answer was "I was not aware of them." I am not sure it had progressed that far.

Mr. FULTON. At that time hadn't NASA already removed certain items that they considered were dangerous or below safety requirements? Wasn't NASA in the process of experimenting and trying to reach good results for safety in this capsule?

Dr. THOMPSON. Could I add something else?

Teflon has come into use for insulation. We have been shown examples of Teflon clothing material that may be useful. All those things are in the process of development. We are assured they are being very carefully considered for development in the space flight.

Mr. FULTON. Wasn't NASA already doing so?

Dr. THOMPSON. It was underway. We learned about it when we first started this review. That work had been underway for a considerable period of time.

Mr. KARTH. Colonel Borman, in your recommendation (a) where you use the word "management," I assume you mean NASA management at the Cape or a combination of NASA management at the Cape and the prime contractor management?

Colonel BORMAN. NASA management.

Mr. KARTH. If all of those recommendations were instituted, how much time do you think would be added to the program prior to the first launch?

Colonel BORMAN. I don't believe these recommendations would add much time. There are other pacing items, in my opinion—again you are asking me to testify in areas that I admit I am not expert in.

I really can't accurately evaluate the timelag in any of these. Looking at them now I don't believe any would require a great deal of time.

Mr. RYAN. Colonel, on this question of safety you referred to the appendix (d) (7) (57).

Colonel BORMAN. Yes, sir.

Mr. RYAN. That appears to be a memorandum from the chief safety officer to the Apollo Review Board.

Colonel BORMAN. Yes, sir.

Mr. RYAN. It lists pressure testing and operations with hazardous gases. When, before or after the accident, were those specified as being hazardous?

Colonel BORMAN. Pressure testing means pressure-testing tanks.

Mr. RYAN. What are "operations with hazardous gases"?

Colonel BORMAN. Hypergolic fumes, nitrogen, or any of those type gases. Oxygen was never considered a hazardous test gas—is that right, John?

Mr. WILLIAMS. I think that is correct.

Mr. RYAN. Paragraph 5 states, "Apollo procedure submittals had been very delinquent in meeting the 30-day time requirement. The late submittal of procedures has been brought to the attention of North American Spacecraft Operations in various meetings and correspondence. Some procedures have been submitted with as little as 2 days' allowable safety review time."

Is that correspondence and are summaries of those meetings available for us?

Colonel BORMAN. I am sure they are. We do not have them here.

(The information referred to follows:)

Chief, Test and Operations Management Office, KE
Chief, Safety Office, RE
Operations Checkout Procedures for KSC Safety Review

1. Review of NAA S/C 017 OCP status dated September 16, 1966, indicates that the allowable time between OCP publication and test date is only 6 days.

2. KSC Safety has repeatedly requested 30 days for review of procedures, but to date, a workable solution has not been established to assure our receiving the procedures by the required date.

3. The present schedule for S/C 017 OCP publication is not acceptable to KSC Safety. RE-1 must have a minimum of 14 working days to give the procedures proper review.

4. RE requests that your office initiate action to eliminate the aforementioned problem.

JOHN R. ATKINS.

Mr. J. Simmons, SCO-63
Chief, Operations Safety Branch, QAS-23
OCP-PO-K4620, GO_2 Servicing System Test, and OCP-PO-K-4621, GH_2 Servicing System Test

1. Subject procedures were received on the morning of May 2, 1966, with the cover letter stating that the tests were scheduled for May 2 and 4, 1966.

2. It is not normal for this office to approve a flimsy copy of the checkout procedures. We can make comments on flimsy copies, but it appears that most procedures are changed before they are published in the hardback copy.

3. The two subject procedures do not have a NASA Systems Engineer's signature, so we must assume that the NASA Systems Engineers do not approve the procedures.

4. By receiving these procedures with only one day to review them, this office cannot review them properly.

5. These two procedures will not be reviewed nor approved until a NASA Systems Engineer's signature has been affixed.

6. Further flimsy copies of any procedure will not be approved by this office. We will submit comments only to flimsy copies.

7. These two tests do not have KSC Safety approval at this time, and KSC Safety will not condone the running of these tests with GO_2 and GH_2 in the MSO until we have received and reviewed the proper procedure.

JOHN. T. McGOUGH.

Chief, Safety Division, QAS–2
Manager, Apollo CSM Operations, SCO–8
Transmittal of Apollo S/C 011 Technical Information
Ref: Your memo dated April 26, 1966, same subject

1. Based upon the information contained in the referenced memo, NAA was requested to prepare a package showing documents anticipated submittal date.

2. NAA's response is enclosed. It should be noted that in most cases the scheduled transmittal dates do not comply with the 30-day pre-test safety review requirement. It should be further noted that most of these cases concern documents previously approved for S/C 009 and that the content is virtually identical.

3. Due to the advanced schedule that has been initiated for S/C 011, it is our feeling that the dates presented by the contractor in the enclosure represent the "best possible" and can not be improved.

4. If these dates are not satisfactory then the utilization of filmsy or advance copies for KSC and ETORS safety reviews must be reconsidered.

5. If this is unacceptable, QAS should contact PPR and negotiate the resulting S/V schedule impact.

6. This office will insure delivery of the documents to KSC Safety at the earliest possible date.

GEORGE T. SASSEEN.

MAY 9, 1966.

John F. Kennedy Space Center
National Aeronautics and Space Administration
Kennedy Space Center, Florida
Attention Manager, Apollo CSM Operations (SCO–8)
Contract NAS 9–150, Safety Significant OCP's of Transmittal of

In order that the current status of safety significant documentation submittal for CSM 011 may be more fully understood, enclosures (1) through (5) are submitted for your attention. It should be noted that the only areas where NAA has not met the full 30 day safety review requirements are a limited number of OCP's as can be identified from enclosure (3). The under-support of the 30 day safety review is primarily a result of a facility ORD compression of 14 days and compression of the launch schedule. You are assured that NAA is making a determined effort to recover as much of the 30 day review time as possible and will continue this effort.

It may be to the advantage of the KSC Safety Office to reconsider its position of not reviewing advanced copies of OCP's in respect to those OCP's showing under-support. An advanced review in combination with the complete file of specifications and drawings, currently in possession of KSC Safety Office, plus the knowledge that in most instances the OCP is a rerun of S/C 009 procedures, may reduce review time on the final released OCP to a degree that schedule impacts can be avoided.

The NAA Apollo System safety personnel will be most happy to assist in any way possible to support your safety personnel in their reviews of procedures.

NORTH AMERICAN AVIATION, INC.
J. L. PEARCE,
Director, Apollo CSM Operations, Florida Facility, Space and Information Systems Division.

Status of safety significant OCP's for S/C 011

Item	OCP	Date transmitted to NASA safety	Date scheduled for transmittal to NASA safety	Remarks
1	FO-K-0007 countdown		July 30	
2	FO-K-0033 countdown demonstration.		July 12	7 days for safety review, OCP is very similar to S/C 009 0033 except Cryo is used.
3	0034 CSM altitude chamber test		June 2	7 days for safety review.
4	FO-K-0035 combined systems test	May 4		16 days for safety review OCP is very similar to S/C 005 0035 except test is conducted in altitude chamber.
5	FO-K-0038S/C hypergolic loading		July 21	7 days for safety review, OCP combines OCP's 4082, 4622, 4624, and 4700 as approved for S/C 009.
6	FO-K-1096 water glycol servicing system test, altitude chamber, MSOB.	Apr. 22		Operation completed.
7	FO-K-1210 water glycol servicing system test, cryogenic test facility.	Apr. 14		Do.
8	FO-K-2016 forward compartment buildup.	Apr. 22		Do.
9	FO-K-3045 LES buildup	Apr. 14		Do.
10	FO-K-3060 C/M, S/M, CSM or SLA transportation and handling.	do		Do.
11	FO-M-3071 C/M-B/M mate	do		30 days for safety review.
12	FO-K-3071A C/M-S/M mate	May 6		7 days for safety review. This is an "A" revision to the basic which has had the full 30-day review period.
13	FO-K-3112 LES/DPC to C/M date/demate and thrust vector alinement verification.	Apr. 14		30 days plus for safety review.
14	FO-K-3113 C/M LES weight and balance and thrust vector alinement.	Mar.		Do.
15	FO-K-3116 CSM/SLA mating	Apr. 14		Do.
16	FO-K-3117 S/C transportation to pad and mate.	Apr. 22		Do.
17	FO-K-4058 electro explosive devices receiving inspection, storage and preinstallation checkout.	Apr. 14		Operation completed.
18	FO-K-4065 LES motor receiving, inspection, storage, and handling.	do		Do.
19	FO-K-4066 pitch control motor, receiving inspection, storage and handling.	do		Do.
20	FO-K-4067 jettison motor receiving, inspection, storage, and handling.	do		Do.
21	FO-K-4070 C/M RCS functional and leak test.	Apr.		OCP approved by KSC safety.
22	FO-K-4072 S/M RCS quad leak and functional test.	Apr. 22		Do.
23	FO-K-4074 SPS functional and leak test.	Apr.		Do.
24	FO-K-4079 SLA ordnance installation and removal.	Apr. 14		30 days plus for safety review.
25	FO-K-4082 propulsion pad functional test.		do	7 days for safety review very similar to OCP 4074 as approved by KSC safety also was used on S/C 009, all specifications and drawings have been approved.
26	FO-K-4086 SPS fuel servicing system test, manual control, LC 34.	Apr. 27		16 days for safety review similar to procedure used on S/C 009, all specifications and drawings have been approved.
27	FO-K-4089 SPS ovidizer servicing system test, manual control, LC 34.	May 3		14 days for safety review, similar to procedures used on S/C 009, all specifications and drawings have been approved.
28	FO-K-4231 S/A SIM RCS fuel servicing test, manual control, LC 34.		May 13	7 days for safety review, similar to procedure used on S/C 009, all specifications and drawings have been approved.
29	FO-K-4237 S/M RCS oxidizer servicing system test, manual control LC 34.		May 18	7 days for safety review, similar to OCP used on S/C 009, all specifications and drawings have been approved.
30	FO-K-4243 helium servicing system test, manual control, LC 34.	Apr. 30		10 days for safety review similar to OCP used on S/C 009, all specifications and drawings have been approved.

Status of safety significant OCP's for S/C 011—Continued

Item	OCP	Date transmitted to NASA safety	Date scheduled for transmittal to NASA safety	Remarks
31	FO-K-4249 LO_2 servicing system test, manual control, LC 34.	.....	May 23	8 days for safety review, all specifications and drawings have been approved.
32	FO-K-4252 LH_2 servicing system test, manual control LC 34.	.....	May 31	Do.
33	FO-K-4254 fuel servicing system test, propulsion test complex.	Mar. 1	.....	Operation completed.
34	FO-K-4601 oxidizer servicing system test, propulsion test complex.	March	.....	Do.
35	FO-K-4602 pressurization servicing systems test, propulsion test complex.	March	.....	Do.
36	FO-K-4615 fuel cell and cryo servicing cryogenic test facility.	May 3	.....	OCP approved by KSC safety.
37	FO-K-4616 cryogenic storage system verification, cryogenic test facility.	Apr. 29	.....	Do.
38	FO-K-4617 SC ordnance installation and removal.	.....	July 8	7 days for safety review, similar to OCP used on S/C 009; specifications and drawings have been approved.
39	FO-K-4618 LM_2 servicing system test, manual control, cryogenic test facility.	Apr. 14	.....	Operation completed.
40	FO-K-4619 LO_2 servicing system test, manual control, crygoenic test facility.	...do....	.....	Do.
41	FO-K-4622 SPS tanking/detanking LC 34, section 1, ACE control; section 2, manual control.	.....	July 21	7 days for safety review, same as approved for S/C 009; all specifications and drawings have been approved.
42	FO-K-4624 C/M RCS tanking/detanking LC 34, section 1, ACE control; section 2, manual control.	.....	...do....	Do.
43	FO-K-4700 S/M RCS tanking/detanking LC 34, section 1, ACE control; section 2, manual control.	.....	...do....	Do
44	FO-K-4736 fuel cell cryogenic servicing, LC 34.	.....	July 12	7 days for safety review, OCP is almost identical to OCP 4615 which is approved by KSC safety.
45	FO-K-4738 pyro verification test	.....	May 20	30 days plus for safety review.
46	FO-K-4741 fuel cell servicing, LC-34.	.....	June 9	7 days for safety review, OCP is almost identical to OCP 4615 which is approved by KSC safety.
47	FO-K-8227A S/M RCS quantity gaging system calibration.	Apr. 22	.....	30 days plus for safety review.
48	FO-K-8236 gas chromatograph analysis system and checkout PIA.	.....	May 11	7 days for safety review, complete package; specification drawings and manual has been approved by KSC safety.
49	FO-K-9179A LH_2 transfer unit (S14-026).	Apr. 11	.....	OCP approved by KSC safety.
50	FO-K-9180A LO_2 transfer unit (S14-032).	...do....	.....	Do.
51	FO-K-9187A LO_2 mobile storage unit (S14-065).	...do....	.....	Do.
52	FO-K-9188B LM_2 mobile storage unit (S14-066).	...do....	.....	Do.
53	FO-K-9882 ground equipment loading RCS propellant unit (S14-057) hypergolic test facility and launch complexes.	.....	.....	Safety review not required for S/C 011 per agreement with KSC safety; same as OCP approved for S/C 009.
54	FO-K-9883 ground equipment loading RCS propellant unit (S14-063) hypergolic test facility and launch complexes.	.....	.....	Do.
55	FO-K-9885 loading and unloading SPS propellant unit (S14-059) for propulsion test complex and launch complexes.	Apr. 14	.....	30 days plus for safety review.
56	FC-K-9886 loading and unloading SPS propellant unit (S14-058) for propulsion test complex and launch complexes.	...do....	.....	Do.
57	FO-K-10004 SC installations and removals.	May 3	.....	8 days for safety review very similar to OCP approved for S/C 009.

Subject: Apollo S/C 017 OCP Safety Review

NORTH AMERICAN AVIATION, INC.,
Manned Spacecraft Operations Building,
Kennedy Space Center, Florida.

Attention: Mr. J. L. Pearce

GENTLEMEN: The following listed Apollo S/C 017 OCP's are requested for KSC and Range Safety approval:

OCP No.	*Title*
0005	Integrated Test with Launch Vehicle Simulator
0007	Countdown
0033	Countdown Demonstration
0038	S/C Hypergolic Loading
3112	LES/BPC to C/M Mate/Demate & Thurst Vector Alignment Verification
3116	S/C Transportation to VAB and Mate
4070	C/M RCS Functional and Leak Test
4074	SPS Functional and Leak Test
4617	S/C Ordnance Installation and Removal
4736	Fuel Cell Cryogenic Servicing, LC–39
4747	Propulsion GSE Leak Check
K–5114	Water Glycol Servicing System Test, VAB
K–4720	Helium Servicing System Test, ACE Control, MSS
K–4721	Helium Servicing System Test, Manual Control, MSS
K–4723	SPS Fuel Servicing System Test, Manual Control, MSS
K–4725	C/M RCS Fuel Servicing System Test, Manual Control, MSS
K–4727	SPS Oxidizer Servicing System Test, Manual Control, MSS
K–4729	S/M RCS Fuel Servicing System Test, Manual Control, MSS
K–4731	CSM RCS Oxidizer Servicing System Test, Manual Control, MSS
K–4732	LH_2 Servicing System Test, ACE Control, MSS
K–4733	LH_2 Servicing System Test, Manual Control, MSS
K–4734	LO_2 Servicing System Test, ACE Control, MSS
K–4735	LO_2 Servicing System Test, Manual Control, MSS
K–9187	LO_2 Mobile Storage Unit (S14–065)
K–9188	LH_2 Mobile Storage Unit (S14–066)
K–9885	Loading and Unloading SPS Propellant Unit (S14–059) for Propulsion Test Complex and Launch Complexes
K–9886	Loading and Unloading SPS Propellant Unit (S14–058) for Propulsion Test Complex and Launch Complexes
K–9941	Calibration of Propellant Mass Measuring System Using Oxidizer
K–9942	Calibration of Propellant Mass Measuring System Using Fuel
K–10027	GSE Evacuation and Reinstallation—LC–39, Pad A

The following listed Apollo S/C 017 OCP's are required for KSC Safety information and update:

OCP No.	*Title*
3045	LES Build-up
3071	C/M–S/M Mate
3116	CSM/SLA Mating
4058	Electro Explosive Devices Receiving, Inspection, Storage and Pre-installation Checkout
4072	S/M RCS Functional and Leak Test
4079	SLA Ordnance Installation and Removal
4738	Pyro Verification Test

The North American Aviation, Inc. S/C 017 OCP status dated September 16, 1966, shows six (6) days between OCP publication and test date. This schedule is not acceptable to KSC Safety. For proper review of tests conducted at KSC, KSC Safety will require a minimum of fifteen (15) working days.

It is requested that NAA initiate action to assure KSC/SCO that the above listed procedures required for Safety approval be submitted with sufficient time for proper Safety review.

Your cooperation is appreciated.

Sincerely yours,

ERNEST N. SIZEMORE,
Chief, Planning and Technical Support Office.

Date: September 30, 1966
Requirements & Analysis Branch, KG–1
Chief, Operations Safety Branch, RE–1
Apollo S/C 017 OCP Request for KSC Safety Review

1. Please submit the attached list (Encl. #1) of Operations Checkout Procedures to KSC Safety for review and approval. Encl. #2 contains a list of OCPs which RE–1 requires for update.

2. Review of NAA S/C 017 OCP Status dated September 16, 1966, indicates that the allowable time between OCP publication and test date is only 6 days. KSC Safety has repeatedly asked for 30 days for review of procedures, but a workable solution has not been established to get these procedures to us by the required date.

3. The present schedule for S/C 017 OCP publication is not acceptable to KSC Safety. RE–1 must have a minimum of 14 working days to give the procedures proper review. Request your office initiate action to get these procedures to RE–1 with sufficient time allowed for proper Safety review.

JOHN T. MCGOUGH.

OCPs FOR KSC SAFETY REVIEW AND APPROVAL

OCP No.	*OCP title*
0005	Integrated Test with Launch Vehicle Simulator
0007	Countdown
0033	Countdown Demonstration
0038	S/C Hypergolic Loading
3112	LES/BPC To C/M Mate/Demate and Thrust Vector Alignment Verification
3116	S/C Transportation to VAB and Mate
4070	C/M RSC Functional and Leak Test
4074	SPS Functional and Leak Test
4617	S/C Ordnance Installation and Removal
4736	Fuel Cell Cryogenic Servicing, LC–39
4747	Propulsion GSE Leak Check
K–5114	Water Glycol Servicing System Test, VAB
K–4720	Helium Servicing System Test, ACE Control, MSS
K–4721	Helium Servicing System Test, Manual Control, MSS
K–4723	SPS Fuel Servicing System Test, Manual Control, MSS
K–4725	C/M RCS Fuel Servicing System Test, Manual Control, MSS
K–4727	SPS Oxidizer Servicing System Test, Manual Control, MSS
K–4729	S/M RCS Fuel Servicing System Test, Manual Control, MSS
K–4731	CSM RCS Oxidizer Servicing System Test, Manual Control, MSS
K–4732	LH_2 Servicing System Test, ACE Control, MSS
K–4733	LH_2 Servicing System Test, Manual Control, MSS
K–4734	LO_2 Servicing System Test, ACE Control, MSS
K–4735	LO_2 Servicing System Test, Manual Control, MSS
K–9187	LO_2 Mobile Storage Unit (S14–065)
K–9188	LH_2 Mobile Storage Unit (S14–066)
K–9885	Loading and Unloading SPS Propellant Unit (S14–059) for Propulsion Test Complex and Launch Complexes
K–9886	Loading and Unloading SPS Propellant Unit (S14–058) for Propulsion Test Complex and Launch Complexes
K–9941	Calibration of Propellant Mas s Measuring System Using Oxidizer
K–9942	Calibration of Propellant Mass Measuring System Using Fuel
K–10027	GSE Evacuation and Reinstallation LC–39, Pad A

OCPs RE–1 REQUIRES FOR UPDATE

OCP No.	*OCP title*
3045	LES Buildup
3071	C/M–S/M Mate
3116	CSM/SLA Mating
4058	Electro Explosive Devices Receiving, Inspection, Storage and Pre-Installation Checkout
4072	S/M RCS Functional and Leak Test
4079	SLA Ordnance Installation Removal
4738	Pyro Verification Test

Mr. RYAN. Can you describe what efforts were made by the Safety Review Board to require the contractor to submit their plans within 30 days?

Colonel BORMAN. I can say that there were no plans required for this particular test. There was nothing amiss as far as the Safety Review Board goes, because there was no requirement for a safety review of this test.

Mr. RYAN. What does it refer to?

Colonel BORMAN. A hazardous test.

Mr. RYAN. Which hazardous tests were not submitted on time?

Colonel BORMAN. I would have to check.

Mr. RYAN. The Review Board is saying that there had been a failure and that this has been repeatedly brought to the attention of North American.

Colonel BORMAN. That is right.

Mr. RYAN. I would think this would be of interest to the committee. What hazardous tests were not properly submitted to the Review Board?

Colonel BORMAN. We will have to get that information.

Mr. WYDLER. Looking at those four recommendations that you have listed on the screen, what changes would they require in any present NASA authority or North American procedures?

Colonel BORMAN. Pad crew personnel had not been given instruction in emergency opening of the hatches. It would have to be changed; it would have to be implemented.

Mr. WYDLER. If we asked NASA if they were doing those things the day before the accident, they would have said they were doing them all. There isn't anything they wouldn't have admitted they were not doing. They would say they were doing all that, if we asked them, the day before the accident; wouldn't they?

Colonel BORMAN. Yes, sir. It implies more than what they were doing. We want management to monitor and review all tests, not merely just the ones that have been designated as "hazardous."

If you had asked NASA if they were doing it for a hazardous test they would have said "Yes," and they would have answered you truthfully. The difference between a hazardous test and a nonhazardous one resulted in a considerable difference in the approach to the test.

Mr. GURNEY. This finding and these recommendations are certainly worthwhile. As a matter of fact, they probably would not have made any difference in this accident; would they?

Colonel BORMAN. Except for the first one.

Mr. GURNEY. You couldn't avoid this accident with all these in effect, isn't that right?

Colonel BORMAN. Yes, sir.

Mr. RYAN. Before we leave this question, perhaps Dr. Thompson would like to comment on this memorandum. Perhaps he might provide an example of the kind of procedure which was not submitted in advance and about which there was considerable correspondence. See page (d) (7) (57). What is the reference to? "The late submittal procedures have repeatedly been brought to the attention of North American."

Dr. THOMPSON. In (d) (13–10) there is paragraph 7, investigation of methods presently used to identify hazards in document emergency procedures. It is appendix D, panels 12 through 17. It is page 13–10.

"Investigation of methods presently used to identify hazards and document emergency procedures." This matter is discussed in considerable detail in that paragraph.

Mr. RYAN. Can you describe a hazardous test about which the safety office complained because it was not submitted on time?

Dr. THOMPSON. I am not familiar with the specific case referred to; I cannot describe it to you.

Mr. RYAN. Did your Review Board question the author of this No. 5?

Dr. THOMPSON. The panel determined that and tells you about that; the panel wrote this report. They are the ones that spent time in looking into those matters in detail.

Mr. RYAN. Is there anyone present in the room who can answer this question?

Dr. THOMPSON. Not at this time.

Mr. RYAN. Who could?

Colonel BORMAN. The gentleman who wrote that memorandum.

Dr. THOMPSON. Frank, you are not familiar with it.

Colonel BORMAN. I am familiar with the fact that we talked to the man. The only thing we know as far as specific tests were in that memorandum. They did not involve manned flights.

Mr. WILLIAMS. I can give you an example. I don't know if it is in specific correspondence, or so forth. But a test will come up where we will have to pressure a tank. We will know about it 2 days in advance. It is a new requirement. I cannot give specific memoranda he is talking about, but most probably it involves the hypergolic or cryogenic loading on complex 34. We can get you that information.

Mr. RYAN. It would be helpful to have that for the record. It certainly leaves the impression of a major negligence on a number of occasions.

Colonel BORMAN. There was some concern about the people who conducted this investigation being NASA people. The person who signed that document is in the NASA safety office. One of the dangers of asking people to investigate themselves is that they sometimes become overzealous when people who are supposed to respond to them do not do so in the manner that they think is appropriate.

Mr. TEAGUE. We would appreciate having that information furnished for the record.

(The information referred to follows:)

OCTOBER 5, 1966.

Chief, Test and Operations Management Office, KE.
Chief Safety Office, RE.
Operations checkout procedures for KSC safety review.

1. Review of NAA S/C 017 OCP status dated September 16, 1966, indicates that the allowable time between OCP publication and test date is only 6 days.

2. KSC Safety has repeatedly requested 30 days for review of procedures, but to date, a workable solution has not been established to assure our receiving the procedures by the required date.

3. The present schedule for S/C 017 OCP publication is not acceptable to KSC Safety. RE–1 must have a minimum of 14 working days to give the procedures proper review.

4. RE requests that your office initiate action to eliminate the aforementioned problem.

JOHN R. ATKINS.

MAY 2, 1966.

Mr. J. Simmons, SCO–63.
Chief, Operations Safety Branch, QAS–23.
OCP–FO–K–4620, GO_2 Servicing System Test, and OCP–FO–K–4621, GH_2 Servicing System Test.

1. Subject procedures were received on the morning of May 2, 1966, with the cover letter stating that the tests were scheduled for May 2 and 4, 1966.

2. It is not normal for this office to approve a flimsy copy of the checkout procedures. We can make comments on flimsy copies, but it appears that most procedures are changed before they are published in the hardback copy.

3. The two subject procedures do not have a NASA Systems Engineer's signature, so we must assume that the NASA Systems Engineers do not approve the procedures.

4. By receiving these procedures with only one day to review them, this office cannot review them properly.

5. These two procedures will not be reviewed nor approved until a NASA Systems Engineer's signature has been affixed.

6. Further flimsy copies of any procedures will not be approved by this office. We will submit comments only to flimsy copies.

7. These two tests do not have KSC Safety approval at this time, and KSC Safety will not condone the running of these tests with GO_2 and GH_2 in the MSO until we have received and reviewed the proper procedure.

JOHN T. MCGOUGH.

MAY 18, 1966.

Chief, Safety Division, QAS–2.
Manager, Apollo CSM Operations, SCO–8.
Transmittal of Apollo S/C 011 Technical Information.
Reference: Your memo dated April 26, 1966, same subject.

1. Based upon the information contained in the referenced memo, NAA was requested to prepare a package showing documents anticipated submittal date.

2. NAA's response is enclosed. It should be noted that in most cases the scheduled transmittal dates do not comply with the 30-day pre-test safety review requirement. It should be further noted that most of these cases concern documents previously approved for S/C 009 and that the content is virtually identical.

3. Due to the advanced schedule that has been initiated for S/C 011, it is our feeling that the dates presented by the contractor in the enclosure represent the "best possible" and can not be improved.

4. If these dates are not satisfactory then the utilization of flimsey or advance copies for KSC and ETORS safety reviews must be reconsidered.

5. If this is unacceptable, QAS should contact PPR and negotiate the resulting S/V schedule impact.

6. This office will insure delivery of the documents to KSC Safety at the earliest possible date.

GEORGE T. SASSEEN.

MAY 9, 1966.

John F. Kennedy Space Center,
National Aeronautics and Space Administration,
Kennedy Space Center, Fla.
(Attention Manager, Apollo CSM Operations (SCO–8)).

CONTRACT NAS 9–150, SAFETY SIGNIFICANT OCP'S, STATUS OF TRANSMITTAL OF

In order that the current status of safety significant documentation submittal for CSM 011 may be more fully understood, enclosures (1) through (5) are submitted for your attention. It should be noted that the only areas where NAA has not met the full 30 day safety review requirements are a limited number of OCP's as can be identified from enclosure (3). The under-support of the 30 day safety review is primarily a result of a facility ORD compression of 14 days and compression of the launch schedule. You are assured that MAA is making a

determined effort to recover as much of the 30 day review time as possible and will continue this effort.

It may be to the advantage of the KSC Safety Office to reconsider its position of not reviewing advanced copies of the OCP's in respect to those OCP's showing under-support. An advanced review in combination with the complete file of specifications and drawings, currently in possession of KSC Safety Office, plus the knowledge that in most instances the OCP is a rerun of S/C 009 procedures, may reduce review time on the final released OCP to a degree that schedule impacts can be avoided.

The NAA Apollo Systems Safety personnel will be most happy to assist in any way possible to support your safety personnel in their reviews of procedures.

J. L. PEARCE, NORTH AMERICAN AVIATION, INC.,
Director, Apollo CSM Operations, Florida Facility, Space and Information Systems Divisions.

Status of safety significant OCP's for S/C 011

Item and OCP	Date transmitted to NASA safety	Date scheduled for transmittal to NASA safety	Remarks
1. FO-K-0007 countdown		July 30	
2. FO-K-0033 countdown demonstration		July 12	7 days for safety review, OCP is very similar to S/C 005 0033 except Cryo is used.
3. 0034 CSM altitude chamber test		June 2	7 days for safety review.
4. FO-K-0035 combined systems test	May 4		16 days for safety review. OCP is very similar to S/C 005 0035 except test is conducted in alt. chbr.
5. FO-K-0038S/C hypergolic loading		July 21	7 days for safety review; OCP combines OCP's 4082, 4622, 4624, and 4700 as approved for S/C 009.
6. FO-K-1056 water glycol servicing system test, altitude chamber, B808	Apr. 22		Operation completed.
7. FO-K-1210 water glycol servicing system test, cryogenic test facility	Apr. 14		Do.
8. FO-K-2016 forward compartment buildup	Apr. 22		Do.
9. FO-K-3045 LES buildup	Apr. 14		Do.
10. FO-K-3065 C/M, S/M, CSM, or SLA transportation and handling	do		Do.
11. FO-K-3071 C/M—S/M Mate	do		30 days for safety review.
12. FO-K-3071A C/M—S/M Mate	May 6		7 days for safety review. This is an "A" revision to the basic which has had the full 30-day review period.
13. FO-K-3112 LBS/BPD to C/M date/demate and thrust vector alinement verification.	Apr. 14		30 days plus for safety review.
14. FO-K-3113 C/M LES weight and balance and thrust vector alinement	(1)		Do.
15. FO-K-3116 CSM/SLA Mating	Apr. 14		Do.
16. FO-K-3117 S/C transportation to pad and mate	Apr. 22		Do.
17. FO-K-4058 electro explosive devices receiving inspection, storage, and pre-installation checkout.	Apr. 14		Operation completed.
18. FO-K-4065 LES motor receiving, inspection, storage, and handling	Apr. 14		Do.
19. FO-K-4066 pitch control motor, receiving, inspection, storage, and handling	do		Do.
20. FO-K-4067 jettison motor receiving, inspection, storage, and handling	do		Do.
21. FO-K-4070 C/M RCS functional and leak test	(2)		OCP approved by KSC safety.
22. FO-K-4072 S/M RCS quad leak and functional test	Apr. 22		Do.
23. FO-K-4074 SPS functional and leak test	(2)		Do.
24. FO-K-4079 SLA ordnance installation and removal	Apr. 14		30 days plus for safety review.
25. FO-K-4082 propulsion pad functional test		July 21	7 days for safety review very similar to OCP 4074 as approved by KSC safety also was used on S/C 009. all specifications and drawings have been approved.
26. FO-K-4086 SPS fuel servicing system test, manual control, LC 34	Apr. 27		16 days for safety review similar to procedure used on S/C 009, all specifications and drawings have been approved.
27. FO-K-4089 SPS oxidizer servicing system test, manual control, LC 34	May 3		14 days for safety review, similar to procedures used on S/C 009. all specifications and drawings have been approved.

28. FO-K-4231-S/A SIM RCS fuel servicing test, manual control, LC 34	----------	May 13	7 days for safety review, similar to procedure used on S/C 009, all specifications and drawings have been approved.
29. FO-K-4237 S/M RCS oxidizer servicing system test, manual control, LC 34	----------	May 18	7 days for safety review, similar to OCP used on S/C 009, all specifications and drawings have been approved.
30. FO-K-4243 helium servicing system test, manual control, LC 34	Apr. 30	----------	10 days for safety review similar to OCP used on S/C 009, all specifications and drawings have been approved.
31. FO-K-4249 LO_2 servicing system test, manual control. LC 34	----------	May 23	8 days for safety review, all specifications and drawings have been approved.
32. FO-K-4252 LH_2 servicing system test, manual control, LC 34	----------	May 31	Do.
33. FO-K-4254 fuel servicing system test, propulsion test complex	(1)	----------	Operation completed.
34. FO-K-4601 oxidizer servicing system test, propulsion test complex	(1)	----------	Do.
35. FO-K-4602 pressurization servicing systems test, propulsion test complex	(1)	----------	Do.
36. FO-K-4615 fuel cell and cryo servicing, cryogenic test facility	May 3	----------	OCP approved by KSC Safety.
37. FO-K-4616 cryogenic storage system verification, cryogenic test facility	Apr. 29	----------	Do.
38. FO-K-4617 SC ordnance installation and removal	----------	July 8	7 days for safety review, similar to OCP used on S/C 009; specifications and drawings have been approved.
39. FO-K-4618 LM_2 servicing system test, manual control, cryogenic test facility.	Apr. 14	----------	Operation completed.
40. FO-K-4619 LO_2 servicing system test, manual control, cryogenic test facility	---do----	----------	Do.
41. FO-K-4622 SPS tanking/detanking LC34: sec. 1, ACE control; sec. 2, manual control.	----------	July 21	7 days for safety review, same as approved for S/C 009; all specifications and drawings have been approved.
42. FO-K-4624 C/M RCS tanking/detanking LC 34: sec. 1, ACE control; sec. 2, manual control.	----------	---do----	Do.
43. FO-K-4700 S/M RCS tanking/detanking LC 34: sec. 1, ACE control, sec. 2, manual control.	----------	---do----	Do.
44. FO-K-4736 fuel cell cryogenic servicing, LC 34	----------	July 12	7 days for safety review, OCP is almost identical to OCP 4615 which is approved by KSC Safety.
45. FO-K-4738 pyro verification test	----------	May 20	30 days plus for safety review.
46. FO-K-4741 fuel cell servicing, LC 34	----------	June 9	7 days for safety review, OCP is almost identical to OCP 4615 which is approved by KSC Safety.
47. FO-K-8227A S/M RCS quantity gaging system calibration	Apr. 22	----------	30 days plus for safety review.
48. FO-K-8236 gas chromatograph analysis system and checkout PIA	----------	May 11	7 days for safety review, complete package; specifications, drawings, and manual has been approved by KSC Safety.
49. FO-K-9179A LH_2 transfer unit (S14-026)	Apr. 11	----------	OCP approved by KSC Safety.
50. FO-K-9180A LO_2 transfer unit (S14-032)	---do----	----------	Do.
51. FO-K-9187A LO_2 mobile storage unit (S14-065)	---do----	----------	Do.
52. FO-K-9188C LM_2 mobile storage unit (S14-066)	---do----	----------	Do.
53. FO-K-9882 ground equipment loading RCS propellant unit (S14-057) hypergolic test facility and launch complexes.	----------	----------	Safety review not required for S/C 011 per agreement with KSC Safety; same as OCP approved for S/C 009.
54. FO-K-9883 ground equipment loading RCS propellant unit (S14-063) hypergolic test facility and launch complexes.	----------	----------	Do.
55. FO-K-9885 loading and unloading SPS propellant unit (S14-099) for propulsion test complex and launch complexes.	Apr. 14	----------	30 days plus for safety review.
56. FO-K-9886 loading and unloading SPC propellant unit (S14-058) for propulsion test complex and launch complexes.	---do----	----------	Do.
57. FO-K-10004 SC installations and removals	May 3	----------	8 days for safety review very similar to OCP approved for S/C 009.

[1] March. [2] April.

Subject: Apollo S/C 017 OCP Safety Review.

NORTH AMERICAN AVIATION, INC.,
Manned Spacecraft Operations Building,
Kennedy Space Center, Fla.
(Attention Mr. J. L. Pearce).

GENTLEMEN: The following listed Apollo S/C 017 OCP's are requested for KSC and Range Safety approval:

OCP No. and Title:

0005 Integrated Test with Launch Vehicle Simulator.
0007 Countdown.
0033 Countdown Demonstration.
0038 S/C Hypergolic Loading.
3112 LES/BPC to C/M Mate/Demate & Thrust Vector Alignment Verification.
3116 S/C Transportation to VAB and Mate.
4070 C/M RCS Functional and Leak Test.
4074 SPS Functional and Leak Test.
4617 S/C Ordnance Installation and Removal.
4736 Fuel Cell Cryogenic Servicing, LC–39.
4747 Propulsion GSE Leak Check.
K–5114 Water Glycol Servicing System Test, VAB.
K–4720 Helium Servicing System Test, ACE Control, MSS.
K–4721 Helium Servicing System Test, Manual Control, MSS.
K–4723 SPS Fuel Servicing System Test, Manual Control, MSS.
K–4725 C/M RCS Fuel Servicing System Test, Manual Control, MSS.
K–4727 SPS Oxidizer Servicing System Test, Manual Control, MSS.
K–4729 S/M RCS Fuel Servicing System Test, Manual Control, MSS.
K–4731 CSM RCS Oxidizer Servicing System Test, Manual Control, MSS.
K–4732 LH_2 Servicing System Test, ACE Control, MSS.
K–4733 LH_2 Servicing System Test, Manual Control, MSS.
K–4734 LO_2 Servicing System Test, ACE Control, MSS.
K–4735 LO_2 Servicing System Test, Manual Control, MSS.
K–9187 LO_2 Mobile Storage Unit (S14–065).
K–9188 LH_2 Mobile Storage Unit (S14–066).
K–9885 Loading and Unloading SPS Propellant Unit (S14–059) for Propulsion Test Complex and Launch Complexes.
K–9886 Loading and Unloading SPS Propellant Unit (S14–058) for Propulsion Test Complex and Launch Complexes.
K–9941 Calibration of Propellant Mass Measuring System Using Oxidizer.
K–9942 Calibration of Propellant Mass Measuring System Using Fuel.
K–10027 GSE Evacuation and Reinstallation—LC–39, Pad A.

The following listed Apollo S/C 017 OCP's are required for KSC Safety information and update:

OCP No. and Title:

3045 LES Build-up.
3071 C/M–S/M Mate.
3116 CSM/SLA Mating.
4058 Electro Explosive Devices Receiving, Inspection, Storage and Preinstallation Checkout.
4072 S/M RCS Functional and Leak Test.
4079 SLA Ordnance Installation and Removal.
4738 Pyro Verification Test.

The North American Aviation, Inc. S/C 017 OCP status dated September 16, 1966, shows six (6) days between OCP publication and test date. This schedule is not acceptable to KSC Safety. For proper review of tests conducted at KSC, KSC Safety will require a minimum of fifteen (15) working days.

It is requested that NAA initiate action to assure KSC/SCO that the above listed procedures required for Safety approval be submitted with sufficient time for proper Safety review.

Your cooperation is appreciated.

Sincerely yours,

ERNEST N. SIZEMORE,
Chief, Planning and Technical Support Office.

MEMORANDUM

SEPTEMBER 30, 1966.

Requirements and Analysis Branch, KG–1.
Chief, Operations Safety Branch, RE–1.
Apollo S/C 017 OCP request for KSC safety review.

1. Please submit the attached list (Encl. #1) of Operations Checkout Procedures to KSC Safety for review and approval. Encl. #2 contains a list of OCPs which RE–1 requires for update.

2. Review of NAA S/C 017 OCP Status dated September 16, 1966, indicates that the allowable time between OCP publication and test date is only 6 days. KSC Safety has repeatedly asked for 30 days for review of procedures, but a workable solution has not been established to get these procedures to us by the required date.

3. The present schedule for S/C 017 OCP publication is not acceptable to KSC Safety. RE–1 must have a minimum of 14 working days to give the procedures proper review. Request your office initiative action to get these procedures to RE–1 with sufficient time allowed for proper Safety review.

JOHN T. MCGOUGH.

OCP'S FOR KSC SAFETY REVIEW AND APPROVAL

OCP No. and title:

0005 Integrated Test with Launch Vehicle Simulator.
0007 Countdown.
0033 Countdown Demonstration.
0038 S/C Hypergolic Loading.
3112 LES/BPC To C/M Mate/Demate and Thrust Vector Alignment Verification.
3116 S/C Transportation to VAB and Mate.
4070 C/M RCS Functional and Leak Test.
4074 SPS Functional and Leak Test.
4617 S/C Ordnance Installation and Removal.
4736 Fuel Cell Cryogenic Servicing, LC–39.
4747 Propulsion GSE Leak Check.
K–5114 Water Glycol Servicing System Test, VAB.
K–4720 Helium Servicing System Test, ACE Control, MSS.
K–4721 Helium Servicing System Test, Manual Control, MSS.
K–4723 SPS Fuel Servicing System Test, Manual Control, MSS.
K–4725 C/M RCS Fuel Servicing System Test, Manual Control, MSS.
K–4727 SPS Oxidizer Servicing System Test, Manual Control, MSS.
K–4729 S/M RCS Fuel Servicing System Test, Manual Control MSS.
K–4731 CSM RCS Oxidizer Servicing System Test, Manual Control, MSS.
K–4732 LH_2 Servicing System Test, ACE Control, MSS.
K–4733 LH_2 Servicing System Test, Manual Control, MSS.
K–4734 LO_2 Servicing System Test, ACE Control, MSS.
K–4735 LO_2 Servicing System Test, Manual Control, MSS.
K–9187 LO_2 Mobile Storage Unit (S14–065).
K–9188 LH_2 Mobile Storage Unit (S14–066).
K–9885 Loading and Unloading SPS Propellant Unit (S14–059) for Propulsion Test Complex and Launch Complexes.
K–9886 Loading and Unloading SPS Propellant Unit (S14–058) for Propulsion Test Complex and Launch Complexes.
K–9941 Calibration of Propellant Mass Measuring System Using Oxidizer.
K–9942 Calibration of Propellant Mass Measuring System Using Fuel.
K–10027 GSE Evacuation and Reinstallation LC–39, Pad A.

OCPS RE–1 REQUIRES FOR UPDATE

OCP No. and title:

3045 LES Buildup.
3071 C/M–S/M Mate.
3116 CSM/SLA Mating.
4058 Electro Explosive Devices Receiving, Inspection, Storage and Pre-Installation Checkout.
4072 S/M RCS Functional and Leak Test.
4079 SLA Ordnance Installation and Removal.
4738 Pyro Verification Test.

Mr. GURNEY. One other question, Colonel, on these safety procedures. Did the Board come up with any recommendation or consider the position of whether in the testing procedures you could detect an electrical mishap or a source of energy increase which would contribute to a fire? I think we touched on this a little bit before. What I am really talking about are those lines we looked at earlier this afternoon that obviously rang a bell if you could recognize them. Are there any recommendations about changing the testing procedures so that this condition might have been recognized or could be recognized in the future?

Colonel BORMAN. Dr. Faget covered that. Any such instrumentation would be prohibitive.

Mr. GURNEY. That was the feeling of the Board in general?

Colonel BORMAN. I believe so. He is the director of engineering development.

Excuse me. I think that is right.

6. Finding:

Frequent interruptions and failures had been experienced in the overall communication system during the operations preceding the accident.

The Board did not feel this contributed to the accident.

We are talking about the ground communication system.

Mr. FULTON. Was that because of loose connections or faulty reception?

Colonel BORMAN. This is a design problem. We changed from a four-wire system in the spacecraft to a two-wire system with vox relays on the ground and the relays were not tuned up properly.

Mr. FULTON. Have the astronauts complained about these failures previously? It would seem to me that communication on any test would be of vital importance.

Colonel BORMAN. We determined the overall communication system was unsatisfactory.

Mr. FULTON. Had they complained about it?

Colonel BORMAN. Not to my knowledge. Several other people in NASA complained about it, but I am not sure that this particular crew did.

Mr. FULTON. Who would they be?

Colonel BORMAN. Mr. Craft had some very strong feelings about the inadequacy of the communication system.

Mr. FULTON. Does not this lead to the safety of the astronauts?

Colonel BORMAN. Yes.

Recommendation, ground communications system be improved to assure reliable communications between all test elements as soon as possible and before the next manned flight.

A detailed design review be conducted on the entire spacecraft communication system.

Mr. DOWNING. It was reported that the astronauts complained of a sour odor in the cabin.

Colonel BORMAN. Yes, sir.

Mr. DOWNING. What was it?

Colonel BORMAN. There was no determination of any gases that could have led to a combustible mixture. We have the analysis sheet. It was what we could expect for normal oxygen.

Mr. DOWNING. What were they complaining about?

Colonel BORMAN. They were complaining about a sour milk odor. We did not identify the specific substance that would have caused that.

Mr. DOWNING. The people who were responsible for checking out odors, were they available?

Colonel BORMAN. Yes, sir.

Mr. DOWNING. Did they have an instrument with them?

Colonel BORMAN. The test was delayed while the sample was taken. The analysis of this sample was negative.

Mr. DOWNING. Thank you.

Colonel BORMAN. Next slide.

Finding: (a) Revisions to the operational checkout procedure for the test were issued at 5:30 p.m., eastern standard time, January 26, 1967—209 pages—and 10 a.m., eastern standard time, January 27, 1967—4 pages.

(b) Differences existed between the ground test procedures and the in-flight check lists.

Mr. FULTON. Whose job was it, in the line of authority in administration, to correlate the ground test procedures and the in-flight check list? If differences exist whose job was it to correlate them?

Colonel BORMAN. It would require coordination between the flight crew operations division of Houston and the test organization at Kennedy.

Mr. FULTON. Was that caused by the difference in location or a difference in time, or was it difference of opinion?

Colonel BORMAN. The difference was primarily caused in that the flight checklists were designed for flight. This test was not a launch and consequently some of the switch positions were not the same as they would be during a flight. This finding is brought in only to point out the fact that we must make sure that the two are compatible and that we are using the same checklist for the particular test.

Mr. FULTON. What is the real point of your paragraph (a)?

Colonel BORMAN. In the determinations and recommendations.

Mr. FULTON. But point out what paragraph a means.

Colonel BORMAN. It means that a test procedure had been issued some time before the test was to be run, someone showed up the night before with 209 pages of changes to the test.

Mr. FULTON. Who is that someone?

Colonel BORMAN. John Williams can best answer that.

Mr. WILLIAMS. It would be the test organization.

Mr. FULTON. Where?

Mr. WILLIAMS. Down at Kennedy.

Mr. FULTON. Who are they under?

Mr. WILLIAMS. Under NASA.

Mr. FULTON. Are they part NASA and part contractor?

Mr. WILLIAMS. That is correct.

Mr. DAVIS. I have a question about the previous slide.

On your communications was that all on 28-volt direct current?

Colonel BORMAN. Again, you have exceeded my particular capability to answer. I will have to defer to someone who knows the details of the communicative system. Is there anyone on the Board who knows?

Mr. DAVIS. I want to know if all communications were conducted over 28 volts direct current?

Colonel BORMAN. No; in addition we were radiating also. I think you will get a full explanation from the program office.

Mr. DAVIS. I was told it was 115 alternating current and 28 volts direct current. Were your communications conducted on 28-volt direct current?

Colonel BORMAN. The power that goes to the communication system was direct current.

Mr. FAGET. The radio link is powered by the 115-volt alternating current.

Mr. DAVIS. What about the microphone that you thought had grounded out?

Mr. FAGET. That operates at a very low voltage direct current.

Mr. DAVIS. It was not 28 volts?

Mr. FAGET. No.

Mr. DAVIS. Didn't you testify that the one example of arcing that you knew about occurred on 28-volt direct current?

Mr. FAGET. The one example of arcing that we showed a picture of, that was 28-volt direct current power.

Mr. DAVIS. Would that be the same as your communication power?

Mr. FAGET. No; that was supplying power to the plus yaw thrustors in the service module.

Mr. GURNEY. Again on the same problem, I think we rushed over it a little too lightly.

What were these overall communication failures?

Colonel BORMAN. Primarily the inability of certain test elements to maintain communication with one another and with the spacecraft.

Mr. GURNEY. Is this the same system that will be used in the spacecraft in flight?

Colonel BORMAN. The main problem was with the ground communication system. The problem for this particular test centered in the ground communication system.

Mr. GURNEY. Were there problems in the communication system which the spacecraft would be dependent upon in space?

Colonel BORMAN. Not to my knowledge, for this test.

Mr. GURNEY. Why is the statement made that the overall communication system was unsatisfactory?

Colonel BORMAN. We should have stated that the overall ground communication system was what the Board found unsatisfactory.

Mr. GURNEY. Why is the Board recommending that a detailed design review be conducted on the entire spacecraft communications system?

Colonel BORMAN. Because the block I spacecraft communication system has gone through an evolution of change which resulted in different functions for various switches. It was a rather complex requirement for the crew to ascertain what communication mode that they were in.

I believe you will find that this requirement has been fulfilled in the block II design. I think you asked me to point this out. I think this has been fulfilled in the block II design, but in our recommendations and our findings we were constrained to report on what we investigated.

Mr. DAVIS. Were the communications between the astronauts and the ground control, or whatever you want to call it, conducted by what you call a land line or on radio frequency?

Colonel BORMAN. Both. During the test it was switched around considerably.

Mr. DAVIS. If I had known that, I wouldn't have asked you about the 28-volt direct current. You are using a redundancy of systems?

Colonel BORMAN. Yes, sir.

Mr. WYDLER. You are not implying there was any connection between the communications direct current efficiencies and the accident, are you?

Colonel BORMAN. No, sir. I pointed that out when I made the recommendation.

I think I have covered this slide. We note there are 209 pages added to the checkout procedure. Much of the material was the same. If you want to change two or three lines, you have to change the whole page. It is more convenient to do that because they are all machine typed. Although the quantity—the actual number of changes were not large, it resulted in a large change in the test procedures and the Board did not consider this desirable.

Next slide. We determined that neither the revision nor the differences contributed to the accident. The late issuance of the revision, however, prevented test personnel from becoming adequately familiar with the test procedure prior to its use.

Mr. FULTON. You mean the personnel was acting without becoming adequately familiar with the test procedure?

Colonel BORMAN. Yes, sir.

Next slide. Recommendations: (a) Test procedures and pilot's checklists that represent the actual command module configuration be published in final form and reviewed early enough to permit adequate preparation and participation of all test organization. (b) Timely distribution of test procedures and major changes be made a constraint to the beginning of any test.

I might point out this is one of the more difficult things to accomplish because we do have a dynamic program and it is very difficult to keep all the inputs from all the different organizations in the paperwork channel and get them out in a timely manner.

Mr. FUQUA. Colonel Borman, what do you think is a reasonable time that a pilot should be informed of these changes before the test?

Colonel BORMAN. Two days, in my opinion.

Mr. FUQUA. Maybe this should be spelled out in the recommendation.

Colonel BORMAN. I was not speaking as a Board member. Maybe I should switch the light on and off as you do. I was speaking as a pilot.

Mr. FULTON. We have seen pictures of this particular crew out in the open from time to time, studying these procedures. Were those procedures that they were studying up to date in every instance as time went on in preparation for this manned space flight? Were they current, so that the men were actually looking at current procedures and not getting a hash of old and new?

Colonel BORMAN. Yes, sir; the things we study are the things for the flight. The test procedures for the ground test you would like to have 2 days before to look over. You don't commit them to memory. The ones that they are studying and the ones you spend the most time on are the in-flight procedures. They were up to date and the crew was primarily responsible for keeping them up to date.

Mr. FULTON. There was not a mixture of old and new, you are sure everything was kept up to date on those revisions?

Colonel BORMAN. As far as I know. I can't speak for the 204 crew, but I can check with the backup crew and find out how they went.

Mr. RUMSFELD. Who is responsible for preparing these procedures and checklists?

Colonel BORMAN. We have a crew that is responsible in conjunction with the contractor.

Mr. RUMSFELD. Is it a NASA group in conjunction with the contractor?

Colonel BORMAN. Yes, sir.

Mr. RUMSFELD. Would these recommendations be for those individuals in that particular group?

Colonel BORMAN. I may have misunderstood. The test flight procedures are the responsibility of the contractor and NASA test organization at the Cape.

Mr. RUMSFELD. It is dual responsibility?

Colonel BORMAN. Yes, sir.

Mr. RUMSFELD. Thank you.

Mr. KARTH. Who determines what a major change is and when it constitutes a major change?

Colonel BORMAN. In my opinion 209 pages is a major change.

Mr. KARTH. How about 109?

Colonel BORMAN. This is a qualitative opinion and the Board was of the opinion for this particular test this was a major change. If I were running a test, I would like to have the test procedure as it was going to be run, with the exception of perhaps minor changes, at least 2 days before the test.

Mr. KARTH. The only purpose of my question is: if you have people disagreeing on what major changes are, you may find the test is taking place a long time before the changes have been evaluated.

Colonel BORMAN. Yes, sir. While the recommendation may seem trivial it is one of the more difficult ones to implement.

Next side. Eight. Finding: The fire in Command Module 012 was subsequently simulated closely by a test fire in a full-scale mockup.

Mr. FULTON. What was the result? You tried to do it in the same way so you would get the same result. Tell us how much of a result you got.

Colonel BORMAN. I defer to Dr. Van Dolah.

Mr. FULTON. We could say, the simulation.

Dr. VAN DOLAH. It is a degree of judgment. The Raschel net has been the most probable area of the ignition.

Mr. FULTON. That was nylon.

Dr. VAN DOLAH. And the pressure trace which is our best indication of an effective simulation very closely simulated that we think occurred in 012. It was equipped with a blowout valve located in the same general vicinity as the break in Command Module 012 and the total rise in pressure and fall, decay of pressure came close—within seconds—of the pressure trace in spacecraft 5.

Mr. FULTON. Are you saying the spacecraft proved to you beyond a reasonable doubt that is the way the fire occurred? Can you give us an estimate of how the simulation affected your judgment on the cause of the original fire?

Dr. VAN DOLAH. We had been talking about the fire origin for several weeks prior to the simulation test.

This test was run last Tuesday.

Mr. FULTON. How do you feel about the original fire?

Dr. VAN DOLAH. It merely confirms our original judgment.

Mr. FULTON. It confirms it beyond a reasonable doubt or with some doubt?

Dr. VAN DOLAH. I suppose there will always be some doubt.

Colonel BORMAN. Next slide. Determination: Full-scale mockup fire tests can be used to give a realistic appraisal of fire risks in flight-configured spacecraft.

As Dr. Thompson pointed out, this is a particular new tool.

Next slide. Here we come to a recommendation poorly worded. We really don't mean we want to burn a spacecraft in flight configuration. We are talking about a mockup in simulated flight configuration to be used to determine the risk of fire.

Mr. GURNEY. In these fire tests of a full-scale mockup, has NASA done any other than the one which they think started this particular fire?

Colonel BORMAN. I think all the tests that have been done on full-scale mockups have been in support of the Board's activities. I would have to say that most of the tests have been done in attempting to determine the cause, the ignition source, and the spread of this particular accident, this particular fire.

Mr. GURNEY. This may not be a fair question to you. I judge from the recommendation, or the finding, whichever it was, that there would be other tests simulating other possible sources of ignition.

Dr. FAGET. The program office people have made, I believe, two other tests in simulated mockups using substitute material. I don't believe the Board should be asked to evaluate those tests because I think the program officers are better able to do that for you.

Colonel BORMAN. They didn't do the tests until after the fire. They were done in attempting to gain experience regarding this particular fire.

What we hope is that when we get a reconfigured spacecraft with the Beta cloth and Teflon, we can place ignition sources in different areas and see whether it will burn.

Next slide.

Mr. FULTON. Should we hold up all further manned space flight tests until we retool the whole capsule and make sure that there are no flammable materials in the capsule? For example, should they all be fiberglass or materials of that nature that might melt? When we were down in Houston and saw those tests run, I didn't need any particular shocker to tell me that when we saw static charges run along a wire like a Fourth of July sparkler in various oxygen atmosphere pressures, that particular wire or cable can't be used. Should we have a complete overhaul and a complete new look? Or should we just reduce the flammable qualities? After seeing some of the equipment at Houston with the chairman and some of the others, it certainly told me that a big look should be taken.

What do you think?

Colonel BORMAN. Dr. Thompson.

Dr. THOMPSON. The matter of material selection is a matter that has received the greatest attention and the panel 8 report covers a

great deal of information that has been obtained from that. There is certainly a great deal of promise in substituting materials within a spacecraft. I doubt that this is a major holdup. I think the advancement in materials is such that the revision of the materials or the replacement and substitution of materials with some improvement in rearrangement offers a very drastic reduction in the fire risk by using the materials that are now available as shown by tests that now can be made.

The advantage that we have now over the situation that prevailed just prior to this accident is that this accident has stimulated this method of evaluating a fire risk and prior to that a fire risk was being evaluated by lab samples, the burning rate of small pieces of materials. This simulation technique has shown that such tests do not take into account the geometry, the way the materials are laid out, the way they are woven and laid out, and therefore can be misleading. This simulation device has been validated in our opinion, and in the opinion of the program office, as a very useful tool for not only establishing the points that are of primary interest to the Board, but as a tool to qualify the vehicle that they will ultimately come up with with materials arranged in such a way that the fire risk will be greatly reduced. We expect the program office to use this as a means of qualifying the selection and arrangement of materials in a future flight.

Mr. FULTON. The testing brings up the question of whether our tremendous commercial airplanes with their oxygen drop-down equipment are safe, if there is such a risk of fire? Are these airplanes safe? Are we going to have something like this happen to 85 passengers?

Dr. THOMPSON. I don't believe there is any absolute safety in anything. It is a matter of relative risk that we are dealing with.

Mr. FULTON. Nobody has done this in regard to airplanes, have they?

Dr. THOMPSON. As far as I know, this type of test is a new development, and I don't know who else would use it.

Mr. WAGGONNER. I would be willing to try if it becomes necessary.

Mr. FULTON. We must see the applications of these tests to other fields. We must have an open mind and not proceed with the case in which we don't recognize a risk exists. I don't look at this as a failure of NASA, I look at this as a chance for new progress.

Colonel BORMAN. Shall I go on?

Mr. TEAGUE. Yes.

Colonel BORMAN. Nine. Finding.

The command module environmental control system design provides a pure oxygen atmosphere.

Determination:

This atmosphere presents severe fire hazards if the amount and location of combustibles in the command module are not restricted and controlled.

I think that it is important that we note here, too, it is not a fire hazard in itself, only if the amounts of combustibles are not controlled and restricted.

Recommendations:

(*a*) The fire safety of the reconfigured command module be established by full-scale mockup tests.

(*b*) Studies of the use of a diluent gas be continued with particular

reference to assessing the problems of gas detection and control and the risk of additional operations that would be required in the use of a two-gas atmosphere.

Mr. WYDLER. This is the recommendation of the Board that bothers me the most.

Colonel BORMAN. Which one?

Mr. WYDLER. This whole of finding No. 9. As I read this, but maybe I read it incorrectly, I interpret this as more or less a permissive statement by the Board to go right ahead with the oxygen system that they are using. Is it intended as that?

Colonel BORMAN. Sir, I think I would have to say that the Board feels that if the flammables and the combustibles within the spacecraft are controlled and restricted, and the new configuration is proven by a full-scale mockup test, they see no reason to change it.

Mr. WYDLER. It creates problems. One of the factors that we can control is the pure oxygen atmosphere itself.

Colonel BORMAN. I don't agree with you at all. If I can put on my other hat briefly, I would much rather fly in a spacecraft with a complete pure oxygen atmosphere that has properly tested—had the materials restricted and controlled and has been proven by a full-scale mockup, than I would attempt to modify the present Apollo design to a two-gas system.

Mr. WYDLER. Are you aware NASA is going to go to a two-gas system in their Apollo program?

Colonel BORMAN. I said in the present command model. I don't oppose it for flights in excess of 30 days.

Mr. WYDLER. What are the advantages of the pure oxygen?

Colonel BORMAN. They have been listed many times. Again I am speaking not as a Board member. One of the advantages I like about a single gas system in the present Apollo spacecraft is that it eliminates the requirement to depressurize the cabin as soon as you get in orbit. If you use a two-gas system on the ground and a one-gas system in orbit you have a requirement to purge the system. I don't like to take a new spacecraft immediately after it is inserted in orbit and expose it to a vacuum. I see no reason to change it provided we prove the reconfigured spacecraft does not present a fire hazard.

Mr. DAVIS. Do you have charts prepared that show ignition temperature and show burning rates?

Colonel BORMAN. Yes, sir; we have voluminous data on this.

Mr. DAVIS. It is based on the fact you feel a spacecraft could be constructed that would be reasonably fireproof?

Colonel BORMAN. I flew one for 14 days. The command module designed for lunar mission does not require more than 14 days' duration.

Mr. DAVIS. I will buy that.

Mr. WYDLER. Colonel, you stated before in your testimony, however, that you had learned something here today. You had learned that there is no such thing as a material that is not combustible. It is a question of degree.

Colonel BORMAN. I didn't state that. It must have been someone else. I said there was no such thing as fireproof, only fire resistant.

Mr. WYDLER. That is right. You know any material will burn.

Colonel BORMAN. I don't think Beta cloth will.

Dr. VAN DOLAH. In oxygen it won't.

Colonel BORMAN. Titanium will react with nitrogen so you see there are gases that are normally inert but that will react with certain materials in a violent manner.

Mr. DAVIS. Your basic inert gases are neon, freon, and one other. They won't burn.

Colonel BORMAN. I wouldn't know.

Mr. TEAGUE. Do you think your feeling about oxygen is shared by most of the astronauts?

Colonel BORMAN. Yes.

Mr. TEAGUE. I was told by Colonel Glenn that he felt that way.

Colonel BORMAN. I got home Friday for the first time in a while, and I ran a canvass and I think most of the people feel that way.

New slide. Ten.

Finding:

Deficiencies existed in command module design, workmanship, and quality control, such as:

(*a*) Components of the environmental control system installed in command module 012 had a history of many removals and of technical difficulties including regulator failures, line failures and environmental control unit failures. The design and installation features of the environmental control unit makes removal or repair difficult.

(*b*) Coolant leakage at solder joints has been a chronic problem.

(*c*) The coolant is both corrosive and combustible.

It is difficult to ignite but it will burn if heated to a high enough temperature.

(*d*) Deficiencies in design, manufacture, installation, rework, and quality control existed in the electrical wiring.

(*e*) No vibration test was made of a complete flight-configured spacecraft.

(*f*) Spacecraft design and operating procedures currently require the disconnecting of electrical connections while powered.

(*g*) No design features for fire protection were incorporated.

Mr. HECHLER. Mr. Chairman?

Mr. TEAGUE. Mr. Hechler.

Mr. HECHLER. Perhaps either you or Mr. Webb might care to comment on this question.

A lot of people have raised the point as to whether or not all of these things mentioned under No. 10 could better have been handled by the previous contractor, McDonnell rather than North American, and I just wondered if perhaps Mr. Webb would care to comment on this question.

Mr. WEBB. Mr. Hechler, I would be very happy to make a comment. When we were determining the method by which the Apollo system would be produced, at the beginning of the work, we examined with considerable care the question of how we should make the procurement. Now, we did in fact go out for a competitive procurement and the previous contractor, McDonnell Aircraft Co., who made Mercury and Gemini, was evaluated in that procurement. The present contractor, North American Aviation was selected as a result of this procurement action with a Source Evaluation Board that had a very great deal of help and had done its work carefully.

Dr. Gilruth was responsible for the Source Evaluation Board; Dr. Dryden, Dr. Seamans and I were unanimous in the selection of the

contractor. I think it is fair to say that the Apollo system is very much more complex than anything we have had.

Some people say from 10 to 20 times more complex. I think it is difficult to speculate that a contractor who had a piece of equipment to fly in near earth orbit and could take a good deal of the plumbing out of the spacecraft and put it in an adaptor section that would never have to reenter the earth could have done a better job. His task must be compared with the Apollo which must reenter the earth at very much higher energy dissipation rates with all of the other equipment intact inside the capsule. I think there is no evidence to support those statements today. The fact is that the people who are looking at the equipment at the cape now and making what I regard in many cases as irresponsible criticisms of it are looking at equipment that was designed not only to fly with three men in the cockpit. It also carries all the other equipment necessary to replace the three men so that we can test the Saturn V booster by sending this equipment out at a high altitude and driving it out in the earth's air so we test the heat shield. This is a difficult operation. A great deal of the equipment is put in by what some member of the committee called this afternoon, "handwork"—it doesn't look like a production module of something where you are going to make some 10,000 items. The test results have indicated that the equipment was ready to do its job. I think that all of us are very anxious to have complete confidence in this equipment when we have to make the decision to push the button and let these rockets fly will have again gone over this whole matter with the very greatest of care.

Second, I would like to point out that as we have to learn to develop equipment where there was no design but where the contractor and NASA had to go through the learning process. We had evolved a Block II design which takes into account many things that are criticized by this Board, in fact most of them that are important. I think you could consider Gemini made by McDonnell as a Block II Mercury made by the same company. We are going through a developmental problem on a very much larger and more complex and difficult system. I wouldn't want to leave you with the impression that I or anyone in the position of responsibility at NASA are satisfied with the work that we have done in NASA through our contracts with McDonnell or North American or the others. Every Gemini flight that we flew, as successful as they were, involved difficulties and troubles. I may say we had a good deal of very deep concern in the emergency recovery of those who made the first linkup and had to come down 500 miles off Japan because of a thruster that was not in good shape. So I would say that you not go back to 1961 if you expect to get ahead of the Russians or get near to them. The work of this Board is pointing to every item that every contractor and subcontractor and every responsible official, technical and administrative official in NASA must consider with the greatest of care. We have a strong determination to do all that is necessary to make things better than they have been. I think we will get that response from all of our contractors.

Mr. TEAGUE. We have this Board before us tonight. We have got Mr. Webb and Dr. Seamans coming back. I like Mr. Webb. He has a wonderful reputation but it is not for short answers. The chairman would like to be as flexible as possible. We have this very important group of men here for about another hour. Let us make our questions to them.

Mr. RUMSFELD. With respect to finding No. 10, particularly A and D, let me ask whether everything in the report is unanimous by your Board. Did the Board make a determination as to whether these findings were the result of poor performance by the contractor NASA or whether it was basic management shortcomings that were the actual causitive agents.

Would you go beyond these specific findings as to what permitted those findings to be the case?

Colonel BORMAN. You have to say that there was a problem in the wire runs and in the wire design, manufacture, and installation on the Block I vehicles. The wire bundles were not constructed using three dimensional jigs. The wire was sometimes subjected to insulation stress. Some of the runs were not properly engineered and designed. The environmental control unit had development problems. We had many cases of problems and design difficulties. We removed and redesigned a regulator in spacecraft 012 while it was at the cape.

I think that these are problems that are inherent in most development programs. We are really talking about two systems, the electrical distribution system and the ECU. The electrical distribution leads to the black boxes, the equipment that is required to guide and control the spacecraft, and we found no evidence of problems within the black boxes. But we did see reasons to criticize and ask for improvements in the design, installation and so on of the wire. We asked for a look at the environmental control unit. There is no reason to believe it was a contributor to the initiation of the fire. It had some insulation that contributed to the severity of the fire.

Mr. RUMSFELD. I wonder if for the benefit of the subcommittee it might be useful if a request was made, separately, of NASA and the Review Board with respect to pages D–1311 of D–1313 of the appendix which I now have and have read.

Colonel BORMAN. I wouldn't want to challenge you if you read the entire appendix.

Mr. RUMSFELD. I said I read those pages—this portion. To have the Board submit to the committee a statement with respect to each one of these findings and determinations numbering 1 through 14, on those 4 pages, some of which led to recommendations in the basic report, indicating who had the responsibility with respect to the finding as made. I know this preliminary thing mentioned some of it, but first trying to pinpoint the responsibility and second, trying to pinpoint who the Board is making the recommendation to, who the Board thinks should in fact undertake to fulfill the recommendation.

Colonel BORMAN. I think 10 does not jibe with this one. You are on a different subject.

Mr. RUMSFELD. No. Somewhat different, but the communications question is in both places. Some result in recommendations that you are now reading.

Colonel BORMAN. I understand.

Mr. RUMSFELD. My request runs to just these three pages.

Mr. TEAGUE. Might the Chair suggest that in our executive session we list the things that we would like further things on and ask the Board to submit it to us.

Mr. RUMSFELD. I am convinced I would like to see that. It might

give us some clue as to what other information we want and what other witnesses it might be appropriate to call.

Mr. TEAGUE. Dr. Thompson, would you care to comment on the questions asked by Mr. Rumsfeld?

Dr. THOMPSON. The Board is reporting to the Administrator.

Mr. RUMSFELD. You are reporting to the congressional committee right now.

Mr. TEAGUE. I am sure they will submit anything we request of them. They have certainly been cooperative in every way, form, and fashion.

Mr. SEAMANS. Dr. Thompson is answering the question you asked. To whom are these recommendations being addressed?

Mr. RUMSFELD. You mean that the recommendations are all going to NASA? The Board did not think in terms of a specific part or office of NASA or of a contractor as to who should undertake the recommendation? Is that your point?

Dr. THOMPSON. We were charged to report to the Administrator.

Mr. RUMSFELD. Then the first half of the request could be revised.

Mr. WYDLER. Would you yield to me?

Mr. RUMSFELD. Yes.

Mr. WYDLER. Take item E, "No vibration test was made of a flight configured spacecraft."

Colonel BORMAN. This was an engineering judgment. The program office was of the opinion that a flight test of two manned vehicles was a sufficient vibration test. With block II there will not be an unmanned flight and the Board feels there should be a flight configuration test.

Mr. WYDLER. Who should have ordered that?

Colonel BORMAN. The Board if it thinks it is required.

Mr. RUMSFELD. The Board should submit information as to who was responsible on pages 1311 to D–1313. By whom was it "not considered" for example?

(Information requested is as follows:)

The organizational elements having primary and secondary responsibilities are identified after each Finding. The term primary responsibility means documented functional responsibility for the efforts involved in either the generation, review or approval of the subject matter treated in the Finding. The term secondary responsibility means an operational or developmental participation which, as a normal function, would require an awareness or surveillance of the subject matter treated in the Finding.

At Manned Spacecraft Center the organizational responsibilities have been defined to the directorate level within the Manned Spacecraft Center. The responsibilities fall into three groups:

1. Generation of procedures.
2. Review or approval of procedures or design.
3. Design of spacecraft or ground systems.

Manned Spacecraft Center, as an organization, had the responsibility for one or more of the three groups only in Findings 1-5 and 7.

At Kennedy Space Center, the organizational responsibilities have been defined to an Office or Division Level. The detailed delineation of areas of responsibility at KSC, it is understood, will be furnished by the Associate Administrator, OMSF. Therefore, to avoid unnecessary duplication, the Offices and Divisions have only been identified as having either primary or secondary responsibility.

At North American Aviation Florida Facility, the organizational responsibilities have been defined to the Department or Office level.

Sincerely yours,

FLOYD L. THOMPSON,
Chairman, Apollo 204 Review Board.

Enclosure.

ENCLOSURE 1

FINDING NO. 1

The applicable test documents and flight crew procedures for the AS–204 Space Vehicle Plugs Out Integrated Test did not include safety considerations, emergency procedures or emergency equipment requirements relative to the possibility of an internal spacecraft fire during the operation.

Manned spacecraft center

1. Apollo Spacecraft Program Office: Review.
2. Flight Crew Operations Directorate: Review.

Kennedy Space Center

Primary Responsibility:

1. The Safety Office of the Directorate of Installation Support (DSIS).
2. The Flight Systems Division of the Directorate of Spacecraft Operations (SCO).

Secondary Responsibility:

1. Test and Operations Office of the Directorate of Launch Operations (DLO).
2. SCO Test and Management Office.

North American Aviation Florida Facility (NAAFF)

Primary Responsibility:

1. NAAFF Command and Service Module (CSM) Safety Office.
2. NAAFF Spacecraft Engineering Department.

Secondary Responsibility:

NAAFF Spacecraft Operations Department.

FINDING NO. 2

There are no documented safety instructions or emergency procedures in existence which are applicable to the possibility of a serious internal spacecraft fire.

Manned spacecraft center

1. Flight Crew Operations Directorate: Generation (flight crew procedures only).
2. Apollo Spacecraft Program Office: Review/Approval.

Kennedy Space Center

Primary Responsibility:

1. DIS Safety Office.
2. SCO Flight Systems Division.

Secondary Responsibility:

1. DLO Test Operations Office.
2. SCO Test and Management Office.

North American Aviation Florida Facility

Primary Responsibility:

1. NAAFF Apollo CSM Safety Office.
2. NAAFF Engineering Office.

Secondary Responsibility:

NAAFF Operations Office.

FINDING NO. 3

The propagation rate of the fire involved in the AS–204 accident was extremely rapid (Reference report by Panel 5). Removal of the three spacecraft hatches to effect emergency egress from either the inside or outside involved a minimum of 40 and 70 seconds respectively under ideal conditions.

Manned Spacecraft Center

1. Apollo Spacecraft Program Office: Determined the acceptability of the spacecraft hatch design.
2. Engineering and Development Directorate: Determined the acceptability of the spacecraft hatch design.
3. Flight Crew Operations Directorate: Determined the acceptability of the spacecraft hatch design.
4. Flight Operations Directorate: Determined the acceptability of the spacecraft hatch design.

Kennedy Space Center

None.

FINDING NO. 4

Procedures for unaided egress from the spacecraft were documented and available. The AS-204 flight crew had participated in a total of eight egress exercises employing those procedures.

Manned Spacecraft Center

1. Flight Crew Operations Directorate: Generation.
2. Flight Operations Directorate: Approval.

Kennedy Space Center

Primary Responsibility:

The Emergency Egress Working Group (EEWG) of the Apollo Launch Operations Committee (ALOC).

The EEWG is comprised of appropriate disciplines from NASA, AFETR, and NAAFF personnel. Chairman of both the EEWG and the ALOC is the Director of Launch Operations, KSC.

FINDING NO. 5

The Apollo Flight Crew Hazardous Egress Procedures Manual contains procedures relative to unaided, aided and incapacitated flight crew egress. By scope and definition, this document is concerned only with evacuation of the flight crew from the spacecraft and the pad under hazardous conditions occurring primarily external to the spacecraft during a launch operation.

Manned Spacecraft Center

Flight Crew Operations Directorate: Generation.

Kennedy Space Center

Primary Responsibility:

Same as for Finding No. 4.

FINDING NO. 6

The spacecraft pad work team on duty at the time of the accident had not been given emergency training drills for combating fires in or around the spacecraft or for emergency crew egress. They were trained and equipped only for a normal hatch removal operation.

Manned Spacecraft Center

None.

Kennedy Spacecraft Center

Primary Responsibility:

1. DIS Safety Office.
2. DLO Test Operations Office.
3. SCO Test and Management Office.

North American Aviation Florida Facility

Primary Responsibility:

1. Apollo CSM Safety Office.
2. Spacecraft Operations Department.
3. Technician Support Department.

FINDING NO. 7

There was no equipment on board the spacecraft designed to detect or extinguish a cabin fire.

Manned Spacecraft Center

1. Engineering and Development Directorate: Determined the acceptability of the design.
2. Flight Crew Operations Directorate: Determined the acceptability of the design.
3. Flight Operations Directorate: Determined the acceptability of the design.

4. Apollo Spacecraft Program Office: Determined the acceptability of the design.

Kennedy Space Center

None.

FINDING NO. 8

Frequent interruptions and failures had been experienced in the overall communications system during the operations preceding the accident. At the time the accident occurred, the status of the system was still under assessment.

Manned Spacecraft Center

Apollo Program Offiice: Review.

Kennedy Space Center

Primary Responsibility:

1. DIS Safety Office.
2. DLO Test Operations Office.
3. SCO Test and Management Office.

North American Aviation Florida Facility

Primary Responsibility:

1. Apollo CSM Safety Office.
2. Operations Office.

North American Aviation Downey

Spacecraft Design Engineering.

Air Force Eastern Test Range

Range Safety Division.

FINDING NO. 9

Emergency equipment provided at the spacecraft work levels consisted of portable CO_2 fire extinguishers, Rocket Propellant Fuel Handler's Gas Masks and 1¼-inch diameter fire hoses.

Manned Spacecraft Center

None.

Kennedy Space Center

Primary Responsibility:

1. Safety Office of the Directorate of Installation Support (DIS).
2. Test and Operations Office of the Directorate of Launch Operations (DLO).
3. Test and Management Office of the Directorate of Spacecraft Operations (SCO).

North American Aviation Florida Facility

1. Apollo CSM Safety Office
2. Operations Office

Air Force Eastern Test Range

Range Safety Division.

FINDING NO. 10

There are steps and doorways on the Launch Complex 34 Apollo Access Arm and in the environmental enclosure (White Room) which constitute safety hazards, particularly under emergency conditions.

Manned Spacecraft Center

Apollo Spacecraft Program Office: Review.

Kennedy Space Center

Primary Responsibility:

1. Emergency Egress Working Group.
2. DIS Safety Office.
3. DLO Test Operations Office.
4. SCO Test and Management Office.

North American Aviation Florida Facility

1. Apollo CSM Safety Office.
2. Operations Office.

Air Force Eastern Test Range

Range Safety Division

FINDING NO. 11

During the preparation of S/C test procedures at KSC, safety considerations for hazardous operations and documentation of applicable emergency procedures are limited in most cases to routine safety reference notations and emergency power-down instructions.

Manned Spacecraft Center

None.

Kennedy Space Center

Primary Responsibility:

1. DIS Safety Office.
2. SCO Test and Management Office.

North American Aviation Florida Facility

1. Spacecraft Engineering and Operations Departments.
2. Apollo CSM Safety Office.

FINDING NO. 12

Under the existing method of test procedure processing at KSC, the cognizant Safety Offices review only those procedures which are noted in the OCP outline as involving hazards. Official approval by KSC and AFETR Safety is accomplished after the procedure is published and released.

Manned Spacecraft Center

None.

Kennedy Space Center

Primary Responsibility:

DIS Safety Office.

FINDING NO. 13

Criteria for defining hazardous test operations are not complete.

Manned Spacecraft Center

None.

Kennedy Spacecraft Center

Primary Responsibility:

1. DIS Safety Office.
2. Directorate of Spacecraft Operations.

North American Aviation Florida Facility

Spacecraft Management Office.

FINDING NO. 14

Requirements for the review and concurrence of KSC S/C test procedures by MSC are not well defined.

Manned Spacecraft Center

Apollo Program Office.

Kennedy Space Center

Primary Responsibility:

Apollo Program Office.

Mr. WAGGONNER. Did the Mercury program manager ask for and achieve a flight-configured spacecraft flight vibration test before an actual test?

Colonel BORMAN. We did on Gemini. I will have to defer to someone else on Mercury.

Max, did you vibrate Mercury?

Dr. FAGET. Yes.

Mr. WAGGONNER. Was it done in Gemini?

Colonel BORMAN. The only manned flight vehicle that was vibrated was No. 3, the first manned flight vehicle.

Mr. RYAN. May I refer to, in finding No. 10, deficiencies in design?

Colonel BORMAN. Yes, sir.

Mr. RYAN. Who was responsible for the design?

Colonel BORMAN. This was a joint responsibility. Certainly the contractor is responsible for providing an efficient design. NASA has a responsibility for approving that design.

Mr. RYAN. It is a function of procurement.

Colonel BORMAN. That is one of the aspects.

Mr. RYAN. Deficiencies in manufacture, installation, inspection, in quality control—who was responsible?

Colonel BORMAN. Both the contractor and NASA.

Mr. WEBB. May I give a brief answer?

Mr. TEAGUE. Yes.

Mr. WEBB. In the transition from Mercury to Apollo, we decided not to build in Government labs the competence to build detailed design. Instead, we gave the full information to the contractor expecting them to do as much as possible and to try to develop a system where the maximum amount would be done in industrial teams while we kept enough in-house competence to make sure the work was done. There is a shared responsibility but there was a shift between Mercury, Gemini, and Apollo in this regard.

Mr. RYAN. As a result of this shift, we have Finding 10D.

Mr. WEBB. And you have Block II coming along that incorporates a great many of the things that represents the same transition you have from Mercury to Gemini.

It is as if you started out to build another Rayburn Building about three times the size of this and 10 years from now.

Mr. RYAN. It was never intended to fly.

In what kind of atmosphere, I don't know. In any event, should not NASA have inspected and supervised this industry team to a greater extent?

Mr. WEBB. I think this will be explored in considerable detail as you have the contractor tomorrow and have us later. I can't answer that in complete brevity.

Mr. TEAGUE. Direct your questions to the Board.

Mr. RYAN. I directed my question to the Colonel, and Mr. Webb felt he had to supply the answer.

Colonel BORMAN. I think we both gave the same answer.

Mr. GURNEY. Let us go into this a little more. What deficiencies do you mean in quality control? Let us talk about the electrical wiring.

Colonel BORMAN. Improper installation, improper runs; we found cases where wires were supposed to be routed in particular channels and they were not installed in the particular channels. We had cases where the wire bundles were so located that it made removing items behind them extremely difficult.

This is what we mean by poor design of the wire runs.

Mr. GURNEY. My question is directed toward quality control. That, I suppose, is not a matter of manufacture. It is a process of inspection.

Somebody is responsible for seeing that you get quality. What were the deficiencies in quality control?

Colonel BORMAN. I think the problem enumerated in the design led to deficiencies in the electrical distribution system.

Mr. GURNEY. Is that supervised by the manufacturer or NASA?

Colonel BORMAN. Both ways.

Mr. GURNEY. How? Is there a man sitting there to see that it is done right?

Colonel BORMAN. Mr. White is responsible. He can answer it better than I.

Mr. WHITE. The basic responsibility rests with the contractor. NASA has resident inspectors on site and they approve the procedures used by the contractor and do double checking of the inspection by the contractor in certain cases; not in all details, but they do bear the final responsibility.

Mr. GURNEY. Take the electrical wiring. Tell us how it is done. How do you inspect this and make sure you get proper quality control which wasn't obtained? Can you tell us a little bit about it?

Mr. WHITE. Yes.

Basically the inspection process involves comparing the manufactured article with the engineering requirements to be sure that the engineering requirements have been fulfilled.

In the case of the wiring, the engineering criteria, standards for installation of the wiring, were in some cases not complete and the inspectors use their knowledge of accepted practices to determine whether or not the wiring installation was satisfactory.

Mr. GURNEY. Here the deficiency was a lack of guidelines to determine whether it came up to the proper standard?

Mr. WHITE. That is correct.

Mr. GURNEY. Who was responsible for furnishing that?

Mr. WHITE. The basic responsibility rests with the contractor.

Mr. GURNEY. In this case the contractor didn't lay down the standards and NASA didn't follow up?

Mr. WHITE. Yes, sir.

Mr. DOWNING. Baron was a quality-control inspector for North American and he cited numerous irregularities and defects which he tried to point out. Did he report to the NASA quality-control inspector at the plant site?

Mr. WHITE. I really couldn't say. I am not that familiar with Mr. Baron's position.

Mr. TEAGUE. Would the gentleman yield to me?

Mr. DOWNING. Yes.

Mr. TEAGUE. We will have the director of quality control from North American, and we will have their chief of quality control from Cape Kennedy.

Mr. GURNEY. If we can just complete the wiring example, we have gotten as far as a lack of set of standards. Where do we go from there? Were there any deficiencies in quality control of the installation?

Mr. WHITE. Quality people inspect what the manufacturing department has produced. When they didn't have proper criteria against which to evaluate the manufactured article, they used their judgment. When they found something questionable, they would write it up as a squawk, it is a form they use commonly called a "squawk," and bring it to the attention of the engineers.

The engineers would label it acceptable or bring it up to higher authority.

Mr. GURNEY. Did this extend to anything further than the lack of standards?

Mr. WHITE. I think that is the basic problem.

Mr. GURNEY. What other quality-control problems did you find in the spacecraft?

Can you cite us other examples?

Mr. WHITE. There were some slight deficiencies in filling out the necessary paperwork. I would say these were not serious. They were of the nature that you might find in any comparable program. None of the system operates perfectly since there are human beings involved, but I think the lack of standards is the basic problem.

Mr. KARTH. Isn't it true, Mr. White, while quality control is extremely important, in fact a vital component, it is extremely difficult to have good quality control when you have a badly designed product? Quality control is fine when you have specifications that are very strict and rigid and must be met, and can only be met if adequate inspection is made. It seems to me that quality control is extremely difficult to achieve if you have a badly designed product to begin with.

Mr. WHITE. We have to differentiate between "quality control" as a department within a plant, and the quality of the end product. "Quality control" is comparing the final product with the engineering requirements. If the requirements are not satisfactory, the product quality may not be satisfactory.

Mr. KARTH. In this particular instance under 10 it seems that quality control is superfluous. If it is designed poorly, I don't think quality control does anything but makes the poor design poorer.

Mr. WHITE. It allows poor quality to continue to exist.

Mr. GURNEY. Were there then other poor quality-control procedures besides the electrical wiring?

Mr. WHITE. Insofar as the established procedures are concerned, I believe they were adequate. I don't think we found a deficiency in established procedures. There was a lack of rigor in following the procedures. The plan was adequate.

Mr. GURNEY. You think there were poor inspection procedures with individuals not fulfilling their jobs in quality control.

Mr. WHITE. It is a judgment being made on the unconservative side in many cases.

Mr. GURNEY. In the quality-control procedures and inspections, I understand the primary responsibility is with the contractor to lay them out, to lay out his quality-control program and then for NASA to check to see if that was adequate as far as the plan and procedures are concerned.

Mr. WHITE. That is correct.

Mr. GURNEY. Then to check to see if the job is done under the procedure.

Mr. WHITE. That is correct.

Mr. GURNEY. The Board felt all these things were deficient in some respect?

Mr. WHITE. Yes.

Mr. RYAN. On that question, I am concerned about the answer which has been made by several of the witnesses tonight to the effect that the basic responsibility rested with the contractor. It would seem to me that

the ultimate and final responsibility should rest with NASA who, after all, ordered the work done. They had a responsibiilty to see whether or not it was sufficient and adequate.

Mr. WHITE. I would like to correct the impression that I might have left when I used the work "basic." The ultimate responsibility is NASA's.

Mr. RYAN. Do you concede NASA failed in its responsibility to properly inspect the design and manufacture and the installation of the electrical wiring?

Mr. WHITE. Yes, to the extent that the deficiencies remain.

Mr. RYAN. Deficiencies resulted; that is the reason we are all here.

Mr. FULTON. The question comes up as to the procedures that that type of information can get to the astronauts. None of you astronauts knew anything about these deficiencies in workmanship and quality control existing in the command module design, did you?

Colonel BORMAN. Yes, sir. I was a backup crew member for the sister spaceship. Last year I was spending most of my time at Downey going through tests. We realized we had problems, and we expected them, but we thought they had been coped with and that adequate protection was being provided in the development program.

Mr. FULTON. You were unaware that this had occurred; is that not correct?

Colonel BORMAN. What, sir?

Mr. FULTON. Deficiencies existed in the command module design, workmanship and quality control such as (*a*), (*b*), (*c*), (*d*), (*e*), (*f*), and (*g*).

Colonel BORMAN. We were aware they existed. I believe they were being considered and coped with, but obviously we didn't cope with them at all.

Mr. FULTON. The answer is now that after there is a special, careful examination, we can see that they have not been corrected, nor the levels of design of safety or quality control met.

Colonel BORMAN. You are again approaching the idea of an inspector general.

Mr. FULTON. No; I am not.

Mr. WEBB. May I have 30 seconds?

Mr. FULTON. I want to find out the responsibility the astronauts have and what the method of communication is, because I don't want them to be at the end of the rope with no knot.

Colonel BORMAN. The environmental control unit was removed from this spacecraft on the 27th of October and again around the first part of December. The second time it was removed was because five drops of coolant fluid were found on the floor underneath it. Because of this, the environmental control unit was removed and sent back to the contractor.

The people were trying to do their best, but they obviously didn't correct all their deficiencies. There is no question in my mind that the wiring in Spacecraft 12 left much to be desired.

Mr. FULTON. My point is that since that is the fact, No. 1, you astronauts didn't know it; and No. 2, you actually had no means of finding it out on your own initiative.

Colonel BORMAN. This is one of the other things, if I may say about NASA. I have never been excluded from any meetings. We have been

to all the design reviews. We know pretty much the pulse of the spacecraft. It is not of significance that the astronauts didn't know it.

The entire organization didn't realize the essential seriousness or the potential problem. May we hear from Mr. Webb?

Mr. WEBB. If this had not taken place——

Mr. TEAGUE. You have not been recognized. We have about 40 minutes.

Mr. MILLER. Mr. Chairman.

Mr. TEAGUE. Well, let me finish.

We have about 40 minutes. We have some other questions. Before this is over you can talk as long as you want to.

Mr. MILLER. I will save my time for Mr. Webb.

Colonel BORMAN. May we have the next slide?

Mr. GURNEY. Let me ask a couple of questions before we get away from this.

How often do NASA Quality Control people make a thorough inspection of a contractor's operation?

Mr. WHITE. This is done on a continuing basis. Actually a large crew of NASA people in the plant——

Mr. GURNEY. I know there are people right within the plant. I am asking what about a fieldman or supervisor coming around to see that they are doing their job?

Mr. WHITE. There are audits made by the Manned Spacecraft Center people of the contractor's operation.

Mr. GURNEY. How often?

Mr. WHITE. About every 6 months, I believe.

Mr. GURNEY. Is it felt that is not enough?

Mr. WHITE. I don't believe more frequent audits would solve the problem. It is more a matter of correcting the day-to-day operation.

Mr. GURNEY. Is this a thorough audit? Do you have unexpected visitations?

Mr. WHITE. These audits that I mentioned are not unexpected. They are planned and they go into the contractor's operation very deeply.

Mr. GURNEY. If you are expecting something, sometimes you get ready for it; if you are not expecting it, sometimes you don't.

Mr. WHITE. The presence of the NASA people in the daily operation should check adequately on the daily operations.

Mr. GURNEY. Isn't it possible for people working side by side—you know, nobody likes to be regarded as a snooper or too much of a checker-upper—sometimes need to be prodded by somebody else that is a little farther away from the scene?

Mr. WHITE. I admit this possibility exists. However, quality people are by nature snoopers. They are used to being held in contempt by the people they work with.

Mr. GURNEY. They get used to their role.

Mr. WHITE. Yes.

Mr. GURNEY. Suppose a quality control person in North American said, "This wiring isn't good," and the engineer says, "Yes; it is."

What happens at that stage?

Mr. WHITE. Ordinarily the engineer's action would close the item

Mr. GURNEY. Do the engineers override quality control people?

Mr. WHITE. I wouldn't use the word "override." Quality operation is——

Mr. GURNEY. You mean there are trade-offs.

Mr. WHITE. Quality control is assuring that the engineering requirements have been met. If the engineer says they have been met, then quality control backs out and say it is OK.

Mr. GURNEY. Were there any instances where the quality control prevailed instead of the engineer saying it is all right? Did that show up?

Mr. WHITE. Not to my knowledge.

Mr. RYAN. May I ask a question about item No. 10, paragraph (g), "No design features for fire protection were incorporated"?

Colonel BORMAN. Yes, sir.

Mr. RYAN. Did you discover whether or not the possibility of fire had ever been discussed by those who were designing the spacecraft?

Colonel BORMAN. The prime method of extinguishing fires on board in orbit was to depressurize. The method of combating fire was to expose the spacecraft to a vacuum. We had the same problem with Gemini VII where a great deal of time was spent in flight suits, not in pressure suits, so you could not expose a spacecraft to vacuum to extinguish a flame.

The next recommendation is to provide an auxiliary breathing outlet to protect the crew from toxic fumes during the flight.

Mr. RYAN. Was it considered and discarded for any reason, whether for speed or haste?

Colonel BORMAN. Not as far as I know. We did not do it on Gemini VII. We did not consider the risk significant enough to provide the additional means.

Mr. WINN. Speaking of speed and haste, Mr. White, I would like to ask you, in your review of quality control procedures and inspections, did you find any indications of trying to proceed too fast on the part of either NASA or the contractor? You mentioned some forms that were not filled out. What do you attribute that to?

Mr. WHITE. I don't believe that lack of adherence to some of these standard operating procedures was a matter of haste or schedule pressures. It was a matter of overlooking something that should have been done.

Mr. WINN. Would you consider this sloppy workmanship on the part of the inspectors or NASA? If there are forms to be filled out, there must be a reason for this, and you said some——

Mr. WHITE. Apparently a lack of discipline.

Mr. WINN. Who oversees this discipline?

Mr. WHITE. The overseeing, the supervision, is done by the first line supervision of the contractor, but, again, is doublechecked by the NASA quality people on the spot. It is a shared responsibility.

Mr. WINN. If they both don't fill in the forms and nobody calls it to somebody else's attention, then who is the next guy that puts his thumb on it?

Mr. WHITE. It rests first with the NASA quality people on site in the plant. They, in turn, report to the quality people in the Program Office at the Manned Spacecraft Center.

Mr. WINN. Then as I understand it, there was negligence somewhere just on this small part?

Mr. WHITE. Yes; the lack of applying the necessary discipline.

Mr. WINN. Thank you.

Colonel BORMAN. Next slide recommendations:

(*a*) We recommend an in-depth review of all elements, components, and assemblies of the environmental control system to be conducted to assure its functional and structural integrity and to minimize its contribution to fire risk.

(*b*) Present design of soldered joints in plumbing be modified to increase integrity or the joints be replaced with a more structurally reliable configuration.

(*c*) Deleterious effects of coolant leakage and spillage be eliminated.

(*d*) Review of specifications be conducted, three-dimensional jigs be used in manufacture of wire bundles, and rigid inspection at all stages of wiring design, manufacture, and installation be enforced.

(*e*) Vibration tests be conducted of a flight-configured spacecraft.

(*f*) The necessity for electrical connections or disconnections with power on within the crew compartment be eliminated.

(*g*) Investigation be made of the most effective means of controlling and extinguishing a spacecraft fire. Auxiliary breathing oxygen and crew protection from smoke and toxic fumes be provided.

Next slide:

The Board found (11):

An examination of operating practices showed the following examples of problem areas:

(*a*) The number of the open items at the time of shipment of the command module 012 was not known. There were 113 significant engineering orders not accomplished at the time command module 012 was delivered in NASA; 623 engineering orders were released subsequent to delivery. Of these, 22 were recent releases which were not recorded in configuration records at the time of the accident.

(*b*) Established requirements were not followed with regard to the pretest constraints list. The list was not completed and signed by designated contractor and NASA personnel prior to the test, even though oral agreement to proceed was reached.

(*c*) Formulation of and changes to prelaunch test requirements for the Apollo spacecraft program were unresponsive to changing conditions.

(*d*) Noncertified equipment items were installed in the command module at time of test.

(*e*) Discrepancies existed between NAA and NASA MSC specifications regarding inclusion and positioning of flammable materials.

(*f*) The test specification was released in August 1966 and was not updated to include accumulated changes from release date to date of the test.

Mr. WAGGONNER. Colonel, were the NASA astronauts informed or aware, or should they have been made aware of, if they were not, of the findings that you have just described to us in sections (*b*), (*d*), and (*e*)?

Colonel BORMAN. Sections (*b*), (*d*), and (*e*); let us take (*b*) first. I am sure that the flight crew was aware of the fact that the constraint list was not signed. We have representatives at the meetings when the constraints list is gone through. In this particular case an oral agreement was reached, although the formal part was not completed.

(*d*), the crew could not help but be aware of this. As you may well be aware, we try to control the configuration so we reach the

ultimate configuration at the time of launch. We don't go through every test with the spacecraft in the condition in which it will be launched. As an example, we have protective covers around the umbilicals. In this case they were flammable.

Mr. WYDLER. You are criticizing it.

Colonel BORMAN. We overlooked the possibility of a spacecraft fire. As I said before, although I would have been very willing to run this OCP at that particular time, after seeing what happened and realizing the possibility that we have with combustibles, I certainly wouldn't do it now.

Mr. WYDLER. How about paragraph (*e*)?

Colonel BORMAN. The discrepancies that existed between North American and NASA MSC specifications regarding inclusion of and positions of flammable materials. I am not sure that the crew would be aware of it, because of the basic lack of concern or understanding of the hazard of a fire on the ground.

The differences were primarly, in the fact, that NASA's regulations or expectations were more stringent regarding positioning of flammable materials.

Mr. DAVIS. May I ask this question: Any time that you need to make a connection between a component that uses electrical current with a power-on situation, you almost always get arcing. I notice in the previous slides you recommended that that type of situation be avoided.

Colonel BORMAN. It is in Block II.

Mr. DAVIS. How many times did it occur in Block I?

Colonel BORMAN. Every time you removed the communications cable you actually make or break a connection that has power on it. When you unplug or plug in the television you make one. This was not used during this particular test. A television was not powered. These plugs required making or breaking when power was on.

Mr. DAVIS. That was onboard?

Colonel BORMAN. Yes. This has been corrected in Block II.

Mr. DAVIS. Is there a significant difference between making and breaking a connection of 115 alternating current and 28 direct current?

Colonel BORMAN. I don't like to make or break any of them when they have power on them. I don't think it is good practice.

Mr. DAVIS. Is it a big problem? Will it be a big problem in Block II to avoid the necessity of doing it?

Colonel BORMAN. It is already done.

Mr. FULTON. Under paragraph (*f*) it states the test specification was released in August 1966 and was not updated to include accumulated changes from release date to date of the test.

I previously asked you on the pictures of these astronauts going over their material in preparation for these tests whether it was all up to date when they were studying it; was it kept up to date?

I was a bridge officer in World War II, and one of the worst situations we ever got into was a mixture of old and new. Here, under paragraph (*f*) it looks as if there was a mixture of old and new so that some of them were up to date and others were not. How can you operate when everything is not all up to date and everyone not briefed when you come up to a certain point of testing?

Colonel BORMAN. We may be confusing the test specifications with the operational procedure. Test specifications tell you what to expect

from certain instruments and readings. This was not updated. That was poor practice.

Mr. FULTON. When the astronauts are being briefed, they will have to know the capability of the instruments and the components. If they are not briefed in that they ought to know, certainly, it shows examples of not having current practices right up to snuff and up to date.

Going to paragraph (a), I understand in Mercury they sometimes had 900 to 1,000 change orders already passed on them. Is that customary in the development of the program, that so many engineering change orders are already at hand at the time of delivery?

One other point is at the very end that these 22 were recent releases that were not recorded in configuration records at the time of the accident.

It would look as if the material is not up to date, not available and part of it is there and part of it is not. Would you comment on that?

Colonel BORMAN. Yes, sir.

I think the mere numbers of engineering orders are not particularly indicative of an incomplete spacecraft. After all, how many is too many in this case? More significant is the fact that the paperwork at the time was not completely aware of the configuration of the spacecraft. In some cases we didn't know how many were open. The only inference you can draw from it is that the paperwork was not keeping up, in some cases, with the hardware.

Mr. FULTON. The paperwork either means something or else it is behind. The paperwork should go along at the same time so the controls are there. If you comment on the last sentence, 22 were recent releases which were not recorded in the configuration records at the time of the accident.

How do you explain that?

Colonel BORMAN. We were not keeping up with the hardware. John Williams, is that a fair statement?

Mr. WILLIAMS. Twenty-two were released from Downey. It was in the process of being put on the list. It showed up on the next list. It is the serial time required from the release of the engineering order to where it is shown in the records.

Mr. FULTON. Does that mean that the EOS were not available for the personnel or does that mean that the bookkeeping wasn't done in some other place?

Mr. WILLIAMS. It means that it takes a certain amount of time to get the EO's into the system at the Cape. It would point to the fact that EO's were in the system but were not in the records to be worked.

Mr. FULTON. At the time of the test, were all the necessary inputs ready, available and on board with everybody having knowledge of them? Or were part of the records not available, so that the test was run with most of the material available but not all?

Mr. WILLIAMS. As soon as the 22 EO's were put in the configuration record, the next week you would have more. They were released from engineering but not placed in configuration system.

Colonel BORMAN. Mr. Fulton is concerned that this had some effect in the running of the test.

Mr. WILLIAMS. No, sir.

Dr. THOMPSON. This is dealing with a matter that is a little difficult to assess a test. He would be operating to a certain extent on grievances

not all written down but it is on knowledge that he has gained and he is judged to be adequate to proceed. We thought we saw quite a lot of what we call informality. I would say in regard to a test conductor, this is very difficult and I had a head count made to see how many people are actually involved in the operation at the time of this accident. And the figure I obtained was 959 people were actually engaged in the test at the time. I don't think it is too surprising that there was in this flow of information to all the participants some informality or some lack of confirmation. We thought it looked a little excessive. Nobody expected the paperwork to be always perfect. The test conductor has a big army of people. He has a responsibility for proceeding and he has to make some judgments and try to assess the rest. When he is dealing with unknown he may be on a little shaky ground to properly assess those risks.

Mr. FULTON. Are all the factors of input ready and available at the time of test? What kind of a timelag is involved in a failure to meet this deadline? (Mr. Hunt has asked this question.)

Mr. WINN. I asked the question.

Mr. TEAGUE. Mr. Winn asked the question.

Dr. THOMPSON. What did you want to know.

Mr. WINN. I asked a question based on F. Someone said they were put in computers. We found it didn't end up in the manual for the tests.

Mr. WILLIAMS. I was talking about A. I was talking about the 22 recent releases which were not recorded. It takes time.

Mr. WINN. What would the timelag be?

Mr. WILLIAMS. I don't have it, I will get the answer.

(Information requested is as follows:)

The best recorded time for a North American spacecraft engineering order to be received and recorded in the Configuration Verification Record Book is two days after release in Downey. The average time is between five and seven days.

Mr. HECHLER. Mr. Chairman.

Mr. TEAGUE. Mr. Hechler.

Mr. HECHLER. I would like to ask Colonel Borman a quick question about the procedure and attitude of the Board on these deficiencies. I think one of the strongest parts of the reports is that you have been frank and critical about some of those operating practices that need improvement.

Taking this group that you have now on the screen, just how do the members of the Board approach a thing like this. Do some of them have additional things that they feel ought to be added.

Colonel BORMAN. How did we arrive at the final findings, recommendations and so on?

Mr. HECHLER. Are there some members of the Board that would like to add some individual recommendations?

Colonel BORMAN. We have been over them a number of times, but if they have any, I will be happy to yield. We have considered these very carefully. I think we have unanimous agreement on all of them. Is that correct?

Does that answer your question?

Mr. HECHLER. Yes.

Mr. DADDARIO. Colonel Borman, if we might go back to the finding, emergency fire rescue and medical teams were not in attendance, as I recall. The report says that the pad leader came to the ground and

advised the three doctors that the three men were dead. My question goes to the three doctors who were there. Were they there in an official capacity or were they just bystanders? What was their function? What were they to have done? What function did they perform?

Colonel BORMAN. Two doctors were in an official capacity monitoring the crew's biomed recordings in the blockhouse. The other was a Pan American doctor. Two were there. At the time of the alarm.

Mr. DADDARIO. Is the fact that they were in the blockhouse partly explained by what you said previously in answer to some questions that you did not expect this kind of hazard to occur in the space capsule?

Colonel BORMAN. This is their normal duty monitoring in the blockhouse.

Mr. DADDARIO. Because they were in the blockhouse and that far away from the capsule, they were not in a position to give some emergency assistance to these men. They did die of asphyxiation. If they were able to be there immediately, if they were on the platform, they would have, I expect, normally taken the necessary steps to see if they could have revived the three men.

Colonel BORMAN. The normal crew egress team does not include a doctor. The theory is to get the crew as rapidly as possible away from the disaster area to an area where medical support is available.

Mr. DADDARIO. Do you mean by that, in the light of the accident which has occurred and the nature of the circumstances surrounding the death of these men, that you are not now recommending that there be medical men available to immediately apply their medical skills and ability to revive men under these circumstances in the event such a tragedy again occurs?

Colonel BORMAN. I think you will find we recommended that they be available.

Mr. DADDARIO. That is A. When you say available, from what you have just said, the function of these men being a different one, that the men would be taken away as quickly as possible from the scene of the tragedy and brought to another place. Would you still say that would be the recommendation you would make when you say that medical teams would be available or that they would actually be on the platform and able to immediately give medical attention in case it was immediately necessary rather than to have them transported to another site.

Colonel BORMAN. I am not responsible for this in NASA. Perhaps Dr. Berry can answer it. I can say from a particular point here just being available, being on site doesn't put them in a position to render aid. These people are in space suits. They are in a spacecraft and we have specially trained people who are there to get them out. The team does not include doctors.

Mr. DADDARIO. On that point I would disagree with you. I wonder if someone might give me their point of view on that.

Dr. THOMPSON. I don't have a point of view on all procedures. We did not try to redesign, to tell what all the procedures should be. There are other times when hypergolic fuels are there that go beyond the risk of this particular state. At various times various people will have risks. What will be worked out—it goes way beyond what the Board has attempted to do. We are not being very specific just where people have certain capabilities should be, we think there should be a decided improvement in the procedures that are applied to these cases.

Mr. DADDARIO. You did determine that these men died of asphyxiation.

Dr. THOMPSON. Yes.

Mr. DADDARIO. If I understand correctly and I have gone into this question from a medical point of view, men under these conditions, if they receive medical attention within a certain period of time, can and have been revived. I would expect that under these circumstances this would be a normal question for your Board to have asked. What was the condition of the men at this time? Would medical attention have helped them? Would this be a proper procedure to incorporate in your findings and in your recommendations for the future?

Dr. THOMPSON. What I learned about it and not knowing anything about it prior to this, is that medical attention of the right type with the right equipment applied soon enough could have saved the astronauts and all those things have to be tied together. Just the mere presence of a doctor along might not have helped materially. If there is other equipment that he has available to treat the victims properly. he could do things that he couldn't do by himself.

I am getting out of my field because I don't know anything about my subject except this is what I have learned. If you want to go into all the procedures that would be appropriate, I think we really would have to talk to other people. Dr. Berry is here. He is in charge of the medical program for the astronauts but I rather doubt that he has completely, or he may have, I don't know, come up with a plan that is appropriate for all the conditions that will occur.

Mr. DADDARIO. I am not able by any means to come to the conclusion that if a medical man were there he might have been able to apply his abilities to attempt to revive these men. But, my question is properly within the nature of your finding in that you found that when the emergency occurred, medical and rescue teams were not in attendance. I assume your Board has come to the conclusion if they were in attendance they might have been helpful.

Dr. THOMPSON. That is what we understand, if we could have got at the victims much sooner with doctors, we might have saved them.

Mr. DADDARIO. If you had doctors on the pad and if the right kind of equipment was there, as you recommend in your findings, these men could have been saved.

Dr. THOMPSON. If they could have been gotten out soon enough.

Dr. SEAMANS. By the time the hatch was opened the medical team would not have helped?

Dr. THOMPSON. It took too long to get them out of the spacecraft.

Mr. WYDLER. Would the gentleman yield to me?

Mr. DADDARIO. Just one moment.

When you say that, what period of time are you talking about? I don't have it right before me, I think I could check back.

Dr. SEAMANS. I was just asking a question to clarify the point.

Mr. DADDARIO. The figures do not indicate themselves the period of time when men being asphyxiated could not be revived. It was a very chancy proposition that they were or were not within the range where they were capable of being helped.

Mr. MILLER. I suggest that you direct your questions to Dr. Berry. This is a medical question.

Mr. DADDARIO. I would be very happy to, Mr. Chairman. I am undertaking this line of questioning because it seems to me that it falls with-

in the scope of this Board finding, I would be very happy to question Dr. Berry on another day.

Dr. SEAMANS. Dr. Berry is here if you care to have him answer the question.

Mr. DADDARIO. Could you take my question into consideration, come to some judgment upon the effect it would have to be of help in the future in a situation such as this?

Mr. TEAGUE. Dr. Berry, would you want to answer? Will you be here with Dr. Mueller?

Dr. BERRY. Yes.

Mr. TEAGUE. We will take it up then.

Mr. WYDLER. I understand that the rescue team was on the way to the pad at the time of the accident. At what time did they come on duty that day?

Colonel BORMAN. It is listed in the Panel 11 report. The whole time line is in there. Unfortunately, I don't have it committed to memory.

Mr. DADDARIO. It was not a rescue team. It happened to be two doctors who had other duties and who came because of the tragedy. They weren't there for that particular purpose.

Colonel BORMAN. There was a rescue team on the way to practice an emergency egress exercise to be conducted at the end of the test.

Mr. DADDARIO. Was it not the two doctors who were advised by the pad leader that the crew was dead?

Colonel BORMAN. Yes, sir.

Mr. RYAN. May we revert to finding 11 and the statement that there were 113 significant engineering orders not accomplished.

Colonel BORMAN. There were more EO's, some were routine such as making sure initiators were not in the escape tower.

Mr. RYAN. Why were they accepted?

Colonel BORMAN. It does not mean the spacecraft is incomplete.

Mr. RYAN. This says 113 significant orders were not accomplished.

Colonel BORMAN. We classified as significant orders those that involved manufacture or work on a spacecraft as contrasted to routine orders that were to accomplish things like removing pyro's, safing pyro's, and so on.

Mr. RYAN. With hindsight, would you say it was proper to have accepted the spacecraft with those orders unaccomplished?

Colonel BORMAN. This is an area you should discuss with the program management and the people responsible for accepting the spacecraft.

Mr. RYAN. Who is that?

Colonel BORMAN. Dr. Mueller and the Apollo program management.

Mr. RYAN. Was Dr. Mueller aware that these were not accomplished?

Colonel BORMAN. You ought to defer that for Dr. Mueller to answer.

Mr. RYAN. What did the Board find?

Colonel BORMAN. The Board found this. We didn't ask Dr. Mueller. We found the spacecraft had that many open items on it.

Mr. RYAN. How many spacecraft were delivered to NASA?

Colonel BORMAN. This was the first manned spacecraft delivered.

Mr. RYAN. This was the first one delivered to NASA. The paperwork was not up to date enough to show that.

Mr. GURNEY. In the conduct of your investigation I understand you took apart spacecraft 14 in order to see how that worked in order to——

Dr. THOMPSON. We took several of the components out as an exercise in determining how to take them out of the other spacecraft.

Mr. GURNEY. Did you see any deficiencies?

Dr. THOMPSON. Some of the judgment of deficiencies are based on what we found in spacecraft 14.

Mr. GURNEY. The deficiencies insofar as the whole accident have followed through in the other spacecraft as well as the one that the fire occurred in.

Dr. THOMPSON. We were looking at Block I spacecraft. We understand Block II have been greatly improved.

Mr. GURNEY. I am talking about the one you took apart.

Dr. THOMPSON. We were not particularly pleased with the wiring.

Mr. GURNEY. Thank you.

Mr. DAVIS. I would like to address one question to Dr. Berry or anyone else who wants to answer.

It is a fact that if the human body has a choice between carbon monoxide and oxygen, the lung system that goes to keep the blood supplied with oxygen will overwhelmingly take in carbon monoxide, would it not, to the exclusion of oxygen?

Dr. BERRY. That is true. Its affinity for carbon monoxide is up to 210 times that for oxygen.

Mr. DAVIS. On 5–9 it says the combined effect of these environmental factors, that faced the astronauts, increase the lethal effect of any factor by itself. It is estimated that consciousness was lost between 15 to 30 seconds after the first suit failed. Chances of resuscitation decreased rapidly thereafter and were irrevocably lost within 4 minutes. I take it that 4-minute interval is arrived at because that is about as long as the brain could do without oxygen.

Dr. BERRY. That is correct, that tends to be a maximum limit. It was probably shorter than that.

I would like to go into that later.

I would like to make one point while I have the floor one second. In case anyone has any other idea, this crew could not have been saved by the presence of a doctor or anyone else. The situation was such that that was not possible in this instance. I would like to make that very clear.

Mr. DAVIS. That was the purpose in asking my question.

Mr. TEAGUE. Frank, we are going to stop with you and I am going to recognize Mr. Rumsfeld to question Colonel Strang. Then I am going to recognize the Administrator for whatever time he may desire and then we are going to adjourn.

Colonel BORMAN. May I say one thing?

Mr. TEAGUE. Yes.

Colonel BORMAN. Thank you. [Laughter and applause.]

Mr. RUMSFELD. I am impressed with Colonel Borman's responses. Not only were they responsive, but also concise. I would now like to pose a few questions to the other Air Force representative on the panel.

Colonel, you are with the Office of the Inspector General of the Air Force; is that correct?

Colonel STRANG. That is correct.

Mr. RUMSFELD. What is your official title?

Colonel STRANG. Chief of the Missile and Space Safety Division, Directorate of Aerospace Safety for the Air Force Inspector General's Office.

Mr. RUMSFELD. In Washington?

Colonel STRANG. Yes. My duty station is Norton Air Force Base, Calif.

Mr. RUMSFELD. I have been impressed with the report as far as it goes. Mr. Webb's letter, dated February 23, 1967, stated the Board will consider the impact of the accident on all Apollo activities. This is a broad charge. Did the Board examine NASA's safety analysis and review program to your satisfaction?

Colonel STRANG. I would rather answer that in this manner. We did not examine them all.

Mr. RUMSFELD. Was there any discussion as to whether or not they would be examined?

Were you not, as a member of this Board, distressed that these basic questions were not looked into by the Board in view of the charge given you and the other members of this panel?

Colonel STRANG. I personally obtained the Kennedy Space Center safety directives, and went through them myself; the directives from the Safety Office as written satisfied me.

Mr. RUMSFELD. To put that another way, are you saying from your experience in the Air Force, the NASA safety procedures, from a broad standpoint within management, compared favorably with those you have had experience with in the Air Force? They satisfy you as an official in the Office of the AF Inspector General?

Colonel STRANG. Broadly. Their procedures are not in the detail we have in the Air Force. That is possible because they work with a higher scientific group of personnel than that in the Air Force.

I would like to clarify that, if I may.

Mr. RUMSFELD. Maybe we ought to strike it from the record. I know what you mean. Go ahead.

Colonel STRANG. I think when you are dealing with many thousands of airmen compared to the lesser number of engineers and highly qualified technical personnel that NASA has, there is a great difference and greater detail is required.

Mr. RUMSFELD. It appears to me that none of the panels under this Board were charged with that responsibility, so that this review on your part was done purely as an individual?

Colonel STRANG. Yes.

Mr. RUMSFELD. Colonel Borman said nothing was sacrificed for crew safety. I realize this and applaud it, and am delighted to hear it. He said NASA was always receptive to astronauts' suggestions. I am sure this was the case, and knowing Dr. George Mueller, I am sure this would be the case with him because he is an able and dedicated man.

Are you in any position to throw any light on what structural situations in NASA management led to the restricted input that resulted in the so-called hazard evaluation gaps? Have you been able to detect any situation in the NASA structure that is different from the Air Force's or that doesn't compare favorably with the Air Force's that leads you to believe that some changes in structure would help to reduce the hazardous evaluation gap?

Colonel STRANG. I just looked at the Kennedy Space Center. If I had looked over all NASA I would be required to look at NASA headquarters' directives which I was not capable of doing nor was I charged with it.

Mr. RUMSFELD. Did you come to any conclusion as to how NASA overlooked the possibility of spacecraft fire in this test?

Colonel STRANG. No. In our many discussions on this very point, it was brought out that first the contractor, in designing the test and developing the test, has to determine whether or not it is a hazardous operation.

This, then, is reviewed by NASA to make the full determination.

Mr. RUMSFELD. So once you begin with an erroneous assumption you can proceed logically to an equally erroneous conclusion.

Colonel STRANG. Possibly. Once it is determined to be hazardous then it is processed through the Safety Office. They have certain procedures that they implement to make sure that they have the proper personnel available, firefighters, rescue teams, and all other necessary precautions are taken.

Mr. RUMSFELD. Has the Air Force investigated the potential hazards at 17 pounds per square inch with 100 percent oxygen?

Colonel STRANG. None other than at Brooks Air Force Base. That is the only one to my knowledge.

Mr. RUMSFELD. Do you believe in the principle of an inspector general?

Colonel STRANG. Most certainly.

Mr. RUMSFELD. From the experience you have had in past weeks on the Board, do you feel that an inspector general or an independent safety review board could conceivably be of assistance to NASA in reducing this hazard-evaluation gap?

Colonel STRANG. I think so. I don't know.

Mr. WYDLER. Would the gentleman yield to me?

Mr. RUMSFELD. Yes.

Mr. WYDLER. The accident that took place in the Air Force installation in which your employees were involved also took place under similar atmospheric conditions.

Colonel STRANG. Yes, sir; two airmen died in the oxygen chamber, as we call them, and they were doing some various tests. I don't have all the details with me.

Mr. WYDLER. It was a pure-oxygen situation?

Colonel STRANG. Yes.

Colonel BORMAN. 18,000 feet.

Mr. WYDLER. But pure-oxygen atmosphere?

Colonel STRANG. Yes.

Mr. WYDLER. Was that by the Air Force?

Colonel STRANG. By the Air Force.

Mr. WYDLER. Do you know if that work was being done for NASA?

Colonel STRANG. I don't know.

Mr. DADDARIO. Would the gentleman yield?

Mr. RUMSFELD. How did you make the decision that in the face of Mr. Webb's broad charge to your Board you would restrict the Board's study and investigation to the extent that it was restricted and not go into these broader questions that I have been discussing and that apparently no panel was assigned to investigate.

How did that decision come about on your part or on the Board's part?

Maybe I am incorrect, but as I read Mr. Webb's charges they are broad, to consider the impact of the accident on all Apollo activities. It goes to these broader questions that I have been raising.

Dr. THOMPSON. We had a certain urgency on us to arrive at a position in a pretty prompt manner. We worked out panels to discuss or explore all the areas. You have seen, I think, these panel reports. Each one of those work panels had an assigned task. It was written out for it.

Mr. RUMSFELD. Why wasn't this assigned?

Dr. THOMPSON. It is included in seven.

Dr. FAGET. In seven and thirteen.

Mr. RUMSFELD. Only in a very narrow sense. If you read the findings and determinations and recommendations not one of them goes to the substance of what I am discussing.

Dr. THOMPSON. We interpreted it this way and set up the panels according to the interpretation we made. We submitted those to the Administrator, and we got an approval as to the scope of our investigation, and so we assumed that that is about as far as we needed to go. But I don't see how you can say we were so restricted.

The findings of panel 7 go into local controls provided by certain systems we may require remote control for safety reasons—it goes into several matters that pertain to safety.

Mr. RUMSFELD. They didn't find their way into the 11 conclusions and recommendations.

Dr. THOMPSON. We stated it more broadly in our own findings. We did not go into that much detail.

Mr. RUMSFELD. Thank you.

Mr. TEAGUE. Mr. Webb, would you like to be yielded to?

Mr. WEBB. I will be very brief. I will thank the Board at the present time for their work. I do think they have been thorough. I believe this committee will find that the establishment of the Board was sufficiently broad for them to do their work without restriction or without interference from NASA, but rather with the help of NASA and with many people such as those distinguished officers of the Air Force and from the Bureau of Mines. Let me say, secondly, that it would be a grave mistake in my view to read the report of this Board without recognizing that we are dealing with a very large research and development program, no spacecraft that we have ever flown could meet every requirement in detail so far as the layout on paper of every requirement.

We have developed the kind of capability with an industrial team and in our own NASA in-house technical capability to form judgments as to the risk to be taken and in this case, my own view—at least until I have had an opportunity to more fully and completely study the report of this Board is that much of the attention to risk was centered on the very large explosive power of the fueled booster of the Saturn class. We have not yet learned to live with the tremendous explosive power of one of these large boosters. And I believe a great deal of our attention insofar as risk relates to the need to work near to and around the risks of such large concentrations and all the collateral risks have not yet been fully appraised, even with the work of this Board. Either the country is going to take the risks and get on

as we did in Mercury and Gemini, or we will not have a manned space flight program.

We have the capability to move ahead. We will be prepared. Nobody could feel worse than Dr. Mueller and Dr. Seamans and Dr. Gilruth and me that everything that could save these men's lives was not done.

The Board has pointed in an important way to the necessity of doing everything that has to be done and not leaving any small or limited part of the job undone on any one site, and it seems to me we will need to tighten up our whole effort, but any kind of approach that tends to destroy the system in order to tighten it up will mean we simply won't have a manned space-flight program. This is what I meant when I said we all share a very grave responsibility.

I hope we will not lose sight of the fact that this team has produced success for this country and can again if given the support needed to do so.

Thank you very much.

Mr. TEAGUE. The last person I shall yield to is our chairman, the gentleman from California.

Mr. Miller.

Mr. MILLER. Mr. Chairman, I want to express my appreciation to this Board. I know they are dedicated men who have worked hard and long in a task that none of us would like to undertake.

I recognize their dedication. While we may differ minutely, I think on the whole that they have rendered a great service to the country and a great service to the program. I join with Mr. Webb's evaluation that if we are going to go on with the program, we have got to take some risks. I don't think anyone questions that.

I think the fact that we have made as much progress as we have in the field of space flight, sending men into a hostile environment, living there and returning, indicates that NASA is a viable organization. I hope that we can, in dedication to the three men who gave their lives, go forward with a program to keep faith with them for the sacrifices they have made.

Mr. WEBB. Thank you.

Mr. TEAGUE. The Chair would like to announce that at 10 o'clock tomorrow we will hear J. L. Atwood, president and chairman of the board, North American Aviation, Inc., accompanied by Harrison Storms, vice president, NAA, and president, space and information division, NAA; Dale Myer, vice president, space division and Apollo program manager, NAA; accompanied by Tom McDermott, director of quality and assurance control, space and information division, NAA, John Hansel, chief, quality control (Cape Kennedy), space and information, NAA.

Dr. Thompson, may I add my word of appreciation to you and your Board for a job well done. And thank you for coming here.

The committee will be adjourned until 10 a.m. tomorrow morning.

(Whereupon, at 10:25 p.m., the subcommittee was adjourned to reconvene at 10 a.m., Tuesday, April 11, 1967.)