STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS		ANALYSIS	
		Investigation/ Validation Action In Work	Validation Completed	Did Not Cause Accident	May have Contributed to Accident
73	Identify all AC wires going to ECU	2-10	3-3	3-3	
	Baseline information only. No Analysis Summary required.	All wires identified for two interface connectors. ITEM CLOSED			
74	AC Bus 2 phase C short during prior test on spacecraft 012 (Ref. DR 0903 dated 1-13-67)	2-10	3-19	3-19	
		This short occurred while obtaining a voltage measurement. A 1/8 amp fuse was blown in the instrumentation circuits. It was determined that the fuse protected the AC 2 instrumentation system and this short had no relation to the accident. ITEM CLOSED			
75	Relay terminal wires exposed on 15 second timer on Spacecraft 012 (Ref DRS 692 dated 11-27-66)	2-23	2-24	2-24	
		Permanent Installation and Removal Record shows relay was potted and properly reinstalled. Post test evaluation shows potting on relay is intact and relay was properly installed. Test data shows relay performed its function properly. ITEM CLOSED			
76	Review of Panel 24 difficulties on 012	3-3	3-14	3-14	
		Thirteen DR actions were noted. The major problem was wire insulation damage because of the very tight envelope allotted to this panel. Tests have shown that electrical continuity was present after the fire and that no damage of any significance has been incurred by the switches, panel wiring or connectors. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS: Investigation/ Validation Action In Work	STATUS: Validation Completed	ANALYSIS: Did Not Cause Accident	ANALYSIS: May have Contributed to Accident
77	Three Saturn S-IVB measurement anomalies 2325:44	2-14	4-1	4-1	
		The reason for this data change has not been found, but at this time, 2325:44, it is considered to be unrelated to the incident. ITEM CLOSED			
78	"Buttermilk Odor" in Suit Circuit G s 1810	2-14	3-7	3-7	
		An evaluation of the reported odor has been completed. No impurities were noted from the K-bottle source; also no particular suspect item was identified as emitting a "sour milk" odor, although some RTV potting compounds have a pungent odor that may fit this odor description. ITEM CLOSED			
79	SCS Yaw ECA Female Connector J95 Blackened Areas	3-3	3-14	3-14	
		Other ECA connectors and mating connector show no similar damage. Pins 4, 42, 80, 81, 82 have a blackened area. The area around pins 80, 81, and 82 has been shown to be a previous repair. The mating connector was perfectly clean. Pins 4 and 42 were spares. It was concluded that the connector had nothing to do with the fire. ITEM CLOSED			
80	Roll Output 2331:14.5 to 2331:15.0	2-13	2-23	2-23	
		Tests at MSC have shown that the rotational controller will produce an output when hit, even though the handle is pinned and locked. The handle was found pinned and locked, and the data therefore indicates a physical blow to the controller by one of the crew members. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS: Investigation/ Validation Action In Work	STATUS: Validation Completed	ANALYSIS: Did Not Cause Accident	ANALYSIS: May have Contributed to Accident
81	Gassing characteristics of Pyro batteries	3-6	3-7	3-9	
		Preliminary tests have been completed at MSC. Results indicate that is only a 2 psi pressure increase at normal room temp. during a 16 day period. Another battery was tested at 105 ± 5 degrees F. and under worst conditions, H_2 venting would occur after approximately four days. Post test inspection of batteries showed them to be in satisfactory condition. (Ref. Board Action 0112). ITEM CLOSED			
82	TTVC was engaged at 2331:18.	2-14	2-23	2-23	
		For some unknown reason, the T-handle of the translation controller was turned to a full clockwise position. There can be much speculation as to how and why it was turned, but the answers are not considered significant. ITEM CLOSED			
83	Start Senior Pilot activity (slight increase in heart rate and change in respiration) 2330:22	2-23	3-1	3-1	
		A moderate increase in heart and respiratory rates at this time. These data do not indicate the degree of activity that would be expected had the Senior Pilot been aware of an emergency situation. ITEM CLOSED			
84	Senior Pilot heart rate increase, aware of danger 2331:01	2-23	3-1	3-1	
		A marked change in the Senior Pilot's respiratory and heart rate was seen at this time and continued until loss of signal. This physiological response is compatible with the realization of an emergency situation. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS: Investigation/ Validation Action In Work	STATUS: Validation Completed	ANALYSIS: Did Not Cause Accident	ANALYSIS: May have Contributed to Accident
85	Shorting in MDAS octopus cable and connectors	2-25	4-1	4-1	
		Shorts were found on the octopus cable which provided power to the MDAS The MDAS was still operating until LOS. The shorting was found to be superficial and a result of the fire. ITEM CLOSED			
86	Astronaut shocked during Spacecraft 101 Crew Compartment Fit and Functional Check	2-24	2-27	3-7	
		The short circuit experienced in Block II S/C 101 at Downey occurred because the torso harness utilized was of Block I configuration and in poor condition due to previous usage. If the same type short occurred in S/C 012. the voltage could not have been transferred to the crewman because of the differences in the overall Block I hardware. ITEM CLOSED			
87	Accumulator quantity and glycol pump inlet pressure start increasing to upper limit 2331:15.4	2-13	3-14	3-14	
		Accumulator quantity change attributed to change in water-glycol pressure. Pressure change attributed to boiling of water-glycol within the lines when subjected to intense heat. ITEM CLOSED			
88	CO_2 absorber outlet temp. starts increasing 2331:16.0	2-13	2-14	2-14	
		Post test observations indicate that loss of pressure suit circuit integrity occurred in the Command Pilot's pressure suit and/or return hose. Such an opening would allow warm cabin air to be drawn into the suit compressor. The CO_2 Absorber Outlet Temp. indicates that the CO_2 Absorber acted as a heat sink until this time when it and the suit manifold temp. began to increase. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS		ANALYSIS	
		Investigation/ Validation Action In Work	Validation Completed	Did Not Cause Accident	May have Contributed to Accident
89	Q Ball circuit integrity	3-6	4-1	4-1	
		The Q-Ball was not electrically mated for the plugs-out test (OCP-0021). However, the cable was "hot" up to the Q-Ball connector. Resistance checks revealed no anomalies in the Q-Ball cable. ITEM CLOSED			
90	Suit flow indication at low limit for Command Pilot from 2331:18.5 through LOS, Senior Pilot from 2331:18.5 through LOS, and Pilot from 2331:19.6 through LOS.	2-22	4-1	4-1	
		When cabin pressure rises rapidly, the increase pressure results in restricting or stopping the flow. In addition, loss of integrity of inlet side of the suit circuit causes a drop in suit flow indication. ITEM CLOSED			
91	Accumulator quantity reached upper limit 2331:17.1	2-22	3-14	3-14	
		Indicates beginning of overpressurization in the water-glycol circuit due to thermal expansion of the fluid. ITEM CLOSED			
92	Glycol evaporator liquid temperature increasing 2331:17.5	2-22	3-14	3-14	
		Heating in the area to the left of, or within, the ECU. Supported by water-glycol pump inlet and outlet pressure and accumulator quantity. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS		ANALYSIS	
		Investigation/ Validation Action In Work	Validation Completed	Did Not Cause Accident	May have Contributed to Accident
93	Command Pilot's Live Mike from approximately 22:18 to some time during the incident	2-23	3-18	3-18	
		Data indicates that the live mike condition began at approximately 22:18 and continued through the time the fire was first reported. An investigation on the Command Pilot's audio circuit has been completed. Based on the findings, it has been concluded that the live mike condition cannot be considered a source of ignition. ITEM CLOSED			
94	Initial investigation determined that cabin air fan no. 1 shorted.	2-22	4-1	4-1	
		Post test inspection of Cabin Fan No. 1 has indicated shorting in Phase A and C circuits. Continuity checks of the cabin fan were satisfactory. The shorts were determined to be in the power cable. Due to the lack of fire propagation material and physical inspection, it is concluded that these shorts were not the cause of the accident. ITEM CLOSED			
95	Etching of Teflon wire insulation a. ECI harness b. Gas chromatograph connector	3-17	4-1	4-1	
		All teflon insulated wiring is required to be etched before potting Pretest records were examined to determine whether they show that these cable connectors were etched as required. Etching of the gas chromatograph wires was accomplished. Etching of the ECI harnesses was not required as it was the latest configuration. ITEM CLOSED			
96	Suit current limiter panel short to teleflex cable	2-22	3-13	3-14	
		Terminal board 61 to be examined for evidence of shorting and 82556 resistors and conformal coating for overheating. A more detailed examination disclosed that there was no actual contact between the teleflex cable and the terminal board, and that there was no evidence of shorting or overheating. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS		ANALYSIS	
		Investigation/ Validation Action In Work	Validation Completed	Did Not Cause Accident	May have Contributed to Accident
97	Panel 150 not installed and lying loose	2-22	3-14	3-14	
		Panel 150 has been inspected for arcing as part of the Spacecraft disassembly plan. (Reference Board Action Item 0120). There was no evidence of arcing or material outflow from any components on the panel. ITEM CLOSED			
98	Command Pilot cobra cable and PGA connectors suspect	2-22	4-1	4-1	
		Cobra cable connector and pressure garment assembly (PGA) connectors have been examined for arcing and condition of pins. No arcs were found. Tests were conducted simulating the disconnections of these connectors while "hot". No ignition occurred in a gaseous mixture of oxygen and methyl ethyl ketone (MEK). ITEM CLOSED			
99	BMAG Power Switch Position During Accident Indeterminate	2-22	3-8	3-14	
		BMAG switch was examined to determine position during test, when position was changed, possibility of false detent position, and effect of this switch being in test position and also being in false detent position. Switch determined to have been in proper position before crew report of fire. ITEM CLOSED			
100	Close-out found on battery terminals and other equipment	2-22	4-1	4-1	
		The flash and firepoint of this polyvinyl chloride tape was established as 485°F. Inspection of the areas in which the tape was used has determined that the tape did not start the fire but did support combustion. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS		ANALYSIS	
		Investigation/ Validation Action In Work	Validation Completed	Did Not Cause Accident	May have Contributed to Accident
101	ECU back pressure controller	2-22	3-21	3-21	
		Back pressure controller examination revealed that motor rotates satisfactorily, and that all electrical continuity was within spec limits. ITEM CLOSED			
162	Senior Pilot inlet hose disconnected	2-24	4-1	4-1	
		The inlet hose of the Senior Pilot was found disconnected. Investigation by Panel 11 revealed a sooting pattern which could have been made if the Senior Pilot's inlet hose was disconnected. It is inferred that the Senior Pilot disconnected his hose in preparation for emergency egress. ITEM CLOSED			
103	Service propulsion system chamber pressure data DC drop	2-22	3-18	3-18	
		The service propulsion system SPS chamber pressure is sampled 100 times a second. The circuitry has been reviewed to determine if this data would show any significant DC power changes. No significant change was noticed during the period of the AC glitch at 2330:54.85. ITEM CLOSED			
101	Battery B Loading	2-22	3-2	3-9	
		Battery B Loading was indicated at 3.52 amps compared to 1.76-1.9 amps for batteries A and C and 2 amps. A detailed evaluation of the data showed the difference was due to a PCM zero shift and not real data. ITEM CLOSED			

STATUS OF INVESTIGATION ITEMS

ITEM NO.	ITEM	STATUS		ANALYSIS	
		Investigation/ Validation Action In Work	Validation Completed	Did Not Cause Accident	May have Contributed to Accident
105	Suit wiring short circuit	3-8	3-28	3-28	
		Short circuit damage has been uncovered in part of the communications cabling on the Command Pilot's suit. Detailed inspection of the shorted wires revealed that the shorting and damage was due to external heat and burning. ITEM CLOSED			
106	DC wiring for the Environmental Control System instrumentation was found burned through	3-23	3-31		3-31
		The probable cause of the accident is in the wiring providing instrumentation power for some of the ECS instrumentation.			

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March [illegible]1, 1[illegible]

INTEGRATION ANALYSIS SUMMARY

System Affected: Communications Subsystem

Item [illegible]
TPS N/A

Observation: Between [illegible] to [illegible] GMT noise sounds were received on S-band

Discussion and Analysis:

The noise sounds were analyzed by Bell Labs and MSC. The results are not conclusive as to what caused the sounds. The sounds were similar to those of tapping and brushing a microphone. During the time period the microphone was "live," noises of this nature occasionally were received; however, the frequency of the noises during the period of [illegible] to [illegible] GMT was much higher. A relaxed breathing cadence was superimposed on the sounds. The sounds were recorded on both the S-band and VHF voice tracks, although the crew was on S-band. This is as expected, due to the ground communication system which retransmits the S-band through a VOX controller circuit over a VHF transmitter. These transmissions are received by the VHF receiver on the ground and are recorded. The ground receiver does not differentiate between transmissions from the spacecraft VHF transmitter and the ground VHF transmitter. The proof that the noises were generated through the S-band is the fact that the noise sounds appear on the S-band track first and, with a short delay, then appear on the VHF track. The delay is the time required for the retransmissions through the VOX controller circuit. Further, some of the sounds were not of sufficient level to trigger the VOX and, therefore, were not recorded on the VHF voice track

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 21, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Guidance and Navigation Subsystem — Item #3, TPS N/A

Observation: Gimbal angle data indicates movement just prior to fire call

Discussion and Analysis:

Analysis of telemetered data from past testing of S/C 012 has shown the following signals are indicators of torque or angular disturburances of the G&N Navigation Base with respect to an inertially stabilized IMU:

1. Gimbal Torque Motor Input
2. Gimbal Angle Resolvers
3. AGC Registers Recording Gimbal Angles.

The recordings of the ten (10) sample per second gimbal torquer input from S/C-012 OCP's 0034, 0034A, 0005 and 0021 were reviewed by personnel from NASA G&N - ACED-MIT in an attempt to correlate individual crew member movement within the S/C to disturbances noted on the gimbal torquer inputs.

The analysis indicated that definite individual crew movement could not be determined.

The gimbal torquer input indicated S/C disturbance but cannot distinguish between left, right or center crewman caused motion, and/or disturbances caused by forces external to the spacecraft.

The AGC CDU registers are telemetered once every two seconds and can only be used to indicate the angular relationship which existed at the sample time. Changes which take place faster then the sampling rate will not be indicated.

Item [illegible] (Cont'd)

Based on the above, it has been concluded that only gross indication of Command Module motion can be determined and correlated.

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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 1 , 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #4.
TPS N/A

Observation: Increase on Ground Power Supply B at [illegible] GMT

Discussion and Analysis:

The four bit increase (4 amps) was observed on the ACE Control Room real time recorder and also on a playback from track 5. The interim output is recorded also on track 3. Track 3 did not show the 4 bit increase. Analysis of the interleaver wave train output at this period of time indicate that the magnitude of the wave train (track 3) output did decrease slightly at this time although the bit stream was readable and the 4 bit increase on power supply B was there.

During this period of time, there was VHF/AM transmitter keying which draws 1.1 amps with no modulation and an additional .5 amp with modulation. The VHF/AM transmitter is powered from the Post Landing Bus which is powered from both Main A and B buses in the CM thru isolating diodes. There was no other activity going on in the S/C at this time that could be detected from the data. Although the data is questionable, there are several factors that could have caused this indication

(1) The power supplies A & B could have momentarily shifted their shared load (Post Landing Bus Load) due to the power supply regulation characteristics. This could have occurred

Item #[illegible] (Cont'd)

without being detected in the data since PSA current is sampled [illegible] milliseconds prior to Power-Supply B current. This phenomenon had been seen for longer periods of time where one power supply current would show a few bits increase and the other decrease.

([illegible]) Another load could have been placed on at this time but since the data shows no other parameter activity during this period, there is no way this can be verified.

With the analysis that has been made and considering the time ([illegible] : [illegible] GMT) of this happening, it is concluded that this event could not have contributed to the cause of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 1 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item # — TPS N/A

Observation: Gas Chromatograph output started to change from [illegible] GMT until loss of data

Discussion and Analysis:

It has been determined that the gas chromatograph (GC) cable acted as an electromagnetic radiation detector (Ref. Item No [illegible]).

The gas chromatograph (GC) was not installed in Spacecraft [illegible] at the time of the accident. The GC connector was placed on the shelf of the gas chromatograph compartment. The connector was not bagged, and AC bus 1 phase A power was applied to the connector through a closed circuit breaker. Twenty-two gauge wire was used, protected by [illegible] amp circuit breaker. The circuit breaker for the GC was found to be open following the accident, with a heavily sooted condition which is indicative of opening during the early portion of the fire. The harness was not tied down in a flight configuration because the GC was not installed.

Two physical peculiarities were noted concerning the GC wiring and the connector. After the accident the harness and connector were found on the floor with the GC connector laying on a big harness. Two spot ties of this harness were found unblackened as a result of being protected by the GC connector.

Item #5 (Cont'd)

The side of the connector that lay against the big harness and protected the two spot ties is badly burned and the potting at the back of the connector is melted. The GC connector was stuck to the big harness and had to be pried loose with a tool. It can be inferred that the connector was burning in a different location but fell or otherwise moved to its final location prior to the time the fire swept across that portion of the floor. It can also be inferred that the connector protruded beyond the GC compartment shelf and was burned in that location before it fell to the floor.

Secondly, the two GC AC wires exhibited peculiar melting characteristics. The output signal leads from the connector were fed through a fiberglass sleeve. One hundred-fifteen volt AC power was carried to the connector through a twisted pair of teflon-insulated conductors. These power conducting wires were run along the signal leads and were occasionally tied together. The power wires show a number of copper balls attached to their surfaces. This is the only instance that wires in this condition have been found in Spacecraft 012. The shorted DC wires to the J185 connector do show a couple of droplets; these are still being examined.

All attempts to simulate this condition by either short circuits or by application of external heat have not resulted in a similar appearance of the AC wires. It is inferred that these wires were subjected to both a short and to external heating from the fire. It is also inferred that this condition resulted as the harness fell through the flame to the floor.

X-ray and continuity tests of the connector pins and input wiring showed no evidence of arcs or short circuits. For this reason, this is not a suspect fire initiator.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 1?, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Communications Subsystem

Item #
TPS N/A

Observation: VHF-FM video drops out for 3 milliseconds at ?3:54.85 GMT

Discussion and Analysis: Tests completed at Collins Radio Company on a similar VHF-FM transmitter (reference Collins Radio Company report dated 2-7-67) show that the received video signal during the noted time can be matched very closely by a momentary dropout of the AC supply (all three phases) to less than 50 volts or a dropout of DC supply to less than ?.5 volts for a period of 15 to ?0 milliseconds. Comparison with Investigation Items 7 and 8 leads to the conclusion that this was an effect of an AC bus ? power interruption.

ENCLOSURE 18-53

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem — Item #7, TPS N/A

Observation: The instrumentation system detected a transient on all three phases of AC bus 2 at 23:30:54.85 GMT

Discussion and Analysis:

An AC bus 2 voltage transient was observed approximately nine seconds before the crew report of fire. There are three reasons this condition could have existed:

(a) Momentary short or interruption of DC bus B input power to inverter number 2.

(b) Momentary short on one or more phases of inverter number 2 output.

(c) Removal of a major portion of the load from inverter number 2.

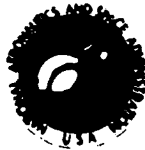
Special tests were conducted on spacecraft 008 at MSC to show the time relationship between the over-voltage indication and associated changes of other equipment outputs from the spacecraft.

Voltage regulation tests were run on the ground power supply at Launch Complex 34 under similar load conditions (30 amps) to that existing on DC bus B in spacecraft 012 at the time of the accident.

These tests indicated that a short circuit in the range of 5 to 25 milliseconds drawing approximately 75 amps caused an immediate drop in bus voltage of 13 to 15 volts, recovering to about 3.6 volts below steady state conditions after one to 1.5 milliseconds. The voltage remained constant until the short cleared at which time it over shot steady state conditions by about 10 volts recovering to steady state by 1. to 1.5 milliseconds.

Item #7 (Cont'd)

It is concluded that the probable cause of the AC bus ' transient and associated indications was a momentary short (' to ' milliseconds) of DC bus B affecting the input voltage to inverter '.



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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 1 , 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Communications Subsystem

Item #
TPS N/A

Observation: C-band transponder drops to zero volts for approximately two seconds from 233:54.8 to [illegible] GMT .

Discussion and Analysis:

Tests by Collins Radio Company (reference TWX dated 1-3[illegible]) indicate that the transponder output characteristics can be matched by a drop in 3 phase AC voltage or phases A and B, or B and C. One phase loss would not cause the effect.

Dropout for very short intervals causes the C-band transponder to go to a protective mode to prevent magnetron damage. Normal recovery time for the C-band transponder is approximately 1.[illegible] seconds.

Comparison with Investigation Items [illegible] and 7 leads to the conclusion that this was an effect of an AC bus [illegible] power interruption.

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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March , 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #
TPS N/A

Observation: Oxygen Flow Rate increased to off-scale high at [illegible] GMT

Discussion and Analysis:

Telemetered data indicate that the high oxygen flow rate conditions for the last 30 seconds (2330:30.4) before the fire call can be attributed to the apparent high level of prime crew suit leakage at low suit-to-cabin differential pressure, magnified by apparent crew activity.

There has been considerable speculation as to whether the high flow could be indicative of a sensor and/or associated wiring difficulty.

The oxygen flow sensor circuit includes two separate outputs. The signal circuit going to the Pulse Code Modulation Telemetry System (PCM) is conducted to the PCM system through a twisted shielded pair of wires. A short circuit between the signal lead and either the return wire or the shield braid would cause a zero output (no flow) reading on the oxygen flow indication. It is highly improbable that any short circuit between the signal lead could occur without a prior short circuiting to the ground lead or shield lead.

Item #9 (Cont'd)

The second output from the oxygen flow sensor circuit goes to a time delay relay to indicate high flow alarm. It is on the ground circuit return side of the relay. A ground circuit completion is required to indicate high oxygen flow. This is supplied from a separate circuit from that going to PCM, and a ground on this line could not affect the PCM flow rate indication.

Single failures could exist within the bridge circuitry controlling the flow sensor which would indicate high flow rates on both the PCM output and the signal to the relay. These, however, will require examination of the oxygen flow sensor box to confirm or deny this possibility. A preliminary examination disclosed shorts to ground in the flow sensor; shorts to ground will produce a zero or no flow output indication. The flow sensor box is being torn down at the present time. It should also be noted that the location of the oxygen flow sensor was a high fire damage area, and that the sensor would be expected to be damaged by the fire.

Based on the above, it is concluded that the high oxygen flow data indication was valid, and that there was no malfunction of the sensor and/or associated wiring prior to the fire call.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control System

Item #12
TPS N/A

Observation: Data indicate initial cabin temperature increase at 2331:04.4 GMT

Discussion and Analysis:

The initial cabin temperature increase (measurement CF0002T) was observed at 2331:04.4 GMT.

This measurement is sampled one time per second on PCM.

Preliminary data determined that the cabin temperature transducer response time is approximately 5 seconds to 63.3 percent of full scale for a step increase; however, initial response time was unknown.

Tests conducted at AiResearch determined that the cabin temperature sensor would show an initial response of .25°F within 200 to 300 milliseconds when subjected to air at 130°F. In addition, the sensor output increased to 63.3 percent of full scale (125°F) in four seconds when subjected to an air temperature of 130°F.

It is, therefore, determined that the time of cabin temperature increase start is accurate to within ± 1 second.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item #13, TPS N/A

Observation: Cabin pressure increase began at 2331:06.818 GMT (battery pressure transducer)

Discussion and Analysis:

This measurement, CC0188P, was not installed in its final configuration since the flight batteries were not installed. The transducer lay on the floor of the cabin and, therefore, sensed cabin pressure instead of battery compartment manifold pressure.

The transducer has a 0 to 20 psia range and a response time of 1 millisecond. No additional filtering occurs on its PCM input circuit.

The measurement is sampled ten times a second on PCM.

It is, therefore, determined that the time of cabin pressure increase start is accurate to within ±100 milliseconds.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item #14, TPS N/A

Observation: Cabin pressure increase began at 2331:08.417 GMT (measurement CF0001P)

Discussion and Analysis:

The transducer has a 0 to 17 psia range and a response time of 100 milliseconds. The measurement is sampled once a second on PCM.

Because of the low sampling rate and limited range of this measurement, the most accurate time and value of cabin pressure increase should be from measurement CC0188P (Item #13).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 1 , 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Guidance & Navigation Subsystem — Item #1, TPS N/A

Observation: The inertial guidance gimbal angles measurements showed a change starting at approximately 2331:1? GMT to a maximum value between 2331:18 and 2331:19 GMT.

Discussion and Analysis: It has been determined that the change in gimbal angles data is attributed to the increase in command module pressure. Following 2331:19 GMT, the gimbal angles data started to return to their original levels. This change in the data traces is determined to be the relief of the pressure or rupture of the pressure vessel. This determination has been substantiated by data obtained during the vacuum chamber test.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 1?, 196?

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #1?
TPS N/A

Observation: Entry battery B power transferred to main bus B and simultaneously entry battery C power transferred to main bus A at ?31:1?:? GMT

Discussion and Analysis:

Two ground measurements and six PCM measurements show that the above occurred. These data are further substantiated by the position of switch S1? on panel ??. The switch position is indicative of pilot action to place the batteries on the buses. This action took place approximately eight seconds after the fire call.

It is conjectured that pilot action may have resulted from smoke obscuring the floodlights, giving the impression of loss of ground power, or the desire to keep power on the suit compressors in the event of loss of ground power because of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 10, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #17
TPS N/A

Observation: Entry battery A power transferred to main bus A and simultaneously entry battery C power transferred to main bus B at 2331:13.6 GMT

Discussion and Analysis:

Four PCM measurements show that the above occurred. These data are further substantiated by the position of switch S9 on panel 22. The switch position is indicative of pilot action to place the batteries on the buses. This action took place approximately nine seconds after the fire call.

It is conjectured that pilot action may have resulted from smoke obscuring the floodlights, giving the impression of loss of ground power or the desire to keep power on the suit compressors in the event of loss of ground power because of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 10, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item #18, TPS N/A

Observation: The master caution warning light came on at 2331:14.7 GMT

Discussion and Analysis: This light was the result of a high oxygen (O_2) flow indication. The oxygen flow rate measurement increased to the upper band limit of 1.06 lbs./hr. or five volts at 2330:59.4 GMT. Whenever the O_2 flow rate instrumentation voltage reaches 5.3 volts or greater and stays at this voltage level continuously for 15 seconds, the master alarm will come on. A time delay was added to inhibit the alarm because of periodic action of the cyclic accumulator every 10 minutes for a 10-second interval.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #14
28
88
TPS N/A

Observation: Suit Supply Manifold Temperature began to increase at 2331:1[illegible] GMT

Suit Compressor Inlet Temperature began to increase at 2331:13.[illegible] GMT

CO_2 Absorber Outlet Temperature began to increase at 2331:1[illegible] GMT

Discussion and Analysis:

The configuration of the pressure suit circuit was such that the crew would be isolated from the cabin at the time fo the fire. Post-test observations of the end of the Command Pilot 's pressure suit umbilical hose segments indicate that the hose returning from the suit to the ECS was "very sooty" and dark. The corresponding hose segment for the Pilot's hose was white and clean. This information would indicate that the loss of pressure suit integrity occurred in the Command Pilot's pressure suit and/or return hose. Such an opening would allow warm cabin gas to be drawn into the suit compressor. The suit compressor inlet temperature (CF0153T, range 50 to 125°F) began increase from 77°F at 2331:13.[illegible] GMT. The CO^2 absorber outlet temperature (CF0154T, range 90 to 200°F) indicates that the CO_2 absorber appears to have acted as a heat sink until 2331:1[illegible] GMT at which time this temperature and suit supply manifold temperature (CF[illegible]T, range [illegible] to 95°F) began to increase.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Communications Subsystem

Item #20
TPS N/A

Observation: A momentary interruption was observed in VHF-FM and S-Bank data between 2331:17.398 and 2331:17.659 GMT

Discussion and Analysis: The momentary interruption in VHF-FM and S-Band between 2331:17.398 and 2331:17.659 GMT is attributed to a soft short circuit occuring in the communication wiring.

ENCLOSURE 18-53

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 16, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Crew Biomedical Equipment

Item #21
TPS(s) S/C-011
S/C-056
S/C-076
S/C-085

Observation: Inspection report of Biomed Recorder

Discussion and Analysis:

The Medical Data Acquisition System (MDAS) was removed from the spacecraft and physically inspected. MDAS was found to be in exceptionally good condition with only minor smoke damage.

The data tape was reduced and valid data obtained except for several noise glitches which appeared on the biomed data channels. These glitches occurred randomly. The first one at 1828:02 GMT and the last one at 2324:00 GMT. These glitches or noise spikes are believed to be caused by RFI which has been duplicated by post test bench checks.

From the MDAS data playbacks, time code amplitude variations were noticed. Representatives from the MDAS tape recorder and tape vendors stated that these variations may be caused by handling (fingerprints, etc.) and by dust.

The MDAS time trace was also inspected for indications of a DC dropout. No dropouts were found. From the time the MDAS was turned on and the timer reset (1735:02 GMT) until LOS of the timer (2331:21.2 GMT), the timer operated normally with no loss or change in timing. Special tests were conducted to determine the effect on the timer from a main DC bus voltage transient. Voltage

ENCLOSURE 18-53

Item #21 (cont'd)

transients from 24 volts to 8 volts and 5 volts for 1.5 ms to 8.8 ms showed no effects on the timing. The only transient that effected the timing was a voltage drop from 28 volts to zero for a duration of 10 ms to 25 ms.

Based on the PCM and the MDAS data, there are no indications that the MDAS contributed to the cause of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 1[illegible], 1[illegible]

INTEGRATION ANALYSIS SUMMARY

System Affected: Gas Chromatograph

Item [illegible]
TPS N/A

Observation: Seven gas chromatograph variations observed in the time period 204:[illegible] to [illegible]:[illegible] GMT.

Discussion and Analysis:

The gas chromatograph (CG) was not installed for this test OCP-K-0021). The connector which carries the telemetry data signals and the required AC power was open ended and was placed on the GC shelf prior to the test. Power to the AC line in the connector was turned on during the test per the test plan.

Examination of records show variations on the GC trace seven (7) times prior to [illegible] GMT. Further investigation of SC-012 data measurements showed that the GC trace variations correlated with power changes in various SC systems.

It was determined that the telemetry data line in the connector has the characteristics of an antenna, and consequently can detect changes in electromagnetic radiation within the spacecraft.

This phenomenon was verified by tests conducted in SC-[illegible] CM at MSC.

The time of the aforementioned trace variations and correlation to system power changes are listed below:

1. [illegible] GMT. GC trace changed in exact correlation with a rise in the VHF/FM RF output (CT[illegible]V) when the transmitter was turned on. The GC output change was 2 to [illegible].

2. 2200:54 GMT. This trace variation correlates with middle gimbal angle stabilization loop, GC 2147, responding to a fine align mode.

3. 2219:23 GMT. This change in the GC trace correlates to G&N going to coarse align.

4. 2220:90 GMT. This change in GC trace correlates with G&N going to fine align.

5. 2234:40 GMT. The Pilot turned updata link to UHF.

6. 2253:13 GMT. ECS reported high O_2 flow and asked the crew if their face plates were open. The crew reported "No".

During their transmissions much SC background noise was encountered.

7. 2255:40 GMT. Spacecraft commander (CMD) had just changed cobra cables and was in the process of communications check at this time.

Conclusions drawn from the above data is that GC telemetry data line acted as an electromagnetic radiation detector.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

Item #23
TPS N/A

System Affected: Communication Subsystem

Observation: Final loss of all spacecraft data observed 2331:21.0 to 2331:22.42 GMT

Discussion and Analysis: The final loss of all spacecraft data is attributed to a loss of power or loss of a coax cable due to the burning and shorting of wire harnesses during fire.

ENCLOSURE 18-53

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 23, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Stabilization & Control Subsystem — Item #24, TPS N/A

Observation: MTVC Pitch Rate Command observed at 2330:54.847 GMT

Discussion and Analysis: This command was seen on CH0074 (MTVC pitch rate) and CH1074 (MTVC yaw rate) as a one (1) bit change-of-state. The SCS frequently sees one (1) bit changes on measurements which are attributed to noise.

All data indicated that the SCS operated normally at the above time and did not contribute to the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem Item #25 #102 TPS N/A

Observation: The Senior Pilot's suit flow dropped to lower limit at 2331:09.618 GMT and then returned to normal flow indication at 2331:11.918 GMT. The Senior Pilot's hose was found disconnected.

Discussion and Analysis: At 2331:09.618 GMT the suit flow rate of the Senior Pilot was at the upper limit of the transducer (saturated) of 25.27 lb/hr. The flow rate per man was actually higher and was approximately 64 lb/hr per man. One-tenth of a second later, at 2331:09.718 GMT the flow rate had dropped to the lower limit of the transducer (6.15 lb/hr) and stayed there until 2331:11.818 GMT. It then returned to the upper limit at 2331:11.918 GMT. The other two suit flow rates remained at the upper limit during this period.

There are three possibilities that could explain the suit flow drop-off. These are:

(a) A momentary short in the suit flow transducer wires would explain the suit flow transducer going to the lower limit and returning to saturated flow again. However, the suit delta pressure and compressor delta pressure show a marked change coincident with the drop in suit flow, indicating that the suit flow in fact changed.

(b) If the suit outlet hose was disconnected, the suit outlet has a check valve in the suit which stops the flow to the suit giving an indication of no flow. The suit delta pressure and suit

compressor delta pressure should increase and, in fact, did increase. The decrease in these parameters within about 2 seconds after the increase can only be interpreted as suit burn-through and/or subsequent reconnection of the outlet hose. Disconnection and reconnection of the outlet hose within a 2 second time period is highly unlikely. If this argument is to hold, the suit must have burned through to re-establish flow and sometime later the outlet hose was reconnected to the suit. The outlet hose was found connected after the accident, which tends to weaken the argument in light of possibility (c) which follows.

(c) The suit inlet hose was found disconnected from the Senior Pilot's suit. An explanation of this could be that the Senior Pilot disconnected his suit inlet for emergency egress at the dropout of the suit flow.

Testing at MSC has confirmed that disconnecting a suit inlet hose will produce a dropout in suit flow similar to that which occurred at 2331:09.618 GMT. In addition the Senior Pilot's inlet hose was found disconnected and sooting was found on the inlet hose connector which infers it was disconnected during the fire.

Based on the above it is concluded that the Senior Pilot's hose was disconnected at 2331:09.618 GMT and caused the dropout in suit flow.

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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March [illegible], 19[illegible]

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item #[illegible]
TPS N/A

Observation: Oxygen surge tank pressure started to decrease at [illegible] GMT

Discussion and Analysis:

High oxygen flow rates were encountered for [illegible] seconds prior to the report of fire. These flow rates are attributed to suit leak rates and crew activity which placed a demand on the suit pressure regulator to supply oxygen at a rate causing a decay in the surge tank pressure.

Test data have shown that flows in excess of [illegible]/hr will result in a decay in the surge tank pressure.

It is concluded, therefore, that the oxygen surge tank pressure decay at [illegible] GMT was the result of high oxygen flows into the suit loop and did not contribute to the initiation of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 27, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item #27 / #38 — TPS N/A

Observation: Suit flow indications begin to fluctuate for the Command Pilot at 2331:12.9 GMT, for the Senior Pilot at 2331:15.4 GMT, and for the Pilot at 2331:14.3 GMT. At 2331:16.? GMT the Pilot's suit flow began to fluctuate violently

Discussion and Analysis: Fluctuations in suit flow indications are characteristic results of restrictions in the suit flow caused by movements of the man

The time period for fluctuations in the Senior Pilot's suit flow coincides with the increased muscular activity indicated by Physiological Data

Increase in cabin pressure against the suit could increase the indication

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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 23, 1967

INTEGRATION ANALYSIS SUMMARY

Item #29
TPS N/A

System Affected: Stablization & Control Subsystem

Observation: Indication of RCS action at 2329:40 GMT

Discussion and Analysis: The data during this period has been reviewed in detail and indicated RCS action was found to be erroneous. The variation does not appear on the digital data from CIF VHF-FM which is best at this time.

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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

Item #30
TPS P1B-004
CM-IV-077

System Affected: Stabilization and Control System

Observation: Rotation Controller output data indicates a transient of 1.5% at 2330:54.85 GMT

Discussion and Analysis:

The Rotation Controller (R/C) was charred, and the pistol grip handle badly burned. The boot at the pistol grip input to the device was partially burned away. The cover of the lid was buckled outward between the attachment screws on each side, evidently due to thermal stresses. The lower left rear corner (nearest astronaut's right knee) of the cover was disfigured and cracked.

A dark residue, apparently foreign to the pistol grip, was observed sticking to the right side of the grip. This residue was removed and determined to be a mixture of nylon and a terephthalate ester by chemical analysis.

The locking pin visually appeared to be intact; however, about one-sixteenth of an inch of unsooted pin was observed at the pin's exit point from the device which indicated that the pin had been slightly pulled out subsequent to soot deposition.

On the bundle, the polyethylene zipper tubing and the silicone rubber shrink sleeving were burned through from the cable egress point for approximately one foot. The cable and zipper tubing were not as badly burned over the remaining length left attached to the unit.

The insulation of four wires approximately one inch from the egress point of the cable from the device was nicked or split for about one quarter of an inch, or had the insulation burned and/or blasted away. Magnified examination of the exposed wiring indicated no arcing or shorting. Functionally these four wires are associated with the R/C direct rotation switch outputs and were not armed with 28 VDC for at least twenty minutes prior to the accident. Also the locking pin was installed at least twenty minutes prior to the accident which would not allow these switches to be actuated.

The radiographs indicated no anomalies in the R/C internal metal parts. In particular, the locking pin was determined to be intact.

The R/C cover was removed and no evidence of foreign material inside the device was observed. The potting on the terminal board in the lower rear corner of the device was darkened and appeared melted on both sides. Charring and crystalization of spot ties, and sooting of internal wire bundles was observed in the lower rear and middle rear of the device. The internal heat pattern appeared to be most intense in the lower rear left side of the device and then progressed upward and to the rear right side through the wires and components. Examination of the cover, which was bulged out (by thermal expansion) when attached to the controller, indicated that a hot gas flow pattern came from above the controller into the case through the cover bulges. The inside of the cover showed very definite indications of a hot gas flow

Item #30 (Cont'd)

pattern where the hot gas came in from outside the controller, was deflected by heavy internal components, and then flowed through the wires and components to the other side of the mechanism.

The review of the data, the continuity check and the insulation check have shown no evidence that the rotation controller or the associated wiring were a cause or propagator of the fire.

Special tests have shown that the null output transients can be duplicated by a momentary interruption of AC Bus 2 Phase A input power. It is therefore concluded that the AC interruption caused the rotation control transient. Information concerning AC interruption is contained in Integration Analysis Summary Item #7.

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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #31
TPS N/A

Observation: Due to the "cold flow" characteristics of the teflon insulation, it is possible to have a breakdown of the spacecraft wiring insulation and resultant electrical shorts.

Discussion and Analysis:

Teflon wire was selected for the spacecraft because of excellent resistance to high temperature, good dielectric properties, lightweight characteristics, etc. It has, however, in common with other plastic materials, cold-flow characteristics which permit the insulation to flow away from localized high pressure over long periods of time. It is possible that localized high pressure points, either between wires or between a wire and structure, could ultimately result in breakdown of the insulation. All wire bundles in the spacecraft which showed damage were carefully inspected for signs of arcing.

From all the investigation of arcs and shorted wires, there is no reason to believe that any of these can be attributed to "cold-flow".

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APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 23, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Stabilization & Control Subsystem

Item #32
TPS N/A

Observation: SCS roll rate oscillations starting at 2331:03.85 GMT.

Discussion and Analysis: The SCS roll rate oscillations at 2331:03.85 GMT are an indication of crew movement in the spacecraft. This item correlates with launch vehicle accelerometer data, IMU gimbal angle data, and nothing more can be gained from additional study to try to determine the degree of crew movement.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 19?7

INTEGRATION ANALYSIS SUMMARY

System Affected: Launch Vehicle

Item #33
TPS N/A

Observation: Launch Vehicle (LV) pitch and yaw accelerometers (DPIAOV-01-02 and CPIBOV-01-04) showed slight oscillation starting at 2331:04 GMT and increasing with maximum oscillation at 2331:20 GMT.

Discussion and Analysis: The LV pitch and yaw accelerometers output data were reviewed to determine relationship with crew movements during the conduct of OCP-K-0021 (i.e., changing of cobra cables). No correlation was seen except during the above period. It is, therefore, determined that these data only indicate movement of the spacecraft after the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power System

Item #34

TPS CM-CA-058

Observation: During an inspection of the S/C harness between inverter #3 and the Junction Box in the LEB, a suspect arc spot was found on the cover plate and wire where it would have been in contact with the plate. The wire has been identified as 28 volt Bus A power in the SCS subsystem.

Discussion and Analysis: No positive identification has been made to indicate that this arc initiated or occurred prior to the fire. The following facts have been determined.

The location of this arc is within the area selected by the Fire Panel as the probable source of the fire.

Water glycol which has been shown by tests to support and propagate fire when spilled on wires was known to have been spilled in this area in an earlier checkout.

The wire bundle was not protected from the sharp edge of the junction box cover plate by the nylon grommet edging.

Several possible propagation paths for the fire, had it been initiated at the junction box, have been found.

Item #3?-(Cont'd)

2

The glycol spillage had been corrected by washing.

No change was noted in high sample rate data (200 samples per second), which should have indicated such a short, until after the time of spacecraft rupture.

Burning noted in the area of the junction box does not appear as severe as would be expected had the fire started here.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March [illegible], 19[illegible]

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control System

Item #35
TPS N/A

Observation: Suit differential pressure begins to increase at 2331:0[illegible].4 GMT

Discussion and Analysis:

The cabin pressure began to increase at 2331:0[illegible].4 GMT.

The oxygen demand regulator senses cabin pressure. An increase in cabin pressure or a decrease in suit pressure will cause the diaphragm of the O_2 demand regulator to be opened allowing O_2 to flow into the suit loop.

The suit differential pressure (ΔP) also began to increase at 2331:0[illegible].4 GMT since it tends to follow the trend of cabin pressure. Crew movement at this time will also add to the increase in suit ΔP.

It is determined that the general rise in suit differential pressure was caused by increased cabin pressure and crew movement.

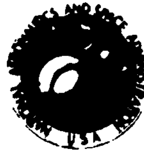
The rapid rise in the slope of suit ΔP curve at 2331:09.[illegible] GMT is attributed to the dropout of the Senior Pilots (SPLT) suit flow.

The drop in the suit ΔP at 2331:11.5 GMT is attributed to the resumption of flow in the SPLT's suit inlet hose. The rapid rise in the suit ΔP starting at 2331:12.4 GMT was caused by the rapid increase in cabin pressure.

Item #3[illegible] (Cont'd)

Information concerning the drop of crew suit flow to lower limits at 2331:1[illegible].[illegible] GMT is discussed in Integration Summary Analysis Item #9[illegible].

It is concluded that the initial crew suit differential pressure increase was caused by crew activities and the latter increase was caused by the rapid rise in cabin pressure.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 31, 1967

INTEGRATION ANALYSIS SUMMARY

Item #36
TPS N/A

System Affected: Sequential System

Observation: Emergency Detection System (EDS) "Engine 8 out" light went out and came back on 8 seconds later, during the EDS tests at 20:52:23 GMT

Discussion and Analysis: During the time of the anomaly the launch vehicle "attitude reference fail" check was being performed. EDS bus 1 was turned off and the astronaut was to verify no change in the panel 5 status light. However, he stated that the "Engine 8 out" light went off. This light came back on 8 seconds later as reported by the astronaut and verified on the voice tape. Data review showed no switching in the cockpit from the time the EDS bus 1 went off for approximately 39 seconds. No further information is available since this is the "B" side of the light and is not instrumented. The "Engine 8 out" light wiring has been checked for continuity both in the spacecraft and the launch vehicle with no abnormalities detected. An intermittent condition of this nature could be located anywhere in the system, however, the event could not have caused the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Items #37, 40, 87, 91, 92

TPS N/A

Observation: Water-glycol accumulator quantity starts decreasing at 2331:13.0 GMT. Glycol pump discharge pressure starts increasing at 2331:14.4 GMT. Accumulator quantity and glycol pump inlet pressure start increasing to upper limit at 3231:15.4 GMT. Accumulator quantity reached upper limit 2331:17.1 GMT. Glycol evaporator liquid temperature increasing at 2331:17.5 GMT.

Discussion and Analysis:

A decrease in the water/glycol (W/G) accumulator quantity was noted at 2331.13 GMT. The quantity indication continued to decrease until 2331.14 GMT.

During the time period 2331:06.4 to 2331:12.4 GMT, the cabin pressure increased from 16.40 to 16.94 and the battery compartment pressure transducer registered an increase from 16.70 to 18.05. Refer to Integration Analysis Summary #13.

The quantity measurement for the W/G accumulator is obtained from a transducer which monitors both the W/G and cabin pressure. The transducer W/G pressure is taken upstream of the accumulator bellows which are also vented to the cabin atmosphere. The bellows are designed to maintain a 7-9 psi differential pressure at the pump inlet and compensate for changes in cabin pressure. After the start of the fire the initial rate of cabin pressure increase was greater than the rate of pressure increase in the W/G lines. The W/G accur.lator transducer, accordingly, sensed the

increase in cabin pressure and interpreted this as a decrease in W/G quantity in the same manner as if the cabin pressure had remained constant and the W/G pressure had decreased.

The accumulator quantity continued to show a decrease until the W/G pressure (recorded at the pump inlet) began to increase at a very accelerated rate (2331:15.4 GMT).

The W/G accumulator quantity transducer again sensed the change in pressure differential and interpreted this as an increase in W/G quantity.

The accelerated rise of W/G pressure is attributed to boiling of the liquid within the lines when subjected to the intense heat of the fire. This phenomenon has been duplicated by testing.

A pressure rise at a slow rate was initially detected at both the inlet and outlet sides of the W/G pumps at 2331:14.4 GMT.

The rate of pressure increase and final pressure measurement for the outlet side of the W/G pumps were less than those recorded at the inlet side. This is attributed to the pumps acting as a restrictor since they are only designed to supply a 29 to 30 psi pressure to the system.

The late sensing of a temperature increase at the glycol evaporator (2331:17.5 GMT) is attributed to system lag. The normal flow sequence of the W/G subsystem during this test is from the pumps through the SM glycol radiators, GSE cooling equipment, W/G reservoir and finally to the glycol evaporator.

In summary, none of the above findings are considered to have contributed to the original cause of the fire but were initiated as a result of the fire. Data indicate that the W/G subsystem continued operating as an integral unit until after CM and line rupture at which time the glycol then acted as a fuel for the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 10, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Ground Support Equipment

Item #39
TPS N/A

Observation: Ground DC power commanded off at 2332:40.4 GMT

Discussion and Analysis: ACE data show that the ground DC power was commanded off at 2332:40.4 GMT and that power was off at 2332:47.4 GMT. This is in accordance with the emergency procedures.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Crew Equipment

Item #41
TPS N/A

Observation: Loose equipment which was stowed in the gas chromatograph compartment

Discussion and Analysis: TPS 583 (checkout TPS) on S/C 012 specified that the following loose items were to be stowed in the gas chromatograph compartment at crew ingress:

1. 2 each - 16 mm seq. cameras
2. 1 each - 16 mm power cable
3. 1 each - hygrometer control unit
4. 1 each - hygrometer sensor cable and sensor
5. 1 each - hygrometer power cable

These items were stowed in plastic bags. The bags were removed by the Spacecraft Technician and passed out of the spacecraft after Command Pilot ingress and prior to hatch close-out.

The six items listed above were still in the Gas Chromatograph Installation Area as of February 10, 1967. The aforementioned spacecraft technician believes that the items have been moved within the area, but there is no evidence to support this belief. The cables were still neatly coiled as they were before the test.

In addition to these six items, the gas chromatograph pyro cable connector and power/sensor cable

connector are believed to have been placed on the floor of the compartment. After the incident, the pyro cable connector was in place on the floor of the compartment; however, the power/sensor connector was found on the aft bulkhead.

The primary area of interest was to determine if the crew had utilized any of the above equipment thereby causing the gas chromatograph cable and connector to fall on the aft bulkhead, therefore providing an explanation for the final location of the chromatograph connector.

Follow-up investigation showed that cameras' lenses and film had not been stowed for this test. It is therefore concluded that no final determination can be made as to crew activity into this compartment.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD.

IN REPLY REFER TO

February 10, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Caution and Warning Subsystem

Item #42
TPS S/C 053

Observation: Elapsed time indicator failure on S/C 014 and ETI inspection on S/C 012

Discussion and Analysis:

The elapsed time indicator for the Caution and Warning System was overheated and charred as a result of a capacitor short during a test on S/C 014 during factory checkout at NAA/Downey.

This time indicator and associated noise suppression capacitor for the Caution and Warning System were physically examined on S/C 012 and found to be satisfactory with no evidence of burning.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March ??, 1967

INTEGRATION ANALYSIS SUMMARY

Item #44
TPS MA-003

System Affected: None

Observation: Bottle of MEK foun in white room

Discussion and Analysis:

A chemical analysis of the Methyl-ethyl Ketone (MEK) bottle found in the white room was completed in accordance with Board Action 0147.

The analysis determined that the material in the squeeze bottle was a very high quality MEK. The vaporization rate through the neck of the squeeze bottle in a controlled environment similar to the white room was established as seven millograms per hour.

Use of the MEK bottle on the day of the accident could not be determined.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 31, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control System

Item #45
TPS CM-CA-136
CM-CA-137

Observation: Two broken pressure transducers were noted on the ECU during post fire inspection

Discussion and Analysis:

The two transducers were identified as the suit inlet pressure and water glycol pump outlet pressure transducers. Both transducer connectors and associated wiring were damaged and electrical continuity checks showed all circuits open. No visual evidence of a fire path from within the transducers was found following removal of the covers. In addition, radiographic examination indicated no evidence of damage within the units

The cabin pressure and water glycol outlet pressure transducer data indicated normal operation both before and after the fire.

The cabin pressure exceeded maximum operating range (17 psia) of the cabin temperature sensor transducer at 23:31:13.4 GMT while the water glycol loop exceeded the transducer maximum operating range (60 psia) at 23:31:15.4 GMT.

It is concluded that the transducer damage did not contribute to but was the result of the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 1[illegible], 19[illegible]

INTEGRATION ANALYSIS SUMMARY

System Affected: Crew Equipment

Item #[illegible]
TPS N/A

Observation: Bonding Straps on Crew Couches missing

Discussion and Analysis:

There are four crew couches grounding straps in the spacecraft, two from the floor to the spacecraft wall and two from the Z-strut to the center couch. The two from the floor to the wall were installed, and the other two were missing. They had not been installed due to parts shortage.

Bonding checks on the crew couches made after the test indicate resistances in the order of 1 ohm. While this is high compared with normal bonding requirements of [illegible] ohms, it is low enough to prevent any static charge buildup. It is thus determined that lack of bonding straps did not increase the possibility of a static charge buildup on the couch relative to the command module structure.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 15, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #47
TPS S/C-082

Observation: Screwdriver caused an arc in wire harness (Ref. DR 0917 dated January 23, 1967)

Discussion and Analysis:

Investigation of this item was performed in accordance with Board Action 0060.

Discrepancy Report (DR) 0917 dated 1-23-67 states, arc drawn on technicians screwdriver during removal of cover panel for C15-1A52 J-Box.

Panel C15-1A52 is a wire junction panel located in the LEB, just left of the #3 inverter and below the gas chromatograph installation.

The technician was requested to remove the panel to allow for trouble shooting behind it. He removed the cover and the two holding screws on the left side of the panel and the bottom screw on the right side. To gain access to the top right screw, he removed bundle spot ties, separated the wires, and inserted the screwdriver between them. In the process of trying to remove the screw, the screwdriver drew an arc. An inspection was made of all the wires in the immediate bundle and one temporary wire repair was made with "mystic" tape. Since the screw head was so badly wollowed out, the screw was finally removed with a pair of vise grip pliers. Because of the offset of the plier jaws, it was not necessary to go between the wires for the screw removal. After the panel was unfastened, it was left ajar for access to accomplish the original purpose of the removal.

The next day a permanent fix of the damaged wire was made with heat shrinkable teflon tubing. The technician then redressed the wire bundle. He then re-installed the panel with the two screws on the left side of the panel plus the left bracket which holds the cover. The technicians on the next shift installed the two screws on the right side, plus the cover holding bracket, and the cover. Because new screws were used and the way the wires were dressed, it was possible to tighten the screws with the screwdriver at a slight angle without going between wires. No tests or reverification checks were made on the wires in the affected bundle.

To get a better understanding of the work which took place, a simulation was made on SC 014 with the same technicians who did the initial work on SC 012.

Inspection February 12, 1967 of SC 012 cover on C-15-1A52 J-Box revealed the following:

1. One wire adhered to the melted plastic on the bottom of the cover plate.

2. The unprotected bottom of the harness badly burned.

3. The portion of the harness behind the cover plate was in good condition.

4. The relay wires were scorched.

5. Nothing suspicious was noted at this time of the wire associated with screwdriver arcing incident.

Re-examination of the cover plate on March 3, 1967 revealed signs of possible arcing caused by another wire.

A final inspection on March 4, 1967 of the wires in the area involved with the screwdriver arcing incident found no evidence which can be attributed to initiation of the fire.

It is concluded that the area in which the wire was damaged by the screwdriver incident during the removal of the cover on C-15-1A52 did not contribute to the accident. However, the splitting of the wire bundles into two bundles and consequent rerouting of part of this bundle created the possibility for damaging adjacent wires in the wire bundle.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 10, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Ground Support Equipment — Item #48, TPS N/A

Observation: Configuration of ACE Control Room #1 and ACE Computer Room #1

Discussion and Analysis: ACE configuration established.

The ACE Control Room #1 and Computer Room #1 configurations have been defined and studied. All of the data indicate that the system operated properly, that no spurious commands were transmitted, and in no way contributed to the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: CM Floodlights

Item #49
TPS(s) CM-CA-054
CM-CA-053

Observation: Review of past floodlight failures and floodlight examination and testing

Discussion and Analysis:

Board Action 0169 directed the removal and investigation of the SC CM floodlights.

Removal and inspection of the floodlights were conducted in accordance with TPS CM-CA-053. Testing and evaluation of test results were conducted in accordance with TPS CM-CA-054.

Six qualified CM Interior Light Circuits were installed in SC 012 CM. These included the Left Hand Overhead (LHOH), Right Hand Couch (RHC), Left Hand Couch (LHC), Right Hand Strut (RHS), Left Hand Strut (LHS) and Right Hand Overhead (RHOH).

All interior lighting floodlights gave physical indications of having sustained extensive fire damage.

Of the six circuits that were known to be operating prior to the fire, three survived and functioned normally within the specification current limits following removal from the SC. The secondary circuits were not energized during the fire. All six of these circuits survived and functioned normally within specification current limits.

The three non-functioning circuits were the LHOH, RHOH and RHS primary circuits. These circuits were open and did not draw an imput voltage up to 28 VDC.

Item #49 (cont'd)

Visual examination of the aforementioned 3 lights indicated that they had been exposed to higher external temperatures than the other lights.

Tests performed by the vendor indicate that the inverter circuit of the lights will cease commutation at temperatures between 230 and 250°F. Failure of the circuit to commutate results in approximately 10 amps current drain and opening of a fuse is approximately 500 microseconds at six amps. After fuse opening, the circuit is open and does not draw current.

Since the lights that contained the non-functioning circuit were the same ones which sustained the higher heat damage it is deduced that their circuits reached temperatures above 230°F and decommutation caused their associated fuses to open.

In summary it is concluded that the floodlights were not an initiator or major propagator of the fire. In addition, the damage to their exterior surfaces and opening of the three primary circuits were caused by exposure to the CM fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 10, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Cryogenic Gas Storage Subsystem — Item #50, TPS N/A

Observation: H_2 tank fan motor variation at 2326:30.4 GMT

Discussion and Analysis:

Variations similar to those noted at 2326:30.4 GMT appeared periodically prior to the accident.

Test Procedure for OCP-K-0021 requires that all GSE access connectors be disconnected during this test.

It was verified that GSE access connector J22 was not connected at the time of the accident. Connector J22 normally carries the H_2 Fan Motor measurement (SF0363V).

Verification was accomplished by physical checks at LC34, 2030 GMT, February 2 and by review of Quality Control LC34 checklist, FO-K-10011, for OCP-K-0021.

The H_2 tank fan motor variation noted at 2326:30.4 GMT is attributed to random noise. This incident did not contribute to the S/C 012 accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 15, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Stabilization Control Subsystem — Item #51, TPS S/C-022

Observation: Hole in the translation hand controller

Discussion and Analysis:

The translation control was mounted on CM 012 at the L/H side of the L/H couch and was noted after the accident to have a relatively large part of the upper R/H rear corner missing.

The translation control was inspected for fire damage at the MAB laboratory with the following results:

a. In general, the damage due to fire and intensity of charring and sooting is most evident at the upper right rear corner. Charring and sooting diminishes from that corner in general toward the bottom front area and the bottom rear area where little evidence of soot or heat searing is visible.

In this initial inspection, it did not appear that heating came from within the device. It also appears that the missing cover corner has been caused by a blow from the outside after the cover had heated above an embrittling temperature (greater than 1000°F). (Ref. Summary Report of TPS PIB-002)

b. The translation control was functionally tested and verified to be functioning normally. This indicates that the fire damage did not degrade the functional performance of the device. (Ref. Summary Report of TPS PIB-005.)

It is determined that the hole in the translation controller did not result from an action which may have contributed to the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 15, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Waste Management Subsystem

Item #52
TPS N/A

Observation: Waste Management Subsystem blower failure (S/C 008)

Discussion and Analysis:

The Waste Management Subsystem (WMS) blower motor failed on S/C 008 after approximately three hours of continuous operation. Normal operation of the blower is for short periods (approximately five minutes or less) to provide gas flow only for the vacuum cleaner. Previously, the blower was used to provide gas flow during collection of urine and feces. Due to a design change, the WMS blower is no longer utilized during these operations and the hard lines involved connecting the blower to the selector valve have been disconnected and plugged. However, the electrical control of the blower by the selector valve has not been changed. Therefore, when the selector valve is moved to either the urine or feces position, the blower is started and forced to operate against a dead headed system. S/C 012 Waste Management Subsystem configuration was the same as S/C 008.

The WMS blower selector switch per recorded configuration was off at pre-ingress of the crew. Review of the OCP-K-0021 shows that the WMS blower selector switch was off immediately prior to the accident. Also, post test switch check list shows the WMS selector switch in the off position. Therefore, it is determined that WMS blower did not cause the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control System
Guidance and Control System

Item #53
TPS CM-CA-220

Observation: A survey should be made of the failure history of heaters of the types used on the spacecraft to determine if any failure modes can be related as a cause of the accident.

Discussion and Analysis: The following heaters were on board the spacecraft:

(a) Potable water heater - not powered for the Plugs Out Test
(b) IMU Heaters - no electrical short or burn-up type failures have occurred for this type of heater. These heaters were in sealed units.
(c) Eyepiece Heaters - one reported failure due to broken heater cable caused by insufficient cable length. The cable was lengthened.
(d) Gyro Heaters - two "out-of-spec" failures reported (tolerance $\pm 2^{\circ}$F). No electrical short or burn-up type failures. These heaters were in sealed units.
(e) Steam Duct Heater - not powered for the Plugs Out Test
(f) Urine Dump Heater - not powered for the Plugs Out Test

The review of failures on the S/C 12 heaters and of these generic types of heaters show no evidence of problems which could be associated with the accident.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #54
TPS N/A

Observation: Leakage of Water/Glycol

Discussion and Analysis:

There has been a history of water/glycol leakage and spillage in spacecraft 012. Some of this occurred during tests at the factory and some occurred before and during the removal of the ECU at KSC. The characteristics of the inhibitor used in the coolant water/glycol fluid leaves a residue that is electrically conductive, hygroscopic and flammable. Leaks of water/ glycol occurred in the lower equipment bay and Environmental Control Unit area during earlier tests on Spacecraft 012. These leaks were mopped up and connectors and accessible wire harnesses were washed with distilled water and alcohol, and dried with nitrogen.

After the accident, all connectors were carefully disconnected, photographed, and inspected for any signs of internal burning or arcing. No evidence of internal arcing or burning was found which indicated a fire source. However, if the leakage or spillage had not been adequately cleaned up, it would provide a flame propagation path.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: CM Reaction Control Subsystem

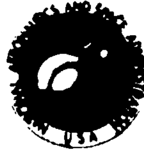
Item #55
TPS N/A

Observation: CM Reaction Control Subsystem (RCS) thruster temperature indicates pressure shell rupture

Discussion and Analysis:

Measurement CR 4501T CCW engine wall "A" system CM RCS showed nominal outside air temperatures (67.7°F) until 2331:19.8 GMT.

This time matches well the time indicated by G&N measurements and pressure measurements for pressure shell rupture (approximately 2331:18 to 2331:19 GMT). It is determined that the high temperature indicated by the RCS engine is an effect of the release of flame in the area by the pressure shell rupture.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 2?, 19?7

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #56
TPS S/C-061
CM-MA-005
CM-MA-00?

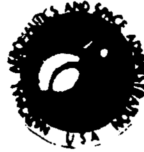
Observation: Lithium Hydroxide Canisters utilized were non-flight configuration

Discussion and Analysis:

The lithium hydroxide (LiOH) canisters utilized during the conduct of OCP-0021 were unqualified, non-flight configuration and did not contain the 50% bypass provisions incorporated in the improved flight canisters.

A detailed review of the data associated with the crew oxygen suit loop indicates normal temperatures and circuit integrity until approximately 10 seconds after the "fire" call. At 2331:16 GMT both the suit supply temperature and LiOH canister outlet temperature started increasing which indicates loss of pressure suit circuit integrity, thus allowing warm gasses to be drawn into the suit compressor and thru the LiOH canister.

From the above it has been concluded that integrity of the LiOH canister remained until after the start of the fire. Also damage to the canisters was a result and not the cause of the accident.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 15, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item #57, TPS S/C-007

Observation: Analysis of gas from the two Beckman Analyzers

Discussion and Analysis:

Two (2) Beckman Oxygen Analyzers were located in the Pad 34 S/C White Room to extract cabin and suit gas samples. Serial No. 4 analyzer was utilized in extracting the first cabin gas sample after a twenty (20) minute purge. S/N 3 analyzer was utilized in extracting the suit gas sample and the second cabin gas sample after a ten (10) minute additional purge.

The MAB performed a lab analysis of gas samples taken from the analyzers to determine the presence of contaminants which would be indicative of cabin contamination (reference TPS S/C 012-007).

The determinations of the MAB lab analysis are as follows (reference Report MAB-1?1-67, dated February ?, 1967):

1. Neither of the analyzers contained significant gaseous materials (more than 500 ppm) of anything other than air components. The S/N 3 analyzer did contain trichlorethylene, most of which was absorbed in the gel cartridge.

2. The air in the analyzers can be accounted for by one and probably both of the following:

a The bulbs were squeezed by someone before being impounded.

Item #57 (cont'd)

b. The time delay (approximately one week) between use and analysis resulted in air leakage into the system and/or sample loss. .

Upon completion of the lab analysis, both analyzers were checked by measuring their response to ambient air, 100% aviators breathing oxygen and 100% nitrogen. The results are as follows:

1. Serial No. 3 analyzer

   a. Ambient air - 20% O_2 reading

   b. 100% O_2 - 100% O_2 reading

   c. 100% N_2 - 0% O_2 reading

2. Serial No. 4 analyzer

   a. Ambient air - 14% O_2 reading

   b. 100% O_2 - 100% O_2 reading

   c. 100% N_2 - Below O_2 reading

It is determined that the analysis of gas samples taken from the two (2) Beckman Oxygen Analyzers has given no indication of cabin contamination which may have contributed to the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Communication Subsystem

Item #58
TPS N/A

Observation: On-board recording equipment and electrical connector configuration

Discussion and Analysis: The following recording devices were on-board S/C 012 at the time of the incident:

a. FQ Recorder, V16-754102, S/N Flt 12
This recorder was loaded with tape, the cover was installed and the recorder was electrically connected. The recorder was not on at the time of the incident and would not have been turned on until into the mission run section of the test.

b. DSE Recorder, V16-714385, S/N BAD0003
This recorder was loaded with tape, the cover was installed and the recorder was electrically connected. The recorder was not on at the time and would have been turned on immediately prior to liftoff.

c. MDAS, Part #511076, Serial #6721A
This system was connected to the Senior Pilot, after crew ingress and was in operation from ingress through the incident.

d. DSEA Recorder S/N 104
Note that only one DSEA recorder was installed on the spacecraft. This recorder was installed in the #2 slot, the alternate slot, and existing paperwork indicates the recorder was connected. Physical verification on 4 February indicated that a DSEA recorder was located in the

alternate position, but that neither the power cable was connected to the recorder nor was the adapter cable connected to the recorder. The power cable at the DSEA end was not capped. Due to the activation of S13 and CB49 on Panel 22 AC power was present at the DSEA end of the cable and DC power was present due to the activation of CB 96 on Panel 22.

Inspection of the DSEA cable showed no evidence of arcing.

There is no indication that any of the on-board recording equipment was the cause of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Crew Equipment

Item #61
TPS N/A

Observation: A survey should be made to evaluate the potential magnitude of electrostatic energies in the Command Module.

Discussion and Analysis: Exploratory tests with suit materials and other nonconducting materials used in the spacecraft indicated that large electrostatic energies could be generated, retained and discharged. As a result of the exploratory tests a detailed test program was generated to evaluate the potential magnitude of electrostatic charge buildup and the possibility of a discharge igniting materials or gases in the area of the discharge. Details of these tests can be found in the Panel #8 Final Report.

The electrostatic testing determined that ignition of solid materials by electrostatic discharge is not a probable explanation of an ignition source for the accident.

It is concluded that electrostatic energies from the Command Module non-conducting materials did not contribute to or cause the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 17, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #62
TPS CM-CA-121

Observation: Investigate water glycol pump failure on S/C 008 and inspect S/C 012 pumps

Discussion and Analysis:

The plastic pump cap configuration on S/C 008 water glycol pump allowed leakage which contributed to the pump motor failure.

The S/C 012 water glycol pumps utilized an inconel cap between the magnet side and the magnetic motor side.

Investigation of the ECU water glycol pump was conducted in accordance with Board Action Item #0168.

Tear-down of the pumps revealed that the inconel caps had allowed no leakage and that the motors were in satisfactory condition. It is noted that the water glycol pumps operated satisfactorily before, during and after the fire.

It is concluded the S/C 008 water glycol pump failure was not duplicated on S/C 012 and that the S/C 012 water glycol pumps did not contribute to the initiation of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March [illegible], 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control System

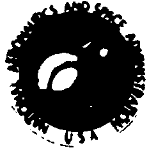
Item #[illegible]
TPS N/A

Observation: Sharp increase in oxygen flow rate, to measurement limit at 2324:03 to 2324:[illegible] GMT.

Discussion and Analysis: Communications and bio-medical data indicates crew activity at this time.

It has been determined from previous tests and early in this test that oxygen flow rates are affected by crew movement and activity.

It is concluded that the sharp increase in oxygen flow rate was caused by crew activity.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 23, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #64
TPS N/A

Observation: Excessive alarm time observed following high oxygen flow indication at 2145:54 GMT

Discussion and Analysis: The oxygen (O_2) flow transducer assembly, C23A2A5, has two outputs; an analog to the data system (PCM and cabin meter), and an event to the 15 second time delay associated with the input to the caution and warning system. The PCM system saturates (reads full scale) at a transducer output of 5.0 volts. Information from AiResearch acceptance testing of this particular transducer assembly indicates the event output does not trigger until the analog output reaches 5.3 volts.

At 21:46:21.5 GMT the master caution was triggered by the 15 second time delay. This was 15 seconds after the H_2O cyclic accumulator assembly had cycled. It is assumed that the accumulator step O_2 flow (the PCM input was saturated at 5 volts as previously noted at 21:45:54 GMT) and was sufficient (above 5.3 volts with a step requirement) to immediately close the "reed" relay (event output) in the O_2 flow transducer assembly. The original high O_2 flow was at a sufficient level or had increased to a sufficient level during the H_2O accumulator cycle to hold the "reed" relay in when the accumulator cycle was complete.

Item #64 (Cont'd)

It can be inferred that this was not a malfunction because this period of high O_2 flow was interrupted by cyclic accumulator action, and because the time delay worked properly at all other times including during the accident. It is concluded that this delay system had nothing to do with the cause of the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 1., 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Instrumentation Subsystem

Item #
TPS 054

Observation: Elapsed Time Indicators, post test inspection

Discussion and Analysis:

All Elapsed Time Indicators (ETI's) used on S/C 012 which are not qualified as flight hardware and were to be removed prior to flight were inspected after the accident. (Reference TPS S/C 012-054).

Excessive external heat indications were observed on all ETI's but there were no visual indications of short circuits. There were no ETI's installed on the C-band transponder, VHF-FM transmitter or HF transceiver and covers were not installed on the connectors. There were no shorting indications observed in the open connectors.

It is determined that the ETI's inspected did not cause or contribute to the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 7, 1967

INTEGRATION ANALYSIS SUMMARY

Item #59
TPS N/A

System Affected: Environmental Control Subsystem

Observation: ECS Fire at AiResearch

Discussion and Analysis:

A fire occurred on April 28, 1966 in the AiResearch altitude chamber used to simulate the Command Module while the Apollo Environmental Control System (ECS) was undergoing a mission-life qualification test. The incident took place after completing 480 hours of a scheduled 500 hour test.

The most probable cause of the fire was a failure of the commercial-quality strip heater used to add heat to the steam duct to preclude freezing of water in the duct. A number of commercial grade electrical heater tapes were wrapped around a number of lines as part of the test or support equipment. Heating tape was being used to raise the steam duct temperatures when the incident occured. The heater tape wire was demonstrated to extrude through the insulation and a fire was initiated under simulated conditions.

It is determined from the above that the ignition source encountered during the ECS qualification incident cannot be associated with the cause of the S/C 012 accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 17, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Communications Subsystem

Item #70
TPS N/A

Observation: VHF-AM receiver failure encountered on S/C 008

Discussion and Analysis:

The VHF-AM receiver #1 failed during a thermal vacuum test on S/C 008. The receiver was returned to Collins Radio Company for checkout and found to function normally. Additional investigation of the spacecraft circuitry revealed that the wire harness between the MDE panel 20 receiver select switch and receiver 1 and 2 had been partially cut and some corrosion was noted on the bared conductors. The harness was spliced and additional tests run.

It is determined that this failure has no applicability to S/C 012 and the cause is attributed to a cut wire rather than a system or component.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 7, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem — Item #71, TPS N/A

Observation: Suit loop return valve leak encountered on S/C

Discussion and Analysis:

During performance of Test #3 on S/C 008, it was noticed that there was atmospheric air in the suit loop (nitrogen contamination) following crew ingress. It was determined that the cabin air entered into the suit loop through the Suit Circuit Return Air Check Valve due to a low Δ-P across this valve assembly. A check of the leak specification on the valve assembly showed that the rate of increase of N_2 in the suit loop was within the allowable leakage. A procedure change was made for S/C 012 which required cracking of the Direct O_2 Valve to maintain positive pressure in the suit loop after crew insertion.

It is determined from the above that the leakage problem encountered on S/C 008 cannot be associated with the cause of S/C 012 accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March , 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Stabilization & Control Subsystem

Item #70
TPS N/A

Observation: Manual Thrust Vector Control (MTVC) Engage came on for five seconds on earlier tests of S/C 012.

Discussion and Analysis:

The MTVC Engage (CH1134) Event Light was seen to come on without actuating the translation control on the following occasions:

1. During Chamber Pump-Down (4 ,000 ft.) for unmanned altitude run of OCP-K-0034A on December 28, 196 . Extinguished after eight seconds.

2. During OCP-K-0005A, apparently while the crew couches were being moved. The light went out with no activity after two seconds.

3. During OCP-K-0005A with no activity in the spacecraft. Light went out when SSRP moved the crew couches.

On the first occasion, the SCS was in the monitor mode with the Delta V Switch "ON". The two other times the light was seen, the SCS was in SCS Attitude Control (Delta V switch - OFF).

An attempt was made to activate the MTVC Engage while in the SCS Attitude Control Mode by turning the Translation Hand Controller (THC) clockwise without success. This action showed that MTVC could not have accidentally been activated to cause the two indications in OCP-K- A (2 and above).

Connectors were wiggled, partially demated and wiggled, and then reconnected in an effort to make the MTVC Mode light come on, but the light stayed out.

With the SCS in the same configuration as it was in OCP-K-0034A (Monitor Mode and the Delta V switch ON), the THC was rotated to MTVC (CW). Observations were made which showed the switch could be detected by other SCS measurements (CH0074 and CH1074 and BMAG outputs). OCP-K-0034A data were reviewed and no activity on CH0074, CH1074 or the BMAG outputs was seen.

Later the Yaw ECA was removed for another problem and the MTVC Engage Signal Conditioner was tested in the Bench Maintenance area and proved to be within specifications. This ECA was then sent to Honeywell for evaluation and the spare Yaw ECA was installed in S/C 012. Threshold level of the PCM system signal conditioner was also tested and found to be in tolerance.

Based on troubleshooting data, the following conclusions have been reached:

1. The MTVC Engage indications in the three instances above were "FALSE" indications since none of the data from OCP-K-0034A or OCP-K-0005A indicated any actual engagement of MTVC (no activity on CH0074, CH1074, or the BMAG outputs.)

2. The malfunction is probably in the harness between the SCS and the PCM system. An intermittent open in a wire or connector would cause the indications.

3. The indication received during the accident in OCP-K-0021 was real. Data review showed activity on CH0074, CH1074, and the BMAG outputs which correlates with the indications received during troubleshooting.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #[illegible]
TPS N/A

Observation: AC Bus phase C short during prior test on Spacecraft 1[illegible]

Discussion and Analysis: AC Bus [illegible] phase C shorted during troubleshooting of IDR [illegible]. The short was J[illegible]9/GSE Pin V to ground and happened while trying to make a voltage measurement on AC Bus [illegible] phase C. The shorted instrumentation circuit contains a 1/[illegible] amp instrumentation fuse (F[illegible], C14A1[illegible]). The blown fuse was removed and replaced with a like unit.

Blowing fuse F[illegible] (1/[illegible] amp) in the instrumentation circuit is not considered to be harmful to the AC[illegible] power system. Therefore, it is concluded that this prior concurrence has no correlation with the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 24, 1967

INTEGRATION ANALYSIS SUMMARY

Systems Affected: Sequential Subsystem

Item #75
TPS N/A

Observation: DRS692 dated 11-27-66 indicated that the terminal wires were exposed on the 15 second timer C23K1 relay

Discussion and Analysis:

The permanent installation and removal record shows that the time delay module was removed from the C15-1A52 panel; and, without violating electrical connections, the exposed wires were potted, and the module remounted. Since the electrical connections were not violated functional retest of the unit was not required.

Post accident evaluation of the relay has shown that the potting on the relay is intact and that the relay was properly installed.

Data review shows that the relay performed its function (15 second time delay from the time of Oxygen High Flow Rate to Caution and Warning Light Function) properly several times during OCP K-0021-1.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Displays and Controls Subsystem

Item #76
TPS(s) CM-CA-030
CM-CA-031
CM-IV-041

Observation: Review of Main Display Console (MDC) Panel 24 difficulties on S/C 012

Discussion and Analysis:

The investigation of MDC Panel #24 was carried out as directed by Board Actions 0145, 0153 and 0160 and in accordance with TPS (s) CM-CA-030, CM-CA-031 and CM-IV-041.

Review of the summary of difficulties which were encountered during fabrication and installation showed that all had been properly dispositioned.

When the MDC Panel #24 was removed and inspected, two areas were observed to require special investigation. These areas were the wire bundles between the Emergency Detection Subsystem (EDS) Power Switch and the Sequence Arm Switches, which showed heat damage and the positioning of the Body-Mounted Attitude Gyro (BMAG) Switch. Discussion and analysis of the BMAG Switch is contained in Integration Analysis Summary Item #99.

Inspection of the wire bundles revealed no visible damage from the burned area to the connectors.

Continuity tests of the panel in the as-found condition showed all normal continuity and circuit resistances. The continuity tests in all other switch positions for Panel 24 also showed normal continuity and circuit resistances.

Analysis of these tests showed that electrical continuity was present after the fire and that no damage of a significant nature had been incurred by the switches, panel wiring or connectors.

It is concluded, accordingly, that the charring of the EDS switch and associated wiring was caused by an external flame source and not by heat generated internally in the switch. In addition, the components of the panel were not a source or a major propagator of the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

Item #17
TPS N/A

System Affected: Launch Vehicle

Observation: Three Saturn S-IVB measurement anomalies were noted at 2305:44

Discussion and Analysis: The measurements were:

(1) LOX tank ullage pressure. EDS #2
(2) External aft skirt pressure, POS #2
(3) 5 volt excitation voltage aft

The level of (1) and (2) increased to 100%. (3) increased to the 100% level more rapidly

The reason for this data change has not been found, but at this time it is felt to be unrelated to the incident. One of the Meas., LOX tank ullage pressure, EDS #2, does interface with the IU and is terminated and open ended in the IU/Spacecraft interface plug

Due to the large time difference between the time of these transients and the Fire Report, it is unlikely that they have any relation to the accident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March [illegible], 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #[illegible]
TPS S/C-[illegible]

Observation: "Buttermilk Odor" was detected in the Suit Circuit

Discussion and Analysis:

The evaluation of the "buttermilk odor" involved the review of the K-bottle analyses of the source, the Beckman Analyzer analyses, the gas sample (Watermelon 1-1) taken at the crew mouthpiece and earlier sample analyses from [illegible] to [illegible]

The review of the K-bottle analyses revealed no unusual impurities and the gas analyses met specifications as required.

The analyses of gas from the two Beckman Oxygen Analyzers revealed no significant information on "buttermilk odor" and the gas was essentially air.

The gas sample taken at the crew mouthpiece (Watermelon 1-1) had two analyses. The first analysis revealed approximately [illegible] ppm of unidentified hydrocarbons which could contribute to an odor condition. A second analysis of the same Watermelon 1-1 sample was run by the Materials Analysis Branch (KSC) in an effort to identify the hydrocarbons with hopes of isolating suspect materials. This second analysis revealed no useful information due to the dilution of the sample and time span since the sample was taken.

Item #18 (cont'd)

A summary of previous analyses, including earlier manned altitude testing samples, revealed no significant information to identify any "buttermilk odor".

No particular suspect item was identified as emitting a "buttermilk odor" although some of the RTV potting compounds have unique, pungent odors that probably come closest to fitting this odor description. These materials are RTV [illegible], [illegible], and [illegible] which have been used in the spacecraft.

None of the reports of odors discloses any area of suspicion relating to the origin of the odor.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Stabilization and Control Subsystem

Item #[illegible]
TPS CM-IV-[illegible]

Observation: SCS Yaw ECA Female Connector J[illegible] had Blackened Areas

Discussion and Analysis:

Spacecraft connector J[illegible], which attached to Yaw ECA mating connector P2[illegible], had blackened areas around the receptacles for pins [illegible], [illegible]1 and [illegible] which appeared to have resulted from arcing. None of these pins saw voltage at the time of the accident.

Connector J[illegible] has been closely examined and the receptacles show to be perfectly clean with no indications of soot.

Mating connector P2[illegible] has been closely examined and the interior around the pins shows to be perfectly clean with no indications of soot, arcing burned spots or degradation of the rubber humidity seal.

The history of connector J[illegible] was investigated and it was found that the section which appears to be blackened had been chipped and potted prior to the fire. This potting was done only to continue the humidity seal and was not required electrically.

It has been determined that the potting compound used on connector J[illegible] became heated and discolored during the fire, thus appearing to have been the result of an arcing condition. Two (2) other pins indicated hot spots around the receptacles. These pins were [illegible] and [illegible] which are both spares and see no voltage.

The suspected connector had nothing to do with the fire.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 23, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Stablization & Control Subsystem

Item #80
TPS N/A

Observation: Plus roll output observed at 2331:14.5 to 2331:15.0 GMT

Discussion and Analysis: A plus roll output was indicated at 2331:14.5 to 2331:15.0 GMT. A special test was conducted at MSC which showed that the rotation controller will give an output when hit even though the handle is pinned and locked. The handle was found pinned and locked, and the date therefore indicates a physical blow to the controller by one of the crew members.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

March 9, 1967

INTEGRATION ANALYSIS SUMMARY

Item #81
TPS N/A

System Affected: Electrical Power Subsystem

Observation: Gassing characteristics of the pyrotechnic batteries

Discussion and Analysis:

The battery complement in the command module consists of three entry batteries and two pyrotechnic batteries. The entry batteries have their individual vents manifolded to an overboard vent line while the pyrotechnic batteries vent into the cabin through their relief valves (cracking pressure set at 30±5 psi).

A preliminary test has been conducted utilizing two pyro batteries, one at normal room temperatures and one at 105±5°F. Pressure increase data indicated only a two psi rise during a sixteen (16) day period on the battery at room temperature. The pressure increase on the battery at 105±5°F had an estimated worst case rise of approximately 21 psi. (This pressure increase had to be estimated due to an instrumentation malfunction during the first 24 hours of the test.) Based on the above pressures increase and adding 10 psi to simulate flight conditions (15 psia ground level to 5 psia in orbit), only the battery at 105±5°F would have vented

Post test inspection of S/C 012 batteries showed they were electrically functional and there was no physical evidence to indicate the existence of an electrical defect, arcing, or self-provided hot spots.

As the cabin temperature in Spacecraft 012 during the conduct of OCP-K-0021-1 was normal throughout the test until the fire, it is concluded that the pyrotechnic batteries relief valve did not relieve and therefore did not cause the incident.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

February 23, 1967

INGEGRATION ANALYSIS SUMMARY

System Affected: Stabilization & Control Subsystem

Item #82
TPS N/A

Observation: MTVC engaged: 2331:18.5 GMT.

Discussion and Analysis: MTVC (manual thrust vector control) is initialed by a clock-wise rotation of the translation controller T-handle. For some unknown reason, the MTVC was engaged at 2331:18.5 GMT. There has been speculation as to how and why it was turned, but the answers are not considered significant. Nothing more can be gained from a study of this item.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Crew Station

Item(s) #83 & 84
T.P.S. N/A

Observation: Moderate increase in the Senior Pilot's heart rate at 2330:22 GMT followed by a high increase rate starting at 2331:04 GMT

Discussion and Analysis: At 2330:22 GMT there was some change in the respiration pattern and a moderate increase in heart and respiratory rates. These data are consistent with some increase in the Senior Pilot's activity, but do not indicate the degree of activity that would be expected had the Senior Pilot been aware of an emergency situation. At 2330:50 to 2330:55 GMT this data had started returning toward baseline levels.

At 2331:04 GMT there was a marked change in the Senior Pilot's respiration and heart rate. There was also evidence of muscle activity in the EKG trace and evidence of motion in the phonocardiogram. The heart rate continued to climb until loss of signal. This physiological response is compatible with the realization of an emergency situation.

The data obtained from the on-board MDAS tape correlates with the above.

ENCLOSURE 18-53

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

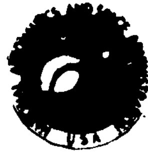
INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power System and Scientific Equipment

Item #85
TPS V16-001-093(MSC)
CM-CA-074

Observation: Shorting in the MDAS octopus cable and connectors.

Discussion and Analysis: Short circuits were found on the octopus cable near connector J 185. The wiring to this connector provides power and bio-medical instrumentation signals to the Medical Data Acquisition System (MDAS). This cable was subjected directly to the flame within the command module and therefore was badly burned. The power circuit breakers were found open after the fire, however, the MDAS was still operating until cabin rupture. The shorted condition on the octopus cable was between the J 185 connector and the MDAS recorder. The DC wires were also shorted near the left end of the gas chromatograph compartment floor. The shorting on the octopus cable was found to be superficial and a result of the fire.



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 7, 1967

INTEGRATION ANALYSIS SUMMARY

Systems Affected: Crew Biomedical - Communications

Item #86
TPS N/A

Observation: Astronaut shocked during S/C 101 Crew Compartment Fit and Functional (C^2F^2)

Discussion and Analysis:

The subject short circuit experienced in S/C 101 C^2F^2 at Downey occurred within the crewman's biomedical communications torso harness rather than the cobra cable assembly. This failure occurred because of the following conditions:

1. The torso harness used was of Block I configuration and was in poor condition due to previous usage.

2. The electrical wiring of the Block I harness was not compatible with the Block II biomedical conditioners used. Although the two systems (harness and signal conditioners) will operate properly, a short such as the one which occurred will cause the 16.8 VDC biomed power to be routed to the chest ground electrode on the crewman.

3. The condition of the harness caused a shield to short 16.8 VDC power due to a break in the shield wiring and the ribbon encasing the wiring.

If the same short had occurred in the S/C 012 configuration, the voltage could not have been transferred to the crewman's chest electrode due to these shields not being carried through the harness and signal conditioners on Block I hardware. The only shields on Block I hardware are floating at the DC-DC converter signal conditioner inputs (16.8 VDC power).

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

Item #89
TPS S/C - 088

System Affected: Sequential Events Subsystem

Observation: The integrity of the Q-Ball circuit should be evaluated

Discussion and Analysis: The Q-Ball was not electrically mated for the plugs-out test (OCP-0021), however, the cable was powered up to the Q-Ball connector. Pin to pin and pin to ground resistance checks revealed no anomalies in the Q-Ball cable. Physical evaluation revealed that the connector of the Q-Ball was mated with the storage connector.

Based on the above data it is concluded that the Q-Ball circuitry did not contribute to or cause the accident.

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Subsystem

Item #90
TPS N/A

Observation: Suit flow indication at low limit for Command Pilot from 2331:18.5 GMT through loss of signal (LOS), Senior Pilot from 2331:18.5 GMT through LOS, and Pilot from 2331:19.6 GMT through LOS

Discussion and Analysis:

Initial review of suit flow PCM data indicated that the final suit flow for the crew members dropped to the lower limit at 2331:18.5 GMT and 2331:19.6 GMT. Further review of the data has revealed that a LOS occurred from 2331:17.4 to 2331:18.4 and that actually all the crew suit flows dropped to the lower limit starting at 2331:16.2 GMT. All suit flows remained at these lower readings until total loss of all S/C communication data. Information concerning crew suit flow indications from 2331:12.9 GMT to 2331:16.2 GMT is contained in Integration Analysis Summary Items #27 and 38.

S/C telemetry data and analytical analysis has determined that the cabin to ECS suit loop differential pressure had increased to 2 psid. This was caused by extremely rapid rate of rise in cabin pressure between 2331:12.4 GMT and 2331:16.2 GMT.

The high differential pressure between the cabin and the suit loop caused the Command Pilot's and Pilot's suit material to be forced against their bodies thereby stopping suit flow.

The Senior Pilot's suit inlet hose was found disconnected following the accident. (Refer to Integration Analysis Summary Items #25 and 102). The aforementioned differential pressure caused cabin atmosphere to reverse the normal flow path and flow back into the ECS suit loop via

Item #90 (Cont'd)

the Senior Pilot's disconnected suit inlet hose.

The arresting of suit flow in the Command Pilot's and Pilot's suit and the reverse flow in the Senior Pilot's suit inlet hose caused the suit loop differential pressure (measurement CF 0148) to drop to zero and the suit compressor differential pressure (measurement CF0137) to drop to a low telemetry reading.

The suit loop differential pressure is measured from a point on the suit supply line above the suit flow limiters to a point on the suit return line above the suit compressor. Telemetry data indicated a sharp rise in suit loop differential pressure starting at 23:31.12.4 GMT until 23:31.15 GMT at which time the restricted suit flow caused the suit loop differential pressure to drop to zero.

Based on the above it is concluded that the ECS system continued to operate in the abnormal environment and that the suit flow telemetry data is valid.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 18, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Communication Subsystem

Item #93
TPS N/A

Observation: Command Pilot had a live microphone

Discussion and Analysis:

The actual cause of the open microphone is not known at this time. Analysis was made of voice recordings taken during on-board troubleshooting by the crew and compared with schematic diagrams. This analysis has isolated the cause to the push-to-talk (PTT) or keying line that runs between the Cobra Cable, translation controller, Command Pilot audio control panel and audio center

1. The separate components have been checked for resistance to ground. All lines measured "open" which is correct.

2. The spacecraft wiring was checked and a 3000 ohm resistance resistance was measured to ground. This 3000 ohm resistance could account for the keyed microphone. However, this resistance could be a result of the fire damage to wire bundles. Later, when an attempt was made to locate the cause of the 3000 ohm resistance, the measurement could not be duplicated. The circuit now measures "open", which is normal.

3. The translation controller PTT button was pushed and released ten times. On the fifth try the button stuck down If the button had stuck during the S/C-012 test the microphone would remain keyed.

Item #93

Post incident review of switch positions in Command Pilot's audio control panel indicate that all switches were in the positions expected. When in this configuration current drawn by the keying line is limited to 20 milliamps at 28 volts. Tests run with a cobra cable show that no sparks were generated with 28 volts and 150 milliamps.

The cause of the live microphone has been attributed to picking up a ground somewhere in the Command Pilot Push-to-Talk circuit in the Spacecraft. The specific source of the ground has not been established. This malfunction, electrical in nature, is not considered to be a fire initiation source. This malfunction may have contributed to the accident, by prompting the crew to be doing some activity to assist in clearing up the overall communications problem.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Environmental Control Sybsystem

Item #94
TPS. S/C-116
CM-CA-179

Observation: Initial investigation determined cabin air Fan No. 1 shorted

Discussion and Analysis:

The cabin air Fan No. 1 circuit breakers for AC phases A and C were found to be open after the accident. Also electrical tests of the fan in the spacecraft indicate the shorted phases. Cabin air Fan No. 2 was found to be in satisfactory condition.

Cabin Fans No. 1 and No. 2 are powered by AC bus 1 and AC bus 2, respectively. Twenty-two gauge wires are utilized, and each phase is protected by a 2 amp circuit breaker. The fans are located in the left-hand forward equipment bay.

Continuity tests of the cabin air Fan No. 1 after removal verified that all pin to pin and pin to ground readings at nominal values. The suspected shorts were determined by tests and inspection to be in the power on plug cable.

Based on the above it is concluded that the cabin air Fan No. 1 did not contribute to the cause of the fire. This determination is based upon the lack of fire propagation material in the area. The physical inspection of the fan itself does not indicate it to be the fire initiation source.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

Systems Affected: Electrical Power Subsystem
Environmental Control Subsystem

Item #95
TPS N/A

Observation: Determine if the teflon wire insulation for the Environmental Control Unit harnesses and the gas chromatograph connector had been etched.

Discussion and Analysis: All teflon insulated wiring is required to be etched prior to potting. Pre-test records were reviewed of the gas chromatograph connector and Environmental Control Unit (ECU) harnesses to determine if they contained teflon wires and if the required etching had been accomplished.

It was determined that etchirg of the gas chromatograph wires was accomplished. The ECU harness had the latest configuration harnesses which did not require etching.

ENCLOSURE 18-53

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #96
TPS CM-IV-110

Observation: Suit current limiter panel short to teleflex cable.

Discussion and Analysis: An early inspection report disclosed that the teleflex cable may have contacted and shorted the suit current limiter panel. Terminal board 61 was then examined in more detail for evidence of shorting, and the 82556 resistors and conformal coating for overheating. This more detailed examination disclosed that there was no actual contact between the teleflex cable and the terminal board, and that there was no evidence of shorting or overheating.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

March 14, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem

Item #97
TPS CM-IV-149

Observation: Panel 150 was not properly installed, but lying loose in the Lower Equipment Bay (LEB)

Discussion and Analysis: Spacecraft panel 150 was electrically mated but not physically installed for the conduct of OCP-K-0021. The panel was inspected as part of the spacecraft disassembly plan (Reference Board Action #0120). The inspection showed that the panel was exposed to high heat as evidenced by considerable sooting and burned wiring. The first three or four inches of wiring from the circuit breakers was burned with exposed conductors on some of the smaller gage wires. The wiring beyond the proximity of the circuit breakers was in good condition, indicating the absence of any sustained overloads. Two wire lugs were bent slightly. There was no evidence of arcing anywhere on the panel or of any material outflow from the components. All physical damage appears to have been caused by the fire. TM data (battery voltages and currents) indicate nominal conditions with the battery system, of which Panel 150 is an integral part. There is, therefore, no evidence which indicates that this panel was a fire cause or propagator.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

Subsystem Affected: Communications Subsystems

Item #98
TPS CM-CA-002
005
61
65

Observation: Examine cobra cable and pressure garment assembly connectors for arcing and condition of pins.

Discussion and Analysis: The following cobra cables (V16-601623) were in the spacecraft for OCP-K-0021-1

V16-601623 - 41 S/N 8238 Command Pilot
- 41 S/N 7384 Senior Pilot
- 51 S/N 7389 Pilot
- 51 S/N 0806 Stowed at start of test
- 51 S/N 0807 Stowed at start of test

During the test cables S/N 0806 and 0807 were unstowed and one was used by the Command Pilot. After the accident one cable was in use at each crew position, one was between the Senior Pilot and Pilot's couches, and one was on the Command Pilot's leg pan. The S/N's cannot be read.

After the accident,the condition of the cable connectors near the dust covers and lanyards was relatively the same condition as the surrounding areas. Connector shells and pins were not fused or otherwise distorted.

A post test check of the cobra cable in use by the command pilot at the start of the test showed that all wiring was in accordance with the drawing and wire list. A microscope examination of the pins showed them to be pitted and corroded.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Biomed-Communications Suit Wiring

Item #105
TPS CM-CA-034

Observation: Four shorted wires were found in the communications wiring between the Command Pilot's suit connector and the helmet communications connector.

Discussion and Analysis: Four shorted wires were found in the communications wiring between the suit connector and the helmet communications connector. The wire insulation was discovered to be brittle, discolored and cracked. The wires were identified as microphone signal, microphone signal return, earphone signal and earphone return. Enclosures 18-48 and 18-49 illustrate the shorted condition of the wires.

An intermittent condition was also noted in the 16.8 volt DC biomed power wire in the torso harness between the suit connector and the biomed connector. This condition is considered to be not relevant to the cause of the accident, in that no biomed power was being supplied to the Command Pilot's suit.

The vendors of the torso harness materials have provided the following information:

(a) The nylon sock around the ribbon cable melts at 480 degrees Fahrenheit.

(b) The silicone, of which the ribbon is made, melts at 5[illegible]0 degrees Fahrenheit.

(c) The milene insulation around the wires cracks at 430 degrees Fahrenheit and melts at 480 degrees Fahrenheit.

From the above information, it is probable that the exterior of the ribbon cable around the area of the damaged wiring was subjected to localized and supervicial heat. This would cause damage to the internal wiring insulation without damaging the silicone ribbon.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO

April 1, 1967

INTEGRATION ANALYSIS SUMMARY

System Affected: Electrical Power Subsystem & ECS

Item #10
TPS CM-IV-[illegible]

Observation: DC wiring for environmental system instrumentation burned through

Discussion and Analysis:

The one suspect is wiring providing instrumentation power for some Environmental Control System instrumentation. This wiring contains both DC bus A and DC bus B power, and is located on the Command Pilot side of the Command Module in the vicinty of the Environmental Control Unit and the Lithium Hydroxide Units.

A momentary short could occur in any of four DC bus B or four DC bus A power wires in this wiring. A short would not affect the equipment being powered by these wires, and would not be reflected in any of seven measurement outputs of transducers being provided power because of diode isolation of redundant power for each equipment.

Tests have shown that a short in any of the four DC bus B wires could cause a drop in DC bus B voltage to a low enough level to cause an interruption to inverter 2. Sufficient current could be drawn through any of the eight wires to create an arc of sufficient energy which could ignite debris netting in the immediate vicinity of the wiring.

ENCLOSURE 18-54a

REVIEW OF SPACECRAFT POWER STATUS

I. POWER SOURCES

A. Internal

There are two basic sources of primary electrical power contained in the spacecraft. One is the entry batteries in the command module, and the other is the fuel cells in the service module.

The entry batteries provide power during the entry and landing period of the flight when the command module has separated from the service module. They are also used to augment the other power sources at times when heavy loads are switched on.

The fuel cells are the principal source of internal power for the spacecraft. They provide the main DC power during most of the mission. For much of the ground testing a simulator is used for the fuel cells. This simulator is composed of battery packs which are connected to the fuel cell circuits in the service module by test cables. It simulates the internal power of the fuel cells.

In addition, there are two pyro circuit batteries in the command module for providing power to the pyro devices in the spacecraft. These batteries and battery busses are isolated from the main spacecraft busses. A bus tie switch is provided to permit application of main bus power to the pyro bus in event of pyro battery loss.

B. External

In addition to the internal power system described above, the spacecraft can be powered by a ground power supply via the service module launch umbilical. This source is normally used for all pre-flight testing with a transfer from this external source to the internal source made during the final minutes of the count down.

II. SPACECRAFT DC POWER SEQUENTIAL HISTORY

The spacecraft was powered up at the beginning of the test using a ground power supply connected to the space-craft via the launch umbilical in the normal external operating mode.

The system for transfer from the ground power supply to the spacecraft fuel cell power supply was tested and operated normally to internal and back to external power at 0938 EST (1438 GMT). Activation and operation of the fuel cells was not a part of this test. A battery pack simulating fuel cells was used in their place.

Fuel cells are not normally used in ground testing because of their limited life. From a DC power point of view, no differences in functions could be expected because of this.

Following the power transfer test, the spacecraft operations were continuted using external power. At 2331:12.4GMT and 2331:13.6GMT the command module internal power entry batteries were applied to the command module main DC busses B & A respectively. The batteries were then in parallel with the ground power input in a configuration similar to the normal flight situation where the batteries supplement the fuel cells. Refer to the attached diagram. Command module pressure and temperature instrumentation had previously indicated the presence of the fire.

At 2332:46.4GMT DC ground power was switched off. Various command module systems continued to operate on entry battery power until about 0530GMT (12:30 am EST) on Saturday, when the batteries ran down. Later detailed examination of the spacecraft interior showed the entry battery switches on the control panel in the "on" position.

III. VERIFICATION OF POWER SEQUENCE

Referring to the diagram, the basic power switching was as follows:

Switch "A"

Closed at approximately 10 sec after the crew report of fire. This is verified by an analysis of entry battery and GSE supply voltage and current measurements CC0206V, CC0207V, CC0210V, CC0211V, CC0212V, CC0222C, CC0223C, CC0224C, GC5025C, and GC5029C.

Post inspection verified the switch to be in the Closed position.

Switch "B"

Closed at approximately one hour prior to the crew report of fire (2234:32GMT). This is normal procedure.

Switch "C"

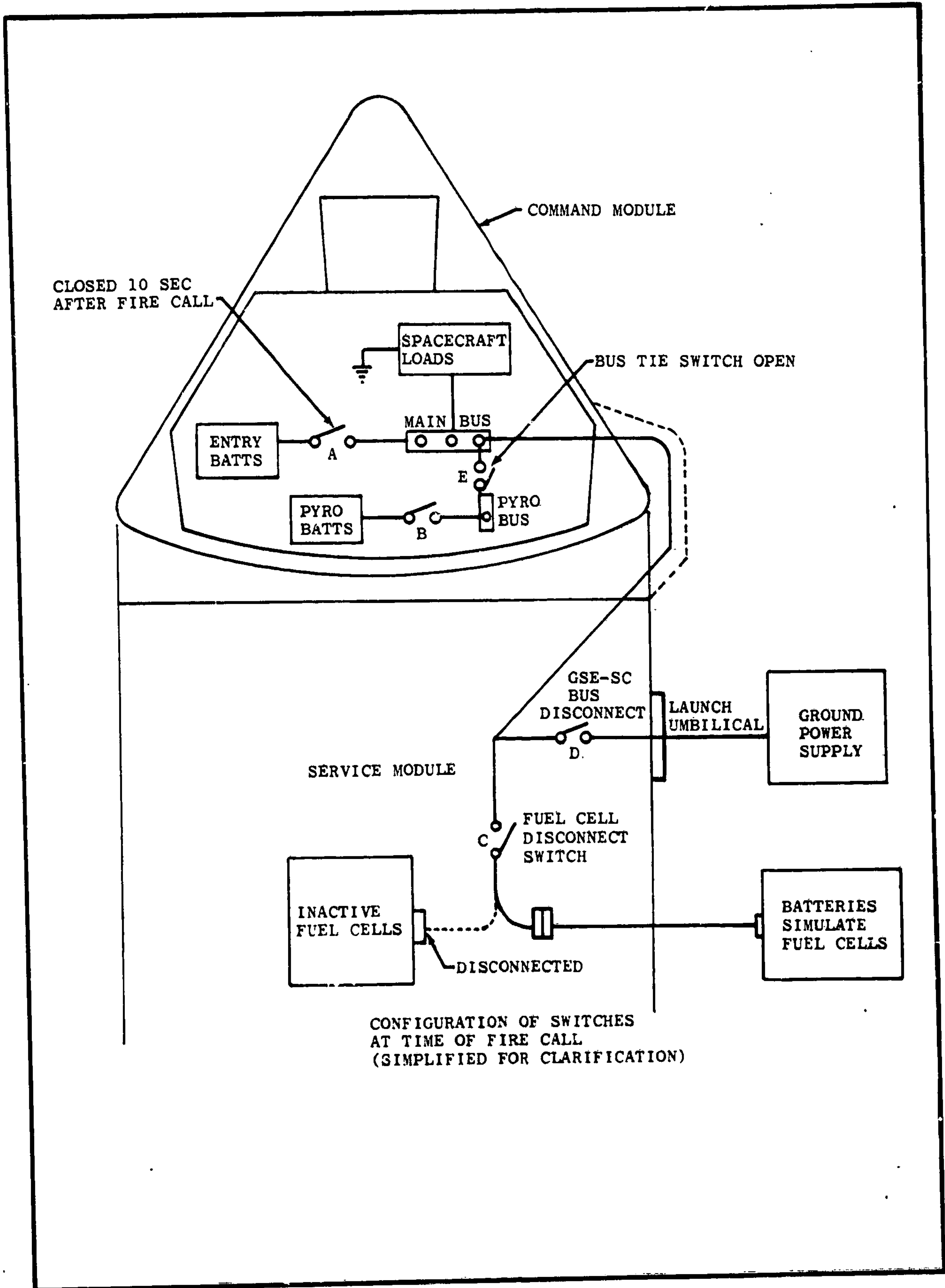
Open since the power transfer test performed about 9 hours earlier. Verified by fuel cell current measurements SC2113C, SC2114C, and SC2115C.

Switch "D"

Closed until approximately 1½ minutes after the crew report of fire (2332:46.4GMT). This was determined by verification of measurement SC2410X.

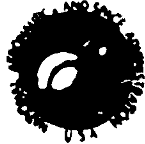
Switch "E"

Open throughout the test. This switch would only be closed in the event of a pyro battery loss. Post inspection verified the switch to be in the open position.



ENCLOSURE 18-54A

D-18-285



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

APOLLO 204 REVIEW BOARD

IN REPLY REFER TO:

February 23, 1967

TO: Panel 18

FROM: Panel 1

SUBJECT: SC 012 Electrical Configuration
(Action Item No.43)

1. At the time of the incident, SC 012 SM jettison controller batteries were installed and electrically connected to the X00-004 circuit breaker box. The two circuit breakers (A&B) were open and consequently there was no power to the jettison controller itself.

2. The following "Q" ball power from the IU stage was turned on at T-45 minutes and remained on through the incident.

   a. "Q" ball power (+28VDC) - from IU bus 6D21.

   b. "Q" ball power (+28VDC) - from IU bus 6D41.

3. The following "Q" ball heater power from the IU stage was turned on at T-45 minutes and remained on through the incident.

   a. "Q" ball heater power (115VAC, 60 cycle).

4. Power (28VDC) at the time of the incident was being applied to the ECS glycol shut-off valve in the SM through the Y00-085 cable from a Harrison lab power supply.

5. MESC indicates power was supplied from the GSE power supply (power supply #5) to the sequential control unit DC bus (28VDC) through the IU umbilical to the spacecraft.

6. SC 012 battery relay bus power at the time of the incident was fed from GSE power supplies #3 and #4 (bus A and bus B power supplies)

7. Other power derived from the IU stage:

   a. 6D110 (+28VDC) used to supervise EDS safe A and B in SC.

   b. 6D91 (+28VDC) used for EDS and is supplied from IU bus 6D11.

   c. 6D92 (+28VDC) used for EDS and is supplied from IU bus 6D31.

   d. 6D93 (+28VDC) used for EDS and is supplied from IU bus 6D41.

   e. Plug supervision bus (+28VDC) supplied by an isolated supply and is used to supervise the mating connectors at the SLA/IU interface (confidence loop).

NOTE: All the above buses were turned on prior to and were on at the time of the incident.

Jesse F. Goree
Chairman, Panel 1

SUMMARY

SYSTEM	TOTAL	OPEN	CLOSED	DUPLICATE	DELETED
ECS	14	0	14		
G&N	3	0	3		
SCS	3	0	3		
SEQ	1	0	1		
RCS	1	0	1		
COMM	8	0	8		
EPS	16	0	16	8	2
CREW SYSTEMS	1	0	1		
	47	0	47		

SUMMARY OF ECS

POTENTIAL INITIATION THEORIES

ECS-1	WMS Blower as an Ignition Source	Closed
ECS-2	Water Glycol Pumps as an Ignition Source	Closed
ECS-3	Suit Compressor(s) as an Ignition Source	Closed
ECS-4	Cabin Fan(s) as an Ignition Source	Closed
ECS-5	Sponge Material in Waste Management Urine Disposal Lock	Closed
ECS-6	Odor in LEB on 1/25/67 Reported by Technician Changing Flight Qual Recorder Tapes	Closed
ECS-7	Glycol Evaporator Temp Sensor as an Ignition Source	Closed
ECS-8	Suit & Glycol Heat Exchangers' "Sponge" Material as an Ignition Source	Closed
ECS-9	LiOH Absorber Element(s) as Ignition Source	Closed
ECS-10	Plumbing Line Appears "Eaten" through	Closed
ECS-11	Heaters within ECS	Closed
ECS-12	Water Glycol Sample Analyses to Determine Contents	Closed
ECS-13	Crushed "Red Wire" at LiOH Diverter Valve Handle	Closed
ECS-14	O_2 Measurement Sensor	Closed

Total	Open	Closed
14	0	14

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-1

SUBJECT WMS Blower as an Ignition Source

SYSTEM OR COMPONENT Waste Management (ECS)

IGNITION SOURCE AND PROPAGATION AC short causing insulation burning.

SUPPORTING FACTORS Difficulty during Spacecraft 008 tests.

NEGATIVE FACTORS Blower not operated during test. Switch "OFF" per switch list and found "OFF" following accident.

CONCLUSION WMS Blower removed and visually inspected. Minor sooting noted on blower outlet. No evidence of arcing. Blower to be analyzed per TPS SC012-CM-CA-242 in MAB. Analysis complete, WMS Blower reclassified as non-initiator.

DATE: 3-22-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-2

SUBJECT Water Glycol Pumps as an Ignition Source

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION AC short, or AC overload due to friction igniting water glycol or insulation.

SUPPORTING FACTORS On last test of spacecraft 008, phases B and C of Pump #1 were shorted to ground, and the pump had a cracked cap and glycol in the motor.

NEGATIVE FACTORS Data on water glycol subsystem, CF0016, CF0018, CF0019, CF0550, CF0549, CF0481, CF0482, CF0483, CF0484, and GSE measurements do not support the subject as a source. Plastic pump caps used on 008. Inconel on 012.

CONCLUSION Inspection and disassembly show that pumps were non-initiator.

DATE 3-21-67 STATUS Non-initiator - Closed.

ENCLOSURE 18-55

ECS-2

TPS SC012-CM-CA-121 W/G pumps inspection and disassembly has been worked in sufficient depth to enable subject pumps to be reclassified as a non-initiator. Electrical insulation resistance and pin to pin resistance values all were within reasonable limits. Internally the unit was clean. Removal of the motor housing enabled verification of the existence of an inconel bearing housing on both pumps, and also enables verification of the dry condition of the external area thereto.

(This preceding constitutes an interim summary to TPS SC012-CM-CA-121)

Rev. 3-22-67

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POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-3

SUBJECT Suit Compressor(s) as an Ignition Source

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION AC short or bearing overheat due to friction, consequently electrical overload.

SUPPORTING FACTORS None

NEGATIVE FACTORS Suit measurements CF0184T and CF1053T do not support the suit compressors as an ignition source.

CONCLUSION Suit compressors have been investigated per TPS's SC012-CM-CA-096 & 098. They are both electrically sound and have been classed as non-iniators.

DATE: 3-21-67 STATUS: Non-initiator - Closed.

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-4

SUBJECT Cabin Fan(s) as an Ignition Source

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION AC Short burning insulation.

SUPPORTING FACTORS AC short in cabin air fan #1 supply wiring: (1) Cabin air fans #1 and #2 motor frozen as found during TPS SC012-CM-CA-178 and -179. (2) Motor of fans #1 and #2 frozen to stator due to melted epoxy used to coat stator.

NEGATIVE FACTORS No shorts in cabin fans. Wiring to cabin fan was found to have insulation burned off, but did not show evidence of arcing.

CONCLUSION Visual examination showed no evidence of combustion. Units are classified as non-initiators.

DATE 3-27-67 STATUS Non-initiator - Closed.

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-5

SUBJECT Sponge Material in Waste Management Urine Disposal Lock

SYSTEM OR COMPONENT Waste Management Disposal

IGNITION SOURCE AND PROPAGATION Low auto ignition point of sponge material, Approx. 240° F.

SUPPORTING FACTORS None

NEGATIVE FACTORS None

CONCLUSION Removed disposal lock is discolored only and has minor sooting on top, apparently from soot settling. Visual inspection reveals no apparent burning from within. UDL has been disassembled, sponge material is undamaged and UDL has been classified as a non-initiator. Ref. TPS SC012-CM-CA-245.

DATE 3-21-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-6

SUBJECT Odor in LEB on 1/25/67 Reported by Technician Changing Flight Qual Recorder Tapes

SYSTEM OR COMPONENT Unknown (Assigned to ECS)

IGNITION SOURCE AND PROPAGATION Spark igniting volatile O_2 + odor mixture or spontaneous.

SUPPORTING FACTORS None.

NEGATIVE FACTORS The technician was interviewed and he reported that the odor similar to ether was detected two days prior to the accident. No reports of an odor similar to ether were made during the test on 1/26/67 or the day of the accident. A report of MEK (Methyl Ethyl Ketone cleaning solvent) was made on the day of the accident at the overboard vent.

CONCLUSION No substantiating evidence by physical evidence. Cleaning solvents could be an initial combustible substance; however, they would require an initiator.

DATE 3-27-67 Non-initiator - Closed.

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POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-7

SUBJECT Glycol Evaporator Temp Sensor as an Ignition Source

SYSTEM OR COMPONENT ECS (Item 2.49)

IGNITION SOURCE AND PROPAGATION DC short - arc, igniting evaporator wicking.

SUPPORTING FACTORS None

NEGATIVE FACTORS Conflagration in this area should cause CF0018 to rise.
CF0018 did not rise until very late - after fire crew call of fire.

CONCLUSION Sensor has been investigated per TPS SC012-CM-CA-116. Resistance check is ok and sensor has been determined a non-initiation. TPSSC012-CM-CA-115 investigated evaporator wicking and the sponge material is unburned, and damp from condensation. Pressure test of evaporator was good. Interim summaries to these TPS's are written.

DATE: 3-21-67 STATUS Non-Initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-8

SUBJECT Suit & Glycol Heat Exchangers' Sponge Material as on Ignition Source

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION Spontaneous - sponge material and glycol and/or oxygen.

SUPPORTING FACTORS None.

NEGATIVE FACTORS

CONCLUSION Glycol evaporator sponge material undamaged, damp from condensation only, classified as non-initiator. Suit heat exchanger visually ok, pressure decay performed, no decay in ten minutes. X-rays taken.

3-21-67 Non-initiator - Closed.

ENCLOSURE 18-55

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POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-9

SUBJECT LIOH Absorber Element(s) as Ignition Source

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION Heat plus volatile gases (methane) retained by absorber elements.

SUPPORTING FACTORS

...VE FACTORS CF0184T, Absorber outlet temperature did not rise until very late after crew call of fire.

...ON Analyze remains of LIOH absorbers. Absorber elements to be investigated locally per TPS SC012-CM-CA-213 and 214. These elements are considered low probability initiators.

... 3-21-67 STATUS Non-initiators - Closed

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-10

SUBJECT Plumbing Line Appears "EATEN" Through

SYSTEM OR COMPONENT Within ECU

IGNITION SOURCE AND PROPAGATION

SUPPORTING FACTORS

[illegible] FACTORS Line is "Burned" through and is in area of intense heat.

Line previously thought to be elsewhere.

[illegible]ION "Line" is on aluminum W/G line not associated with electrical connection or interface. The fact that it is open in no way can be considered an initiation source. This item closed as it is an effect, not a cause.

3-21-67 [illegible] Non-initiator - closed.

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-11

SUBJECT Heaters Within ECS

SYSTEM OR COMPONENT ECS (General)

IGNITION SOURCE AND PROPAGATION Electrical spark, material unknown.

SUPPORTING FACTORS None

NEGATIVE FACTORS Three ECS heaters (potable H_2O, steam duct, and urine dump) were all de-energized for this OCP (K-0021). Circuit Breakers for steam duct and urine dump were open per switch list, and found open after fire. Steam duct and urine dump heaters are external to pressure vessel.

CONCLUSION No visual evidence found on urine dump or steam heaters to support initiation theory. Potable H_2O assembly was investigated per TPS SC012 CM-CA-220 and revealed connector pins were corroded but no signs of arcing. thing abnormal was found upon examination of X-Rays. No evidence was found that would indicate the assembly was a potential initiator.

DATE 3-27-67 STATUS Non-initiator - Closed

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-12

SUBJECT Water Glycol Analyses to Determine Contents

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION Water Glycol

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION TPS #SC012-CM-MA-004 written to perform sample analyses of Water Glycol obtained from various sources in the S/C. W/G in itself cannot be construed as an initiation source, but certainly a propagator or fuel for fire. The W/G fluid is therefore classified as non-initiator.

DATE 3-21-67 STATUS Non-initiator - Closed

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POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-13

SUBJECT Crushed "Red Wire" at LiOH Diverter Valve Handle

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION

SUPPORTING FACTORS None

NEGATIVE FACTORS Item mentioned is not a "Red Wire". It is the nylon braided cloth handle used to remove the LiOH cartridge.

CONCLUSION This item considered closed.

DATE 3-21-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET ECS-14

SUBJECT O_2 Flow Rate Sensor

SYSTEM OR COMPONENT ECS

IGNITION SOURCE AND PROPAGATION Component DC short, burning wire and propagating therefrom.

SUPPORTING FACTORS Hi O_2 flow indication.

NEGATIVE FACTORS Data analysis of CF0035, CF0036, CF0135, CF0136, and CF0137 indicate Hi demand of O_2 flow.

CONCLUSION See attached.

DATE: 3-21-67 STATUS: Non-initiator - Closed
(For associated wiring see EPS-3)

ECS-14 O_2 Flow Rate Sensor:

Crew movement and apparent suit leakage has been correlated for 3 periods of Hi O_2 flow with gimbal angle and biomed data. Fire periods of Hi O_2 flow have been definitely correlated with periods of great crew activity (Cobra cable for instance).

The final Hi O_2 flow has been correlated with gimbal angles and biomed data, and the conditions analyzed lead to the conclusion that the O_2 flow transducer was giving valid data and that there was indeed a demand on the oxygen by the crew due to increased activity. The fact that a C&W signal was obtained from Hi O_2 flow 15 seconds after CF0035Q reached saturation at 23:30:59.4 GMT substantiates the conclusion that the flow transducer did not fail and was giving valid data at the time of C&W stimulation at 23:31:15 GMT.

B. High Oxygen Flow Rate

Telemetered data indicate that the high oxygen flow rate conditions for the last 30 seconds before the fire call can be attributed to the apparent high level of prime suit leakage at low suit-to-cabin differential pressure, magnified by apparent crew activity.

There has been considerable speculation as to whether the high flow could be indicative of a sensor and/or associated wiring difficulty.

The oxygen flow sensor circuit includes two separate outputs. The signal circuit going to the Pulse Code Modulation Telemetry System (PCM) is conducted to the PCM system through a twisted shielded pair of wires. A short circuit between the signal lead and either the return wire or the shield braid would cause a zero output (no flow) reading on the oxygen flow indication. It is highly improbable that any short circuit between the signal lead and a 28 volt DC supply lead could occur without a prior short circuiting to the ground lead or shield lead.

The second output from the oxygen flow sensor circuit goes to a time delay relay to indicate high flow alarm. It is on the ground circuit return side of the relay. A ground circuit completion is required to indicate high oxygen flow. This is supplied from the signal circuit going to PMC, and a ground on this line could not affect the PCM flow rate indication.

Single failures could exist within the bridge circuitry controlling the flow sensor which would indicate high flow rates on both the PCM output and the signal to the relay. These, however, will require examination of the oxygen flow sensor box to confirm or deny this possibility. A preliminary examination disclosed shorts to ground in the flow sensor; shorts to ground will produce a zero or no flow output indication. The flow sensor box is being torn down at the present time. It should also be noted that the location of the oxygen flow sensor was a high fire damage area, and that the sensor would be expected to be damaged by the fire.

Based on the above, it is concluded that the high oxygen flow data indication was valid, and that there was no malfunction of the sensor and/or associated wiring prior to the fire call.

SUMMARY OF G&N

POTENTIAL INITIATION THEORIES

G&N-1	Crew Member Motion Striking Electrical Component, Such as Panel, Connector	Closed
G&N-2	Eye Piece Stowage Unit, Heater Wire Routing G&N, LEB, Optics Stowage & Cond. Enunciator Panel	Closed
G&N-3	PSA Tray Short Circuit	Closed

Total	Open	Closed
3	0	3

POTENTIAL INITIATION THEORIES EVALUATION SHEET G&N-1

SUBJECT Crew Motion Striking Electrical Component Such as Panel, Connector, Etc.

SYSTEM OR COMPONENT Unknown

IGNITION SOURCE AND PROPAGATION Electrical short circuit - many potential fuel sources.

SUPPORTING FACTORS IMU gimbal T/M voltages CG2140 and 2170 reflect sharp vehicle motion at 23:30:54.9 coincident with AC-2 Glitch and Gas Chromatograph trace deflection.

NEGATIVE FACTORS

CONCLUSION Crew activity data are being utilized as supporting data in the evaluation of event time line. May be the cause of initiation. Physical evidence of arcing or wire damage is reported on specific items. (Reference EPS-2, EPS-3, EPS-14, EPS-22, EPS-26, COMM-1)

DATE 3-21-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET G&N-2

SUBJECT Eye Piece Stowage Unit, Heater Wire Routing

SYSTEM OR COMPONENT Optics Heaters or Heater Wires

IGNITION SOURCE AND PROPAGATION Possible failure of heater thermostat, short in heaters or wiring, initial fuel ESU Royalite cover, decal & foam or failure related to enunciator lights.

SUPPORTING FACTORS (1) Materials are combustible with a propagation rate greater than 2.5 inch/second from flammability test results. (2) SCT Eye piece cover found on C/M floor. (3) Scratches on Optics shroud. (4) Eye piece heater blanket and storage area damage. (5) G&N verb code decals were added to S/C configuration the morning of the incident. (6) Condition enunciator gimbal lock lite reads 3 ohms.

NEGATIVE FACTORS Eye piece heaters and thermostats checked ok, with no Propagation path.
Condition enunciator gimbal lock lite resistance value was verified to be nominal.
SCT eye piece cover may have been attached to Velcro by splt prior to incident. The cover dropped from Velcro after fire started.

CONCLUSION Close this item as an initiator. No source of ignition could be found in the electrical wiring or heaters and lights.

DATE 3-23-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET

G&N-3

SUBJECT PSA Tray Short Circuit

SYSTEM OR COMPONENT G&N PSA

IGNITION SOURCE AND PROPAGATION Nickel ribbon wire in module assembly of PSA, potted in urethane foam.

SUPPORTING FACTORS Previous experience of PSA tray short circuit causing ignition of foam (ambient air).

NEGATIVE FACTORS Inspection of PSA trays indicates no internal ignition of tray modules.

CONCLUSION Item closed after visual inspection of trays verified no ignition source in the modules.

DATE: 3-21-67 STATUS: Non-initiator - Closed

SUMMARY OF SCS, SEQ, & RCS

POTENTIAL INITIATION THEORIES

SCS-1	Rotation Control Electrical Short	Closed
SCS-2	Translation Control Electrical Short	Closed
SCS-3	BMAG Power Switch Panel #24 Short	Closed

Total	Open	Closed
3	0	3

SEQ-1	Panel 10 and 11 Component Failure	Closed

Total	Open	Closed
1	0	1

RCS-1	Panel 12 RCS C/M-S/M Indicator Switch Failure	Closed

Total	Open	Closed
1	0	1

POTENTIAL INITIATION THEORIES EVALUATION SHEET SCS-1

SUBJECT Rotation Control Electrical Short

SYSTEM OR COMPONENT SCS

IGNITION SOURCE AND PROPAGATION Electrical short.

SUPPORTING FACTORS Case was warped and the cable was badly burned near the rotation control.

NEGATIVE FACTORS Data review, continuity check, visual and physical examination of the rotation control and associated wiring show no anomalies as a fire cause. Ref. TPS PIB-004, 007; CM-IV-077

CONCLUSION No evidence has been found from hardware or data examination that would indicate this component or its associated wiring was a cause or propagator of the fire.

DATE 3-21-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET SCS-2

SUBJECT Translation Control Electrical Short

SYSTEM OR COMPONENT SCS

IGNITION SOURCE AND PROPAGATION Electrical short

SUPPORTING FACTORS Problems during test with push-to-talk communications circuit. Also fracture in case.

NEGATIVE FACTORS Data review, continuity and insulation resistance check, and physical examination show no anomalies as a fire cause (ringout of associated S/C wiring showed no anomalies). Ref. TPS PIB-002, 003, 005, C/M-IV-058

CONCLUSION No evidence has been found from hardware or data examination that would indicate this component or its associated wiring was a cause or propagator of the fire.

DATE 3-21-67 STATUS Non-initiator - Closed

NATIONAL AERONAUTI ND SPACE DMINISTRATION
APOLLO ... REVIEW B RD

IN REPLY REFER TO

March 9, 1967

TO: A. D. Mardel, Chairman, Panel 18

FROM: C. L. Creech, Displays & Controls Subsystem Ma ger

SUBJECT: Main Display Console Panel Number 24

Detailed investigation of the subject panel was conducte in accordance with TPS CM-CA-030 and TPS CM-CA-031.

The Analytic Report of the above is forwarded herewith f your information and retention.

Carlton L. Creech
Integration and Anal,sis Panel
(Panel 18)

Enclosure

ENCLOSURE 18-55

D-18-315

POTENTIAL INITIATION THEORIES EVALUATION SHEET SCS-3

SUBJECT BMAG Power Switch Short

SYSTEM OR COMPONENT SCS - Panel #24

IGNITION SOURCE AND PROPAGATION AC short, DC short, or arcing

SUPPORTING FACTORS Switch found in OFF position - S/B AC-2. Also light area on panel indicates a possible "false detent" position.

NEGATIVE FACTORS Data review and performance of TPS CM-CA-030 and -031 showed no anomalies as a fire cause. See attached report for complete analysis of BMAG Switch and Panel #24.

CONCLUSION No evidence has been found from hardware or data examination that would indicate this component was a cause or propagator of the fire.

DATE 3-21-67 STATUS: Non-initiator - Closed

AS 204 ANALYTIC REPORT
MAIN DISPLAY CONSOLE PANEL #24

References:

1. TPS CM-CA-030
2. TPS CM-CA-031
3. V16-771424 - Panel Assembly Drawing
4. V16-976716 - Panel Schematic Drawing
5. Photographs - E-5C-21
   62-107C-4 through 6
   122-306C-12
   122-308C-1
   123-307C-5, 6
   123-309C-1 through 6

C. W. Fischer 3/10/67
C. W. Fischer
Systems Engineer
NAA/S&ID

C. L. Creech
Systems Engineer
NASA/MSC

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Abstract

Main Display Console Panel #24, Mission Sequence Control, as removed from S/C 012, presented two areas of special interest for detailed investigation. Soot shadowing on the panel gave evidence that the BMAG power switch, S-39, had been moved after the fire. Charring was present on one corner of the EDS power switch, S-1, and immediately associated wiring. Additionally, the integrity of all other switches and wiring on the panel was of interest.

Conclusions are that the BMAG switch was moved by accidental contact during the fire and again after the fire during power shut off; the EDS switch was charred by externally applied, locally concentrated, heat; the switch and associated wiring are electrically sound and functional; all other switches and wiring on the panel are electrically sound and functional.

Introduction

As removed from S/C 012, MDC Panel No. 24 was observed to have two areas requiring special investigation. The EDS Power switch, S-1, and its attached wiring were charred at one corner. The BMAG Power switch, S-39, was in OFF position as removed but the soot outline of the knob on the panel indicated that the switch had been in the AC-2 position in either the full, or "false", detent position (Ref. Photograph E-5C-21). Additionally, it was desirable to investigate the electrical and functional integrity of all of the switches and panel wiring.

Description of Tests

Tests were performed in accordance with TPS CM-CA-030 and TPS CM-CA-031 to determine the electrical integrity of all switches, panel wiring, and connectors in all positions of all switches. Special tests were performed to determine the effect of placing the rotary switches in "false" detent positions.

Detailed examination was made of the BMAG Power switch to determine the actual position of the switch during the various phases of the fire.

Record was made of a fingerprint found on the BMAG Power switch knob. (Ref. Photograph 123-309C-6.)

Test Results

The continuity tests of the panel in the as-found condition showed all normal continuity and circuit resistances.

The continuity tests in all other switch positions showed all normal continuity and circuit resistances.

The continuity tests of the rotary switches in the "false" detent positions showed that, with the exception of the BMAG Power switch, all continuities and circuit resistances were the same as in the full detent positions. In the AC-1 "false" detent position, the BMAG Power switch continuity and circuit resistances were the same as the full detent position. In the AC-2 "false" detent position, the AC circuits were closed through the switch but the DC circuit was open.

During initial examination of the soot shadow of the BMAG Power switch, a fingerprint in soot, was noted on the switch knob (Ref. Photograph 123-309C-6). Prior to any manipulation of the switch, the fingerprint was photographed and "lifted" by the FBI.

The soot shadow of the BMAG Power switch knob was compared with those of other rotary switch knobs on Panel #24 (Ref. Photograph E-5C-21). It was noted that the TVC-1, Partial SCS Power, and Rate Gyro switch knobs had soot patterns that are broad in outline at the indexing point of the knob and follow the knob contour closely. The BMAG switch knob outline is pointed at the indexing point of the knob and smaller in outline than the knob. There is evidence of a double shadow of the BMAG Power switch knob. (See Photographs E-5C-21 and 123-309C-6.)

Analysis of Tests

The panel electrical continuity and resistance measurements showed that electrical continuity was present after the fire and that no damage of significant nature had been incurred by the switches, panel wiring, or connectors.

In analyzing the BMAG Power switch positions, several areas were investigated.

To establish the initial condition of the switch, Operational Checkout Procedure (OCP) K-0021 was examined. During performance of Steps 14-013 of this procedure, a Master Alarm is obtained when the BMAG switch is turned to AC-2. This was obtained thus indicating that the DC circuit was closed through the switch. Simultaneously, an indication of AC circuit switch closure appeared as Step 14-014 on the T/M record. Step 14-015 indicated satisfactory operation after warmup by confirming that the AGAF Temperature indication in the Caution & Warning Annunciator Matrix on Panel #10 did extinguish.

As noted above, the BMAG, DC heater circuit is not closed throu[illegible] [illegible]e switch in the "false" detent position.

The soot shadow of the knob on the panel shows evidence of a dou[illegible]e shadow with one faint shadow in the full detent position and a denser shadow in the "false" detent position (Ref: Photograph 123-309C-6). When the switch is placed sequentially in these positions, the pointed shadow conforms closely to the overlapped outlines of the knob.

From these facts, it is deduced that the switch was in the full detent position at the initiation of the fire and was later, during fire, moved to the "false" detent position.

In considering the difference between the switch position as indicated by the panel soot shadow, and the OFF position, in which it was found when removed from the spacecraft, the fingerprint on the knob is of significance. The surface of the mylar knob was melted and bubbled indicating that the temperature at its surface had been over 500°F. The high temperature and melting and flowing of the kno[illegible] surface would have destroyed any fingerprint made prior to the fire. The fingerprint on the knob was in soot and, as determined in the process of "lifting" it, entirely on the surface of the knob material.

It is deduced from this that the switch was operated after the fire to move it from the AC-2 "false" detent position to the OFF position. This action was most probably taken by the pad crew during power-down of the spacecraft.

Conclusions

It is concluded that operation and functioning of all switches on Panel #24 were normal throughout the fire. The components of the panel were not a source or a major propagator of the fire.

The charring of the EDS switch, S-1, and associated wiring, was caused by an external flame source and not by heat generated internally to the switch.

The different positions of the BMAG Power switch have been determined, or are deduced, to be:

1. Full detent AC-2 - at fire initiation.

2. "False" detent AC-2 - sometime during the fire.
   NOTE: It is postulated that during the fire the commander contacted the switch with his left foot during attempted egress. During the Mockup #2 exercises, it was noted that the commander's left foot did come very close to Panel #24 during the egress maneuver.

3. OFF - after fire during power-down.

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POTENTIAL INITIATION THEORIES EVALUATION SHEET SEQ-1

SUBJECT Panel 10 and 11 Component Failure

SYSTEM OR COMPONENT Sequencers

IGNITION SOURCE AND PROPAGATION Spontaneous - heat and glycol

SUPPORTING FACTORS Digital Event Timer (DET) on Panel 11 as experienced running hot during operations. If a glycol leak developed from the cold plate, leaking on the DET, it could cause fire.

NEGATIVE FACTORS See attached sheet

CONCLUSION The DET, or other components mounted on Panels #10 and #11 was neither an ignition source nor a propagator for the fire.

DATE: 3-21-67 STATUS Non-initiator - Closed

PANEL 10 AND 11

NEGATIVE FACTORS

Panels #10 and #11 were visually inspected. There is no evidence that the Digital Event Timer (DET) on Panel #11 was running hot. This instrument normally dissipates approximately 4 Watts and consequently has a temperature rise of only 2-3 degrees F. The backpotting if the DET was inspected and found to be sound. It is lightly sooted but still transparent enough to allow the wire connections to the header to be seen. The wire harness has no evidence of overheating and has only a light soot deposit. The panel connector is clean and the pins are straight and clean. The DET is hermetically sealed. There is no evidence that the seal is broken. The digit wheels are visible through a light soot deposit on the cover glass. There is evidence of water glycol drip on the DET case behind the panel. However, the water glycol drip has washed away some of the soot deposit and appears to have occurred late in the progress of the fire. The C&W matrices on Panels #10 and #11 were examined. The backs of these matrices were lightly sooted but had no evidence of overheating. The cable harnesses and connectors were clean and in good condition. The legend plates on the panel side of the matrices were sooted but the glass covers were all intact and the legends legible. Some deterioration of the RTV Silicone rubber potting material is evident on the matrix around the panel openings where a flue effect allowed hot gases to pass between the panel edge and the matrix edge. However, the matrix bodies are intact and are not distorted. There is no evidence of water glycol drip in the matrices.

POTENTIAL IGNITION THEORIES EVALUATION SHEET RCS-1

SUBJECT Panel #12 RCS C/M-S/M Indicator Switch

SYSTEM OR COMPONENT RCS

IGNITION SOURCE AND PROPAGATION Spark or heat plus glycol. DC short or spontaneous.

SUPPORTING FACTORS (1) Panel #12 switch (S-2) just completed potting still in cure cycle. (2) Official last switch moved per OCP prior to fire. (3) This switch is located in a heavy fire damaged path looking at the exterior of the MDP to the command pilots couch.

NEGATIVE FACTORS See attached sheet

CONCLUSION The Panel #12 S-2 switch was neither an iniator or a propagator of the fire.

DATE: 3-21-67 FATE Non-initiator - Closed

PANEL #12 RCS C/M-S/M INDICATOR SWITCH

NEGATIVE FACTORS

Visual examination of Panel #12 S-2 back potting showed no damage other than light soot deposit. Potting material is still transparent and wire connections to switch terminals are visable through the potting material. The switch is hermetically sealed and all make and break contacts are within the sealed enclosure. The terminals are brought out through a metal-glass header to which the wiring is soldered. The solder connections are then covered with the potting material to protect the joints and terminals from exposure to the C/M atmosphere. The wire harness to S-2 and the associated connector are in good condition with only light soot deposits and no evidence of overheating. The connector interface is clean and the pins are all straight and clean. There is no evidence that the switch, or its associated wiring, were overheated. There is nothing to indicate that the switch, or associated wiring, were ignition source of a propagator of the fire.

SUMMARY OF COMM

POTENTIAL INITIATION THEORIES

COMM-1	MDAS Octopus Cable Connector Short	Closed
COMM-2	Teleflex Cable Short to TB 61-7	Closed
COMM-3	Overheating of Crewman's Electrical Assembly	Closed
COMM-4	Disconnect Spark on 0.020 Milliamp Lines	Closed
COMM-5	RF Power	Closed
COMM-6	USBE Potting Burned	Closed
COMM-7	Shorts in Biomed-Comm Suit Wiring	Closed
COMM-8	MDAS-LEM Recorder Signal Wires Short	Closed

Total	Open	Closed
8	0	8

POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-1

SUBJECT MDAS Octopus Cable Connector

SYSTEM OR COMPONENT Biomed - Experiments

IGNITION SOURCE AND PROPAGATION Octopus cable 28 VDC shorting to ground caused by crewman deforming P-185 connector on scientific compartment "A" panel. Propagation via material on crewman's shoe, connector insert, sleeve, wire insulation.

SUPPORTING FACTORS 28 VDC from Bus B is available at J185 connector. CB 117 on panel 22 open and heavily sooted. This is CB feeding MDAS power.

NEGATIVE FACTORS MDAS data would have indicated a short if power had dropped below 19 VDC for 25 milliseconds or longer. Data does not indicate this occurred.

CONCLUSION Arcing was superficial, appears to be a result of the fire and not a cause.

DATE: 3-21-67 STATUS: Non-initiator - Closed

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POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-2

SUBJECT Teleflex Cable Short to TB 61-7

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Cable shorts TB 61-7 to ground causing 28 volt drop thru 825 ohms wire wound 2 watt resistor. Propagation via resistor heating up and igniting conformal coating which in turn ignites debris trap net.

SUPPORTING FACTORS

NEGATIVE FACTORS (1) Continuity check TB 61-7 to ground.

(2) Visual examination of resistor R7

CONCLUSION TPS CM-IV-110 dated 3-14 references TB 61-7. Resistance checks and visual inspection concluded no shorting or grounds on terminal board. The soot was brushed away from the connector and physical inspection resulted in no indication of short.

DATE: 3-22-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-3

SUBJECT Overheating of Crewman's Electrical Assembly (Cobra Cable, T Adapter, Noise Eliminator & PGA)

SYSTEM OR COMPONENT COMM

IGNITION SOURCE AND PROPAGATION Short inside umbilical could cause overheating of assembly. Propagation from potting compound of crewman's umbilical or portions of crewman's suits.

SUPPORTING FACTORS 1. Suits appear burned.

2. Crewman had changed umbilical to attempt to repair live mike condition.

NEGATIVE FACTORS 1. Replacing to new cable did not repair live mike condition.

2. All leads into umbilical are current limited.

CONCLUSION TPS CA-075, CM-CA-002, 005, 065, 061. These TPS's tested for shorts, grounds, material analysis, and x-rays. All Showed no anomalies that could cause incident. Physical examination did not disclose any evidence of arcing or fire initiation.

DATE 3-21-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-4

SUBJECT Disconnect Spark on .020 Millamp Lines

SYSTEM OR COMPONENT Telecommunications

N. SOURCE AND PROPAGATION Connector of crewman umbilical was disconnected to replace umbilical cable. Propagation from connector insert or umbilical potting compound

SUPPORTING FACTORS Crew thought they were having trouble so they replaced umbilical. The new umbilical did not clear fault symptom.

NEGATIVE FACTORS 1. Disconnect was approximately 20 minutes prior to fire call.

2. Tests ran in O_2 atmosphere showed no appreciable spark at even higher currents.

CONCLUSION As a result of above test, the conclusions are that no appreciable spark caused by disconnect can be determined as cause of incident.

3-21-67 STATUS Non-initiator - Closed

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-5

SUBJECT RF Power

SYSTEM OR COMPONENT RF Systems

IGNITION SOURCE AND PROPAGATION RF radiated energy produces adequate temperature rise to ignite materials. Requires an open RF lead inside the cockpit. Propagation via any combustible near or around the S/C RF coax lines.

SUPPORTING FACTORS Very few, if any. However, adequate RF energy was available in the UHF/FM system and the C-Band system coaxs.

NEGATIVE FACTORS It would require a broken coax. It would require a combustible material in the broken coax area. It would require a unique set of conditions to produce a temperature rise in the material. PCM data indicates normal operation

CONCLUSION Visual inspection of S/C coax, Ant.'s and coax switches show no evidence of arcing or shorting. C-Bank, S-Band, and VHF/FM continued to radiate after LOS period.

DATE: 3-22-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-6

SUBJECT USBE Potting Burned

SYSTEM OR COMPONENT Telecommunications

IGNITION SOURCE AND PROPAGATION ISBE (Unified S-Band Transponder) may have had internal short. Propagation via potting material inside USBE.

SUPPORTING FACTORS USBE potting is burned in blow hole fashion.

NEGATIVE FACTORS USBE transmissions continued well into general fire time. Carrier continued after voice and data terminated.

CONCLUSION Visual, resistance, and functional tests of USBE completed. No anomalies observed that could cause incident. USBE classified to "B" category.

DATE 3-21-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-7

SUBJECT Shorts in Biomed-Comm Suit Wiring

SYSTEM OR COMPONENT Biomedical - Communications

IGNITION SOURCE AND PROPAGATION DC from S/C to suit to ground

Propagation via suit and suit wiring

SUPPORTING FACTORS None - Six shorted wires in communications portion of suit wiring. Possible supporting evidence in communications anomalies. Insulation around wires was more affected by heat than cable sheathing.

NEGATIVE FACTORS Normal operation of components using these wires use only low currents of insufficient energy to create arc which would cause ignition(200° F) in suit. Type of cable used has fairly low heat resistant insulation with higher temperature (600° F) material used in the outer sheath.

CONCLUSION Shorting and damage is apparently due to external heat and burning.

DATE: 3-23-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET COMM-8

SUBJECT MDAS-LEM Recorder Signal Wires Short

SYSTEM OR COMPONENT Experiments - MDAS

IGNITION SOURCE AND PROPAGATION Short circuit on MDAS signal wires to LEM voice recorder, propagation via debris traps.

SUPPORTING FACTORS None

NEGATIVE FACTORS These wires carry 100 PPS IRIG B timing of 5 Volts peak-to-peak.

CONCLUSION TPS CM-CA-076 duplicated suspected short on signal wires which did not draw excessive current. MDAS functioned normally.

DATE: 3-22-67 STATUS: Non-initirtor - Closed

SUMMARY OF EPS

POTENTIAL INITIATION THEORIES

EPS-1	Gas Chromatograph Cable Short (Ref. EPS-2)	Duplicate
EPS-2	Gas Chromatograph Connector Short & Cable Short	Closed
EPS-3	Damaged Wire Harness Under LiOH Door	Closed (Probable Initiator)
EPS-4	Damaged Wire (1C50A16) Near J-Box C15-1A52 (Screwdriver Incident)	Closed
EPS-5	Teleflex Cable Shorting Resistor R7 at C15A7TB61-7 (Reference to COMM-2)	Duplicate
EPS-6	Electrical Short Due to Cold Flow Characteristics of Teflon Wire	Delete (General Category)
EPS-7	Q-Ball Wiring Short	Closed
EPS-8	CB64 on Panel 25 (SCS GRP 2 MNB) Rubbing Against Wire Harness	Closed
EPS-9	Tapes on Entry Batteries (White Room Tape)	Closed
EPS-10	Pyro Batteries Vented to Cabin	Closed
EPS-11	Cabin Fan Failure (Reference ECS-4)	Duplicate
EPS-12	Suit Compressor Overloaded (Reference ECS-3)	Duplicate
EPS-13	Inverter Phase Lock Box Failure	Closed
EPS-14	Panel 150 Lying Loose	Closed
EPS-15	J185 Octopus Cable Connector (Reference COMM-1)	Duplicate

SUMMARY OF EPS POTENTIAL INITIATION THEORIES

EPS-16	Water Glycol Corrosion of Connector(s)	Delete (General Category)
EPS-17	Glycol Pump Overloaded. (Reference ECS-2)	Duplicate
EPS-18	AC Control Box V16-451136 Short	Closed
EPS-19	Evidence of an Arc on Tip of Pin 16 on Panel 20	Closed
EPS-20	Arc of Wire/Cover on J-Box C15-1A52 (Ref. EPS-22)	Duplicate
EPS-21	Wire Short to Junction Box Cover (Ref. EPS-22)	Duplicate
EPS-22	Damaged Wire J-Box C15-1A52 Cover Plate	Closed
EPS-23	Electrical Wires Routed in Front of Heater (Reference P 482 TPS 369 Step 17)	Closed
EPS-24	SPS PUGS Display Unit	Closed
EPS-25	Main Bus B Short to Substructure at S11, Panel 8	Closed
EPS-26	Wiring Arc Near Scientific Equipment Bay LEB Main Bus B 2	Closed Per Fire Board

Total	Open	Closed	Duplicate	Deleted
16	0	16	8	2

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-1

SUBJECT Gas Chromatograph Cable Short

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE EPS-2

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE: 3-23-67 STATUS: DUPLICATE

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-2

SUBJECT GAS Chromatograph Connector Short & Cable Short

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Electrical spark or heat, propagation via plastic cover on connector.

SUPPORTING FACTORS Measurement CT0108 starts to vary at 23:30:49.
CB C15A5C116 found open after fire.

NEGATIVE FACTORS

CONCLUSION Close examination of this connector shows no evidence of arcing at the connector or associated wiring attributable to an electrical short. The damaged plug and wiring has been analyzed - the cause was due to external heating.

DATE: 3-22-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-3

SUBJECT Damaged Wire Harness Under LiOH Door

SYSTEM OR COMPONENT EPS/ECS

IGNITION SOURCE AND PROPAGATION Electrical short on the DC power input wiring to the instrumentation on the O_2 panel. Propagation could have been along the nearby debris net.

SUPPORTING FACTORS Location in area determined as the probable initiation. Possible copper deposits were found on the bottom of the LiOH door. Material is being removed for analysis. Sections of the wire harness and a portion of the panel has been burnt away eliminating physical evidence of potential arcing.

NEGATIVE FACTORS

CONCLUSION This theory is still valid

DATE: 3-24-67 STATUS Probable Initiator - Closed

ENCLOSURE 18-55

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POTENTIAL IGNITION THEORIES EVALUATION SHEET EPS-4

SUBJECT Screwdriver damage by technician 17 Jan. '67 Damaged Wire (1C50A16) on Panel C15-1A52

SYSTEM OR COMPONENT RCS/EPS

IGNITION SOURCE AND PROPAGATION Electrical spark from DC short propagating along the wire covering.

SUPPORTING FACTORS On DR 0917, the exposed conductor 1C50A16 was temporarily repaired with 7503 Mystic Tape and permanently repaired using heat shrink sleeving per standard repair manual.

NEGATIVE FACTORS The harness was diligently examined by a member of the Fire Panel and by EPS engineering. There is no evidence of an arc from this source. Measurement CH2087 would have indicated zero if the wire had shorted. No zero indication was noted.

CONCLUSION Based on the above data and observations, reference TPS CM IV-192, it is concluded that this item was not the ignition source.

DATE: 3-21-67 STATUS Non-initiator - Closed

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DISCREPANCY RECORD

WIRE

RW

NONE

DISCREPANCY

PIRR# 781

INITIATOR'S SIGNATURE

STAMP NUMBER

ORGANIZATION AND LOCATION

DATE

ENGINEERING DISPOSITION

MR ACTION REQUIRED

CONT. ACTION

REPLACEMENT PART NO

SERIAL NO

OTHER SYSTEMS AFFECTED

NONE

RETEST ACCEPTED

DATE | CONTR | NASA

ITEM NO | DISPOSITION | ITEM REWORK | ITEM ACCEPTANCE

1/18/67

1/19/67

NASA ACCEPTANCE

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ENCLOSURE 18-55

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Page __ of 2 Pages

NASA - KSC
DISCREPANCY RECORD

S/C 012 S/C 011

PART NAME	CONTRACTOR PART NO	SERIAL NO	NEXT ASSEMBLY / DRAWING NO
WIRE	V16-440012	02	V16-600002

7 SUPPLIER	8 SUPPLIER PART NO	9 REF DOC NO	10 TIME/CYCLES IN USE (HR / MIN / SEC)	11 FAULT	12 FUNCTION

13 DISPOSITION	14 ORIGIN	15 SYSTEM	16 WITHHOLDING TAG NO	17	18	19

ITEM NO	DISCREPANCY
	CONT. DISPO.

20 INITIATOR'S SIGNATURE	21 STAMP NUMBER	22 ORGANIZATION AND LOCATION	23 DATE
[illegible signature]	[illegible] 94	NAA Pad 34	1/17/67

ENGINEERING DISPOSITION

24 MR ACTION REQUIRED	25 CONTINUATION SHEET REQUIRED (KSC FORM 4-...)	26 SCRAP TAG NO	27 REPLACEMENT PART NO	28 SERIAL NO
✓ YES ☐ NO	☐ YES ☐ NO			

SYSTEM RETEST REQUIRED	30 FAILURE ANALYSIS REQUIRED	31 OTHER SYSTEMS AFFECTED	32 RETEST ACCEPTED (DATE / CONTR / NASA)
☐ YES ✓ NO	☐ YES ✓ NO	NONE	

ITEM NO	DISPOSITION	ITEM REWORK SHOP STAMP	ITEM ACCEPTANCE CONTR.	NASA
4.	CONCLUSION ... STEP 1 & 2 OF DISCREPANCY, THE EXPOSED ... [illegible]	[stamp]	[stamp]	[stamp]

FOR FURTHER ... CHANGE IN DISPOSITION ... ADDITIONAL ... FORM

FINAL ACCEPTANCE 1-19-67

QRC RECEIVED JAN 26 1967 NAA

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ENCLOSURE 18-55

D-18-341

POTENTIAL INITIATION THEORIES EVALUATION SHEET

EPS-5

SUBJECT Teleflex Cable Shorting Resistor R7 at C15A7TB61-7

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE COMM-2

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE: 3-23-67 STATUS: DUPLICATE

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-6

SUBJECT Electrical Short Due to Cold Flow Characteristics of Teflon Wire

SYSTEM OR COMPONENT EPS, SPS, RCS, T/C, G&N, SEQ, C&W, & Scientific Experiments

IGNITION SOURCE AND PROPAGATION Electrical spark, propagation via Velcro, debris trap.

SUPPORTING FACTORS None

NEGATIVE FACTORS Detailed examination of harnesses in suspect areas revealed no evidence of shorting or arcing due to the cold flow characteristics of teflon. Reference TPS CM-IV-192.

CONCLUSION This item is a general statement and cannot be tied to a specific location or initiation theory. It will be covered by a general discussion in the Panel 18 report. Transferred to General Discussion.

DATE 3-24-67 : Closed as a specific item.

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-7

SUBJECT Q-Ball Wiring Short

SYSTEM OR COMPONENT SEQ

IGNITION SOURCE AND PROPAGATION Electrical spark, propagation via S/C harness.

SUPPORTING FACTORS None

NEGATIVE FACTORS Pin-to-pin and pin-to-ground resistance checks revealed no anomalies in these circuits. Reference TPS SC012-088 which performed resistance checks on Q-Ball wiring.

CONCLUSION Wiring was extended to CM pressure shell. The continuity checks and physical evaluation of connector at Q-Ball revealed that it was mated with the stowage connector.

DATE 3-22-67 STATUS Non-initiator - Closed

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-8

SUBJECT CB64 on Panel 25 (SCS GRP 2 MNB) Rubbing against wire harness

SYSTEM OR COMPONENT SCS

IGNITION SOURCE AND PROPAGATION . Electrical spark

SUPPORTING FACTORS Indications of interference between CB64 & wire harness behind Panel 25. Indentation in Teflon insulation on wire harness matches with "white" deposit on terminal of CB 64.

NEGATIVE FACTORS No visual indication of any arc was noted.

CONCLUSION Close this item. Detailed examination of panel revealed no indications of shorts or arcs.

DATE 3-22-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-9

SUBJECT Tapes on Entry Batteries
(White Room Tape)

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Glycol residue on tape covering battery terminals provides a conductive path which after a prolonged period gets hot and ignites.

SUPPORTING FACTORS Tape on battery terminals - flammability of material.

NEGATIVE FACTORS Location removed from Fire Panel indicated most probable ignition area. No mechanism to provide conductive path.

CONCLUSION Inspection shows no adjacent ignition source which would be a propagation path.

DATE: 3-23-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-10

SUBJECT Pyro Batteries Vented to Cabin

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Outgassing of Batteries

SUPPORTING FACTORS None

NEGATIVE FACTORS Venting occurs only during excessive charging or discharging. Subsequent tests verify the pyro batteries had not been subject to any condition which could have resulted in venting. No indication of fire initiation in this area.

CONCLUSION Close this item based upon lack of supporting factors and result of lab tests. Physical inspection of the batteries showed no external evidence of KOH which probably indicates no venting.

DATE: 3-22-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-11

SUBJECT Cabin Fan Failure

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE ECS-4

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE 3-23-67 STATUS DUPLICATE

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-12

SUBJECT Suit Compressor Overloaded

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE ECS-3

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE 3-23-67 STATUS DUPLICATE

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-13

SUBJECT Inverter Phase Lock Box (Pa[illegible] 208) Failure

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Heat

SUPPORTING FACTORS None

NEGATIVE FACTORS The three circuit breakers CB 1, 2, and 3 on Panel 209 which supplied all power to the phase lock box (Panel 208) was open per OCP and found open subsequent to the fire.

CONCLUSION Close this item. The phase synch box was examined and shows no indication of overheating or other evidence of ignition source. The phase lock box was not energized from switch position information.

DATE: 3-22-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-14

SUBJECT Panel 150 Lying Loose

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Electrical spark or heat.

SUPPORTING FACTORS Panel 150 has circuit breakers which connect directly to the 3 entry batteries and 2 pyro batteries. This panel was not installed in place and was "resting" on a harness.

NEGATIVE FACTORS No evidence of arcing or fire initiation in this area.

CONCLUSION Close this item. Extensive examination of panel 150 revealed no evidence of arcing or shorting. Electrical checks substantiate Nominal resistance and functional circuit breakers.

DATE: 3-22-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-15

SUBJECT J185 Octopus Cable Connector

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE COMM-1

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE 3-23-67 STATUS: DUPLICATE

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-16

SUBJECT Water Glycol Corrosion of Connector(s)

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION This item is very general. A discussion will be included in the Panel 18 Final Report.

DATE: 3-24-67 STATUS: Closed as a specific item

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-17

SUBJECT Glycol Pump Overloaded

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE ECS-2

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE: 3-23-67 STATUS: DUPLICATE

ENCLOSURE 18-55

D-18-354

C-4

POTENTIAL IGNITION SOURCE EVALUATION SHEET EPS-18

SUBJECT AC Control Box V16-451136 Short

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Electrical short and/or heat propagating via an unknown mechanism.

SUPPORTING FACTORS Burned conformal coating on terminals 13 and 23 of motor switch S5.

NEGATIVE FACTORS Visual examination showed no evidence that the teflon on the wire was damaged. Electrical tests, reference TPS CM CA-056, indicated that the circuit was still intact.

CONCLUSION Based on the above tests and visual inspection, it is concluded that this item was not the ignition source. A member of the Fire Panel concurs.

DATE 3-21-67 Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-19

SUBJECT Evidence of an ARC on Tip to Pin 16 on Panel 20

SYSTEM OR COMPONENT T/C

IGNITION SOURCE AND PROPAGATION Electrical spark

SUPPORTING FACTORS Visual inspection indicates that the tip of Pin 16 (VHF/AM +28 VDC) has arced.

NEGATIVE FACTORS Arc is only on tip radius of pin. Tip radius is not rubbed when connector is mated. There is no evidence of overheating or arcing of pin or mating connector. The small mark on the tip radius of the pin most probably occurred during panel checkout prior to installation and was not rubbed off when the connector was mated.

CONCLUSION

There is no evidence that this item was an initiator of the fire.

DATE 3-22-67 STATUS Non-initiator Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-20

SUBJECT ARC of Wire/Cover on J-BOX C15-1A52

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE EPS-22

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE 3-23-67 STATUS DUPLICATE

ENCLOSURE 18-55

D-18-357

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-21

SUBJECT Wire Short to Junction Box Cover

SYSTEM OR COMPONENT

IGNITION SOURCE AND PROPAGATION

DUPLICATE - REFERENCE EPS-22

SUPPORTING FACTORS

NEGATIVE FACTORS

CONCLUSION

DATE 3-23-67 STATUS DUPLICATE

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-22

SUBJECT Damaged Wire J-Box C15-1A52 Cover Plate

SYSTEM OR COMPONENT EPS/RCS (+Yaw Normal Power MNA)

IGNITION SOURCE AND PROPAGATION Arcing of the DC power to the cover plate.

SUPPORTING FACTORS High energy source (250 amp power supply through a 20 amp circuit breaker and #16 wire). Evidence of arcing or welding on the panel cover plate and on the adjacent power wire. Propagation could have been by the wire coating glycol residue, and/or nearby debris net, Velcro, etc. ignited either locally or at a distance by flying sparks. This area matches the Fire Panel's theory about where the fire started.

NEGATIVE FACTORS No evidence of a momentary overload on Main Bus A.

CONCLUSION This theory is not prime suspect.

DATE 3-24-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET — EPS-23

SUBJECT: Electrical Wires Routed in Front of Heater (Reference P482 TPS 369 Step 17)

SYSTEM OR COMPONENT: EPS/ECS

IGNITION SOURCE AND PROPAGATION: Overheated wiring in vicinity of urine dump heater.

SUPPORTING FACTORS: None.

NEGATIVE FACTORS: Heaters not on per OCP. C/B's verify this configuration. Heater located in aft compartment. No evidence of fire having originated in this area.

CONCLUSION: Since no power was applied to this circuit and physical evidence indicated fire did not originate in aft compartment, close this item.

DATE: 3-28-67 STATUS: Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-24

SUBJECT SPS PUGS Display Unit

SYSTEM OR COMPONENT SPS

IGNITION SOURCE AND PROPAGATION 28 VDC and 115 V, 400 Cycle, was present within the PUGS Display Unit at the time of accident. All PUGS circuit breakers were closed.

SUPPORTING FACTORS None

NEGATIVE FACTORS TPS S/C012-CM-CA-092 was performed satisfactorily which verified the functional integrity of the PUGS Display Panel Assembly. All data obtained was within specified accuracy of applicable process spec. MA0210-0171, Sect. 61.

CONCLUSION The only visible damage to the PUGS Display Panel Assembly is a cracked glass on the face of unbalance meter. This unit should have in no way contributed to the S/C 012 accident.

DATE 3-24-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-25

SUBJECT Main Bus B Short to Substructure at S11, Panel 8

SYSTEM OR COMPONENT Main Display Console

IGNITION SOURCE AND PROPAGATION Potential short circuit or arc through area of conformal coating on one terminal of S11 that contacted substructure behind Panel #8.

SUPPORTING FACTORS Continuity check through damaged area of conformal coating on S11 terminal shows potential short circuit to substructure. Microscopic examination of substructure disclosed minute area of sparking, or arcing, in area of terminal contact.

NEGATIVE FACTORS Area of sparking to substructure is minute. The arc pits can only be observed under at least 10 power magnification. There is no evident damage due to overheating to the conformal coating on the switch terminal.

CONCLUSION An intermittant short to the substructure existed from S11 through the conformal coating. However, the size of the observed arc pits and the lack of heat caused decomposition of the conformal coating indicate that the heating was insufficient to have been the ignition source.

DATE 3-24-67 STATUS Non-initiator - Closed

POTENTIAL INITIATION THEORIES EVALUATION SHEET EPS-26

SUBJECT Wiring Arc near Scientific Equipment Bay 2
LEB Main Bus B

SYSTEM OR COMPONENT EPS

IGNITION SOURCE AND PROPAGATION Electrical arc igniting battery tape.

SUPPORTING FACTORS Evidence of arcing. Battery tape was burned. A short on Main Bus B could account for the AC Bus #2 voltage transient.

NEGATIVE FACTORS Inspection by the Fire Board resulted in the conclusion that the absence of a propagation path negates this theory.

CONCLUSION This theory should be closed based on the results of the Fire Board inspection.

DATE 3-27-67 [illegible] Non-initiator - Closed

ENCLOSURE 18-55

POTENTIAL INITIATION THEORIES EVALUATION SHEET

SUBJECT STATIC CHARGE BUILDUP IN SUITS

SYSTEM OR COMPONENT PRESSURE GARMENT ASSEMBLY

IGNITION SOURCE AND PROPAGATION POSSIBILITY OF STATIC CHARGE BUILDUP AND DISCHARGE BETWEEN SUITED ASTRONAUT AND S/C.

SUPPORTING FACTORS SUIT AND COUCH PAD MATERIAL WAS BURNED.

NEGATIVE FACTORS TPS S/C 014 CM 038 WAS PERFORMED WITH A SUITED PERSON, VENTILATED WITH DRY AIR. READINGS OF CAPACITANCE AND VOLTAGE BETWEEN SUBJECT AND S/C WERE BELOW THE ENERGY REQUIREMENTS TO IGNITE ANY SOLID MATERIALS FOUND IN S/C.

CONCLUSION A SUITED PERSON CANNOT GENERATE SUFFICIENT ELECTROSTATIC ENERGY TO IGNITE ANY SOLID MATERIALS FOUND IN S/C

DATE: 3/27/67 STATUS: Non-initiator - Closed

BRIEF SUMMARY OF SIGNIFICANT
SPECIAL TEST RESULTS

1. Effect of Water-Glycol on Gas Chromatograph Cable and Connector

Tests conducted to determine the reaction of the cable and its contribution to the accident if water-glycol had contacted the gas chromatograph connector. Tests indicated that no voltages appeared at the two shielded signal leads until all connector pins were completely immersed. At that point a 400 cps, approximately 4.5 volt, signal was noted. Ignition did not occur; however, what appeared to be localized boiling was noted in the area of two 115-volt connector pins which were adjacent to each other on the connector.

2. Effects of Water-Glycol on Spacecraft Connectors

During the checkout phase of Spacecraft 012 operations, water-glycol leaks and spillages were encountered. Some of the spacecraft harnesses were wetted and subsequently cleaned with water and alcohol, and dried with nitrogen. Test conducted to determine if the cleaning procedure was adequate and to determine the effects of exposure of electrical connectors to water-glycol. Test incomplete at this time as 20-day cycle started on March 14, 1967. Tests being conducted at KSC.

3. Determine ΔP vs CDU Gimbal Angles

A test was conducted on Spacecraft 008 at MSC to obtain data on CDU gimbal angle changes at various cabin differential pressures. This data was then used for correlation with data available from Spacecraft 012.. All of the data are contained in the Panel 10 Final Report.

4. Corner Ignition Test

A test was conducted at MSC in a 14.7 psia, 100% oxygen environment to determine whether ignition of a nylon chafing strip at the left-hand portion of the lower equipment bay will ignite the remaining flammable materials in the immediate vicinity. Test disclosed that all debris netting and Velcro on flight qual recorder burned completely as a result of the nylon ignition.

5. Boilerplate Mock-up Fire Tests

Boilerplate A at MSC was mocked-up as close as possible to the Spacecraft 012 internal cabin configuration with respect to flammable materials. A fire was then started to try to reproduce the Spacecraft 012 accident. Five tests have been conducted to date, under various pressure and oxygen environments. The test results are covered in detail in the Panel 8 Final Report.

6. Wet Wire Fire Ignition Test

A test was conducted at MSC to determine whether water-glycol will ultimately lead to shorting and ignition when dripped on wires with deliberate flaws. The test indicated that a conductor carrying 3 amp 28 volts DC did ignite approximately 8 hours after exposure to a water-glycol drip.

7. Summary of Spacecraft 008 DC and AC Electrical Tests

The results from each of the electrical tests conducted on Spacecraft 008 are summarized in the following paragraphs. The many tests and test conditions were primarily compared to the PCM data obtained at the time of the AC electrical transient on Spacecraft 012, to establish what condition or set of conditions would duplicate that data.

(a) Effect of Rapid Switching of Non-Essential Bus from DC bus A to DC bus B

This test condition did not produce data similar to that on Spacecraft 012.

(b) Effect of Inverter Switching to Supply AC Buses

This test condition did not produce data similar to that of Spacecraft 012. The over-shoot amplitudes on the AC bus voltages were too low and too rapid.

(c) Effect of Load Switching on the AC Buses

This test condition did not produce data similar to that of Spacecraft 012. The drop in voltage on the AC bus due to switching any of the large electrical loads was

regulated by the inverter to maintain the DC bus voltage above the minimum required to cause a dropout of the VHF/FM transmitter and C-band beacon.

(d) Effects of Shorts of Various Durations and Levels on AC bus 2 Circuits

These tests did not produce data similar to that of Spacecraft 012. The prime difference was the lack of proper amplitude for the three AC bus 2 voltages. However, dropout effects of the VHF/FM transmitter and C-band beacon, and the recovery time for the AC voltages were similar to that of Spacecraft 012.

(e) Effects of Interrupting DC Power to the Control Relays which Control Switching of AC Power to the VHF/FM Transmitter and C-band Beacon

These tests did not produce data similar to that of Spacecraft 012. The dropout of the transmitter and beacon could be reproduced; however, the effect on the AC voltages was not present.

(f) Effects of DC Shorts of Various Durations and Levels on the DC bus

DC shorts of a 5 to 20 milliseconds duration for current values of about 80 amps or greater are required to drop the voltage on the DC bus sufficiently to cause the inverter to lose regulation. These tests indicated that shorts of several milliseconds duration and of sufficient current drain can closely reproduce the Spacecraft 012 data indications at the time of the AC bus 2 transient.

(g) Effects of Momentary Interruption of DC Power to the Inverter

A DC interruption of 2.5 to 20 milliseconds duration will reproduce the Spacecraft 012 data indications at the time of the AC bus 2 transient.

(h) Determine Arcing Damage to Wires of Various Sizes Used Within the Spacecraft, With Current Limited to Values Commensurate with Circuit Characteristics of the Spacecraft

The wire damage due to arcing was found to be primarily a function of the resistance at the shorting point. A relatively high current passing through a short of very low resistance would cause little or no damage as compared to a relatively low current passing through a short of several ohms resistance.

(i) Effects of Shorting Power Leads in the Octopus Cable to the MDAS Recorder

A momentary short on the octopus cable power wires would not cause a drop of voltage on the DC bus sufficiently low enough to cause the inverter to lose regulation. Also, the effect of a momentary short appeared on the biomed monitoring channels of the MDAS recorder as transients. A short of greater than 8 milliseconds duration would cause the time reference of the MDAS to lose time.

8. <u>TV Simulation Using Spacecraft 008</u>

Several individuals witnessed the Spacecraft 012 accident on television monitors. A test was accomplished utilizing

Spacecraft 008 to substantiate the visual resolution that one could expect over a television monitor system. No additional conclusions or observations resulted from the conduct of this test.

9. Cobra Cable Spark Ignition Tests

The minimum ignition energies of several solvents used in the Spacecraft and the problems experienced with the communications system indicated that the connect or disconnect of a cobra cable could be suspect as a spark or ignition in a simulated Spacecraft 012 environment. Separation of the cobra cable did not produce any visible sparks or ignition.

10. Suit Electrostatic Discharge Tests

Tests were conducted to determine the energy that can be transferred from a suited person when the suit is electrostatically charged. Tests conducted in Spacecraft 014 indicate that insufficient energy is generated for ignition to occur.

11. Mock-up 2 Mobility Evaluation Test

This test was conducted to determine the capability of a crew to see certain areas of the Spacecraft and to perform certain actions with respect to time.

12. Gas Chromatograph Cable and Connector Tests

Special tests disclosed that an output from the gas chromatograph connector can be produced by:

(a) Physical movement or disturbance of the wiring and or the connector

(b) Application of external heat to the wiring and/or the connector.

13. Voltage Regulation Tests at Launch Complex 34

These tests indicated that a short circuit in the range of 5 to 25 milliseconds, drawing approximately 75 amps, caused an immediate drop in DC bus voltage of 13 to 15 volts.

14. Gas Chromatograph Cable Arcing Test

A test was conducted using Spacecraft 008 to determine whether arcing would occur if the gas chromatograph connector was dropped onto a metal surface. No arcing took place.

15. Test to Reproduce Copper Flow Found on Gas Chromatograph Cable

Tests were conducted to reproduce a copper flow condition found on the AC wires of the gas chromatograph cable. All attempts to simulate the condition by either short circuits or by application of external heat did not result in a similar appearance of the wires.

16. Pyrotechnic Battery Hydrogen Outgassing Tests

Tests have been conducted on pyrotechnic batteries to determine the outgassing characteristics at ambient and elevated temperatures. Based on these tests, it was concluded that the battery relief valves did not relieve and admit hydrogen to the Command Module.

17. Flammability Propagation Rates of Debris Netting

Tests were conducted at KSC to determine the flammability propagation characteristics of the debris netting of that type located in the Command Module floor at the ECU. Tests conducted at an ambient pressure, 100% oxygen atmosphere, produced a burning rate of approximately 2 inches per second, burning in a horizontal direction. Refer to the Panel 8 Final Report for more information on other materials' flammability test results.

18. Water-Glycol Flammability Tests

A number of water-glycol flammability tests have been conducted at KSC and at MSC, and are still continuing at this time. Some of the tests indicate that the inhibitor agent in the water-glycol coolant fluid does provide a flame propagation path along electrical harnesses exposed to leakage and spillage of water-glycol.

List of References

Reference	Description
18-1	"Screening Committee Final Report", dated March 24, 1967
18-2	"Structural Assessment Report", dated February 8, 1967, prepared by NASA-MSC, Mr. P. C. Glynn
18-3	"Explanation and Discussion of ECS Water/Glycol Circuit Prior to and After the Fire Report", dated February 6, 1967, prepared by NASA-MSC, Mr. F. H. Samonski
18-4	"Spillage of Ethylene Glycol/Water (RS89-a) as a Possible Cause of Fire in SC204", dated February 20, 1967, prepared by NASA-MSC, Dr. W. R. Downs
18-5	"ECS Oxygen System Description and Interim Data Evaluation", dated February 9, 1967, prepared by NASA-MSC, Mr. F. H. Samonski
18-6	"Communications Analysis Report", dated February 15, 1967, prepared by NASA-MSC, Mr. O. A. Beers
18-7	"Mock-up 2 Mobility Evaluation Test Results", dated March 9, 1967, prepared by NAA-Downey, Mr J. W Montgomery
18-8	"Analysis of Tape Recorder Transmissions From Apollo Spacecraft on January 27, 1967", prepared by Bell Telephone Laboratories, Incorporated
18-9	"Analysis of Tape Recorded Transmission From Apollo Spacecraft 012", dated March 23, 1967, prepared by NASA-MSC, Instrumentation and Electronic Systems Division