

OXYGEN TANK NO. 2 DESIGN

Findings:

- a. The cryogenic oxygen storage tanks contained a combination of oxidizer, combustible material, and potential ignition sources.
- b. Supercritical oxygen was used to minimize the weight, volume, and fluid-handling problems of the oxygen supply system.
- c. The heaters, fans, and tank instrumentation are used in the measurement and management of the oxygen supply.

Determinations:

- (1) The storage of supercritical oxygen was appropriate for the Apollo system.
- (2) Heaters are required to maintain tank pressure as the oxygen supply is used.
- (3) Fans were used to prevent excessive pressure drops due to stratification, to mix the oxygen to improve accuracy of quantity measurements, and to insure adequate heater input at low densities and high oxygen utilization rates. The need for oxygen stirring on future flights requires further investigation. [...]

SUMMARY ANALYSIS OF THE ACCIDENT

The following discussion treats the accident in its key phases: initiation, propagation of combustion, loss of oxygen tank no. 2 system integrity, and loss of oxygen tank no. 1 system integrity. [...]

Key Data:

- 55:53:20 Oxygen tank no. 2 fans turned on.
- 55:53:22.757 1.2-volt decrease in ac bus 2 voltage. [...]
- 55:53:22.772 11.1-ampere "spike" recorded in fuel cell 3 current followed by drop in current and rise in voltage typical of removal of power from one fan motor - indicating opening of motor circuit.
- 55:53:36 Oxygen tank no. 2 pressure begins to rise.

The evidence points strongly to an electrical short circuit with arcing as the initiating event. About 2.7 seconds after the fans were turned on in the SM oxygen tanks, an 11.1-ampere current spike and simultaneously a voltage-drop spike were recorded in the spacecraft electrical system. Immediately thereafter, current drawn from the fuel cells decreased by an amount consistent with the loss of power to one fan. No other changes in spacecraft power were being made at the time. No power was on the heaters in the tanks at the time and the quantity gage and temperature sensor are very low power devices. The next anomalous event recorded was the beginning of a pressure rise in oxygen tank no. 2, 13 seconds later. Such a time lag is possible with low-level combustion at the time. These facts point to the likelihood that an electrical short circuit with arcing occurred in the fan motor or its leads to initiate the accident sequence. The energy available from the short circuit was probably 10 to 20 joules. Tests conducted during this investigation have shown that this energy is more than adequate to ignite Teflon of the type contained within the tank. [...] This likelihood of electrical initiation is enhanced by the high probability that the electrical wires within the tank were damaged during the abnormal detanking operation at KSC prior to launch. [...]